REPUBLIC OF KENYA

Learning Guide for
NUTRITION AND DIETETICS
LEVEL 6

TVET CDACC
P.O. Box 15745–00100 Nairobi, Kenya

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LEVEL 6

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Council Secretary/CEO

TVET Curriculum Development, Assessment and Certification Council

P.O. Box 15745–00100

Nairobi, Kenya

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Foreword

The provision of quality education and training is fundamental to the Government's overall strategy for social economic development. Quality education and training will contribute to achievement of Kenya's development blue print and sustainable development goals. This can only be addressed if the current skill gap in the world of work is critically taken into consideration.

Reforms in the education sector are necessary for the achievement of Kenya Vision 2030 and meeting the provisions of the Constitution of Kenya 2010. The education sector has to be aligned to the Constitution and this has triggered the formulation of the Policy Framework for Reforming Education and Training (Sessional Paper No. 4 of 2016).

A key provision of this policy is the radical change in the design and delivery of the TVET training which is the key to unlocking the country's potential in industrialization.

This policy document requires that training in TVET be Competency Based, Curriculum development be industry led, certification be based on demonstration and mastery of competence and mode of delivery allows for multiple entry and exit in TVET programs.

These reforms demand that industry takes a leading role in TVET curriculum development to ensure the curriculum addresses and responds to its competence needs.

This learning guide in Nutrition and Dietetics is aimed at enhancing a harmonized delivery of the Competency-Based Curriculum for Nutrition and Dietetics Level 6 by all implementing training institutions.

It is my conviction that this learning guide will play a critical role towards supporting the development of competent human resource for the Nutrition and Dietetics Sector's growth and sustainable development.

Principal Secretary,

Vocational And Technical Training
Ministry of Education

Preface

Kenya Vision 2030 is anticipated to transform the country into a newly industrializing, "middle-income country providing a high-quality life to all its citizens by the year 2030". The Sustainable Development Goals (SDGs) further affirm that the manufacturing sector is an important driver to economic development. The SDG nine that focuses on Building resilient infrastructures, promoting sustainable industrialization and innovation can only be attained if the curriculum focuses on skill acquisition and mastery. Kenya intends to create a globally competitive and adaptive human resource base to meet the requirements of a rapidly industrializing economy through life-long education and training. TVET has a responsibility of facilitating the process of inculcating knowledge, skills and attitudes necessary for catapulting the nation to a globally competitive country, hence the paradigm shift to embrace Competency Based Education and Training (CBET). The Technical and Vocational Education and Training Act No. 29 of 2013 and the Sessional Paper No. 4 of 2016 on Reforming Education and Training in Kenya, emphasized the need to reform curriculum development, assessment and certification to respond to the unique needs of the industry. This called for shift to CBET to address the mismatch between skills acquired through training and skills needed by industry as well as increase the global competitiveness of Kenyan labor force.

The TVET Curriculum Development, Assessment and Certification Council (TVETCDACC), in conjunction with TVET training institution trainers developed the Occupational Standards which was the basis of developing competency-based curriculum and assessment of an individual for competence certification for a Nutrition and Dietetics Level 6. The learning guide is geared towards promoting efficiency in delivery of curriculum.

The learning guide is designed and organized with clear and interactive learning activities for each learning outcome of a unit of competency. The guide further provides information sheet, self-assessment, tools, equipment's, supplies, and materials and references.

I am grateful to the Council Members, Council Secretariat, Nutrition and Dietetics experts and all those who participated in the development of this learning guide.

Prof. Charles M. M. Ondieki, PhD, FIET (K), Con. Eng. Tech.

Chairman,
TVET CDACC

Acknowledgement

This learning guide has been designed to support and enhance uniformity, standardization and coherence in implementing TVET Competency Based Education and training in Kenya. In developing the learning guide, significant involvement and support was received from various organizations.

I recognize with appreciation the critical role of the participants drawn from Technical Training institutes, Universities and Private sector in ensuring that this learning guide is in line with the competencies required by the industry as stipulated in the occupational standards and curriculum. I also thank all stakeholders in the Nutrition and Dietetics Sector for their valuable input and all those who participated in the process of developing this learning guide, in particular, the contributions of Francis Njoroge Muriithi, Josephine Muthoni Miring'u, Alice Wairimu Muraya, Ann Nyawira Kibui, Monicah J. Sitienei, Robert Kiplagat Kandie, Jackline Kerubo, Maryann Wambui Maina, and Gabriel Onduto.

I am convinced that this learning guide will go a long way in ensuring that workers in the Nutrition and Dietetics Sector acquire competencies that will enable them to perform their work more efficiently and make them enjoy competitive advantage in the world of work.

Dr. Lawrence Guantai M'itonga, Ph.D

Council Secretary/CEO
TVET CDACC

Acronyms and Abbreviations

2D	Two Dimensional
5-HIAA	5-Hydroxy Indole Acetic Acid
AA	Amino Acid
ABC	Avidin-Biotin Complex
Ach	Acetylcholine
ACTH	Adrenocorticotropic hormone
AD	Appropriate for Date
ADA	American Dieticians Association
ADH	Antidiuretic Hormone
ADIME	Assessment, Diagnosis, Intervention, Monitoring & Evaluation
AFASS	Affordable, Feasible, Acceptable, Safe and Sustainable
AI	Adequate Intake
AIDS	Acquired Immune Deficiency Syndrome
AIO	All in One
AKD	Acute Kidney Disease
Ala	Alanine
Alb	Albumin
ALP	Alkaline Phosphatase
ALT	Alanine Transaminase
ANC	Antenatal Care
ANP	Antrial Natriuretic Peptide
ANS	Autonomic Nervous System
APA	American Psychological Association
APD	Automated Peritoneal Dialysis
ARF	Acute Renal Failure
ART	Anti-retroviral therapy
ARV	Anti-retroviral drugs
ASP	Alkaline Phosphatase
AST	Aspartate Transaminase
ATP	Adenosine Triphosphate
AV	Atrioventricular
Aw	water activity
AZT	Azidothymidine
BC	Basic Competency
BMI	Body mass index
BMR	Basal Metabolic Rate
BMR	Basal Metabolic Rate
BMS	Breast Milk Substitute
BOP	Blood Osmotic Pressure
BP	Blood Pressure
BPH	Benign Prostatic Hypertrophy
BUN	Blood Urea Nitrogen
BW	Birth weight
CA	Cancer
CAC	Citric Acid Cycle
CAMP	Cyclic Adenosine Monophosphate
CAPD	Continuous Ambulatory Peritoneal Dialysis
CART	combination ARV Therapy
CBC	Complete Blood Count
CB-DOTS	Community-based direct observed treatments
CC	Common Competency
CCK	Cholecytokinin
CCP	Critical Control Point
CCPD	Continuous Cyclic Peritoneal Dialysis
CDACC	Curriculum Development, Assessment and Certification Council
CHD	Coronary Heart Disease
CHF	Coronary Heart Failure
Chn	Children
CHO	Carbohydrate
CHP	Capillary Hydrostatic Pressure
CKD	Chronic Kidney Disease

CNS	Central Nervous System
CO	Cardiac output
CoA	Coenzyme A
CP	Control Point
CPN	Central Parenteral Nutrition
CR	Core Competency
CSF	Cerebrospinal Fluid
CT	Connective Tissue
CT	Computed Tomography
CVD	Cardiovascular Disease
CVS	Cardiovascular System
DAB	3,3'-Diaminobenzidine
DAG	Diacylglycerol
DCT	Distal Convoluted Tubule
DHA	Docosahexaenoic acid
DHIS	District Health Information System
DL	Density Lipoproteins
DM	Diabetes Mellitus
DNA	Deoxyribonucleic Acid
DRI	Dietary Reference Intake
DRI	Daily Reference Intake
EAA	Essential Amino Acids
EAR	Estimated Average Requirement
EBSA	Total body surface area.
ECF	Extracellular Fluid
EFA	Essential Fatty Acids
EFAD	Essential Fatty Acid Deficiency
EN	Enteral nutrition
ENS	Enteric Nervous System
ER	Endoplasmic Reticulum
ER	Expiratory Reserve Volume
ESRD	End-stage Renal Disease
FADH	Flavin adenine dinucleotide with hydrogen
FAO	Food and Agriculture Organization
FAS	Foetal Alcohol Syndrome
FFA	Free fatty acids
FFQ	Food Frequency Questionnaire
FHM	Fortified Human Milk
FHP	Filtrate Hydrostatic Pressure
FRC	Functional Residue capacity
FSH	Follicle Stimulating Hormone
FTP	File Transfer Protocol
FTT	Failure to Thrive
g	Grams
GABA	Gamma ammo-butyric acid
GALT	Galactose-1-phosphate uridyltransferase
GAM	Global Acute Maturation
G-Cells	Gastrin Cells
GERD	Gastro-oesophageal Reflux Disease
GFR	Glomerular Filtration Rate
GH	Growth Hormone
GHIF	Growth Hormone Inhibiting Factor
GIT	Gastrointestinal tract
GMP	Good Manufacturing Practices
GnRH	Gonadotropin-releasing Hormone
GOT	Glutamate Oxaloacetate Transaminase
GPT	Glutamate Pyruvate Transaminase
GUT	Genital Urinary Tract
H&E	Haematoxylin and Eosin
HAART	Highly active anti-retroviral therapy
HACCP	Hazard Analysis Critical Control Point
Hb	Haemoglobin
HBA1C	Haemoglobin A1C test

HBE	Harris Benedict Equation
HBV	High Biological Value
HCA	Heterocyclic amines
HCG	Human Chorionic Gonadotropin
HCL	Hydrochloric Acid
HDL	High Density Lipoproteins
HIV	Human Immunodeficiency Virus
HMGCoA	3-Hydroxy-3-methyl glutamyl CoA
HR	Heart rate
HTN	Hypertension
IBD	Inflammatory Bowel Disease
IC	Inspiratory Capacity
ICF	Intracellular Fluid
ICT	Information Communication Technology
IDA	Iron Deficiency Anaemia
IDD	Iodine Deficiency Disorders
IDL	Intermediate Density Lipoprotein
IFAS	Iron and Folic acid supplementation
IG	Insulin-like Growth factor
IgE	Immunoglobulin E
IgG	Immunoglobulin G
IHC	Immunohistochemical
Ile	Isoleucine
IMAM	Integrated Management of Acute Malnutrition
IPT	Intermittent Preventive Treatment for malaria during pregnancy
IRV	Inspiratory Reserve Volume
IU	International Unit
IUGR	Intrauterine Growth Retardation
IV	Intravenous
Kcal	Kilocalorie
LBM	Lean Body Mass
LBW	Low Birth Weight
LCD	Liquid Crystal Display
LCFA	Long chain fatty acid
LCT	Long chain triglyceride
LDL	Low Density Lipoprotein
Leu	Leucine
LFD	Large for Date
LH	Luteinizing Hormone
LSAB	Labelled Streptavidin Biotin
LUQ	Left Upper Quadrant
M&E	Monitoring and Evaluation
MAG	Monoacylcerol
MAM	Moderate Acute Malnutrition
MCFA	Medium Chan Fatty Acid
MCH	Maternal and Child Health
MCH	Mean Haemoglobin Concentration
MCHC	Mean cell haemoglobin concentration
MCR	Metabolic Clearance Rate
MCT	Medium Chain Triglyceride
MCV	Mean Cell Volume
MCV	Mean Cell Volume
MET	Metabolic Equivalent Term
Mg	Milligrams
MI	Myocardial Infraction
MLA	Modern Language association
MMOL	Millimoles
MNT	Medical Nutrition Therapy
MPH	miles per hour
MSH	Melanocyte Stimulating hormone
MSUD	Maple Syrup Urine Disease
MTCT	Mother to child transmission
MUAC	Mid Upper Arm circumference
NA	Numerical Aperture

NADH	Nicotinamide adenine dinucleotide
NAG	N-Acetylmuramic Acid
NAM	N-acetyl glucosamine
NE	Norepinephine
NEAA	Non-essential Amino Acids
NEC	Necrotizing Enterocolitis
NEMA	National Environmental Management Authority
NG	Nasogastric
NGO	Non-governmental Organisation
NGT	Nasogastric tube
NHIF	The National Hospital Insurance Fund
NIA	Nutrient Intake Analysis
NMJ	Neuromuscular Junction
NPE	Nutrition Program for the Elderly
NRTI	Nucleoside Reverse Transcriptase Inhibitors
NSAIDS	Non-steroidal anti-inflammatory drugs
NSIA	Non-steroidal anti-inflammatory agent
NSSF	National Social Security Fund
OI	Opportunistic Infections
ORS	Oral Rehydration Solutions
OSHA	Occupation Safety and Health Act
OSHS	Occupation Safety and Health Standards
OT	Oxytocin
PAH	Polycyclic aromatic hydrocarbons
PAP	Peroxidase Anti-Peroxidase
PAR	Participatory Action Research
PAS	Periodic Acid Schiff
PCM	Protein Calorie Malnutrition
PCT	Proximal Convoluted Tubule
PCV	Packed Cell Volume
PD	Peritoneal Dialysis
PE	Protein Energy
PEM	Protein Energy Malnutrition
PES	Problem, Etiology, Signs/ symptoms
PESTEL	Political, Economic, Social, Technological, Environmental and Legal
PGIE	Problem, Goal, Intervention, Evaluation
PGs	Prostaglandings
pH	Potential of Hydrogen
PHF	Potentially Hazardous Food
PI	Protease Inhibitor
PICC	Peripherally Inserted Central Catheters
PID	Pelvic Inflammation Disease
PIE	Problem, intervention and Evaluation
PIH	Pregnancy Induced Hypertension
PKU	Phenylketonuria
PLWHA	People living with HIV and AIDS
PMS	Premenstrual Syndrome
PN	Parenteral Nutrition
PND	Peripheral Nervous System
PNS	Peripheral Nervous system
PPE	Personal Protective Equipment
PPN	Peripheral Parental Nutrition
PRL	Prolactin
PRO	Protein
Pt	Patient
PTH	Parathyroid Hormone
RBC	Red Blood Cells
RDA	Recommended Dietary Allowance

RDN	Registered Dietician/ Nutritionist
REE	Resting Energy Equilibrium
REE	Resting Energy Equilibrium
RESOMAL	Rehydration solution for malnutrition
RNA	Ribonucleic acid
RUQ	Right Upper Quadrant
RUTF	Ready to use therapeutic food
RV	Residue Volume
SA	Sinoatrial
SAM	Severe Acute Malnutrition
SAS	Statistical Analysis System
SB	Strand Binding protein
SEM	Scanning Electron Microscope
SFD	Small for Date
SFP	Supplementary Feeding Programme
SGOT	Serum Glutamate pyruvate transaminase
SGPT	Serum Glutamate Pyruvate transaminase
SHH	Sonic Hedgehog
SIDS	Sudden Infant Death Syndrome
SMBG	Self-monitoring of blood glucose
SNS	Somatic Nervous System
SOAP	Subjective, Objective, Assessment, Plan
SPSS	Statistical package for Social Science
SR	Sarcoplasmic Reticulum
SSAC	Sector Skills Advisory Committee
STI	Sexually Transmitted Infections
SV	Stroke Volume
SWOT	Strengths Weaknesses Opportunities and Threats
TAG	Triacylglycerols
TB	Tuberculosis
TCA	Tricarboxylic acid cycle
TE	Total Energy
TEF	Thermic Effect of Food
TEM	Transmission Electron Microscope
TEX	Textile
TFP	Therapeutic Feeding Programme
THS	Thyroid Stimulating Hormone
TLC	Total Lung capacity
Tm	Total Magnification
TPN	Total Parental Nutrition
TV	Tidal volume
TVET	Technical and Vocational Education and Training
UHT	Ultra-High Temperature
UNICEF	United Nations Children's Fund
UV	Ultra-Violet
VAD	Vitamin A Deficiency
Val	Valine
VC	Vital Capacity
VEDV	Ventricular End-diastolic volume
VLBW	Very Low Birth Weight
VLDL	Very Low-Density Lipoproteins
WBC	White Blood Cells
WBC	White Blood Cells
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist hip ratio
XLD	Xylose Lysine Deoxycholate
XRD	X-Ray diffraction

TABLE OF CONTENTS

CHAPTER 1:

INTRODUCTION

1.1 Background Information

This learning guide has been developed in line with the functions of TVET CDACC as stipulated in Article 45 (1a) of the Technical and Vocational Education and Training (TVET) Act No. 29 of 2013, the Sessional Paper No. 2 of 2015 that embrace Competency Based Education and Training (CBET) system. It is therefore, the sole intent of this document to provide guidelines for a Competency-Based Nutrition and Dietetics Ccurriculum for level 6.

This learning guide consists of interactive learning activities, content, self-assessment and relevant and related references that enhances implementing of Nutrition and Dietetics Level 6 qualification. It enables the trainee to acquire the competencies that enable him/her to undertake the various processes in Nutrition and Dietetics. The guide further provides illustration, web links, case studies, examples and resources on how to implement all the learning outcomes/elements described in the Curriculum and occupational standards with a particular focus to a trainee.

1.2 The Purpose of Developing the Learning Guide

Nutrition and Dietetics level 6 curriculum development process was initiated using the DACUM methodology where jobs/occupations were identified. Further, job analysis charts and occupational standards were generated in collaboration with the industry players under the guidance of TVET CDACC (Curriculum Development Assessment and Certification Council). The result of the process was a Nutrition and Dietetics level 6 curriculum. The curriculum was further broken down to end up with units of learning. To effectively implement Nutrition and Dietetics level 6 curriculum, learning guides are required to provide training content and guide the learners and trainers on the learning process aimed at imparting the relevant knowledge, requisite skills and the right attitude to the industry. Learning guides are part of the training materials.

1.3 Layout of the Learning Guide

The learning guide is organized in chapters. Chapter one presents the background information, and purpose of developing the trainee guide. Each of the units of learning/unit of competency is presented as a chapter on its own. Each chapter presents the introduction of the unit of learning/unit of competency, performance standard and list of the learning outcome/elements in the occupational standards.

- **Learning Activities**

  For each learning outcome, the learning activities are presented covering the performance criteria statements and trainees demonstration of knowledge in relation to the range in the occupational standard and content in the curriculum.

- **Information Sheet**

  The information sheet is section under each learning outcome that provides the subject matter in relation to definition of key terms, method, processes/procedures/guidelines, content, illustrations (photographs, pictures, video, charts, plans, digital content, and simulation) and case studies.

- **Self-Assessment**

  Self-assessment is to the performance criteria, required knowledge, skills and the range as stated in the occupational standards. The section further provides questions and assignments in which trainees demonstrate that they have acquired the required competences and an opportunity to reflect on what they have acquired. It is expected that the trainer keeps a record of their plans, their progress and the problems they encountered which will go in trainee's portfolio. A portfolio assessment consists of a selection of evidence that meets the pre-defined requirements of complexity, authenticity and reliability. The portfolio starts at the beginning of the training and will be the evidence for the development and acquisition of the competence (summative and formative) by the student. It is important to note that Portfolio assessment is highly emphasized in the learning guide.

- **Tools, equipment's, supplies and materials**

  Finally the guide presents tools, equipment's, supplies and materials for each learning outcome as guided by the performance criteria in occupational standards and content in curriculum. References, relevant links and addendums are provided for further reading. The units of competency comprising this qualification include the following common and core unit of learning:

Common units of learning

Unit of Learning Code	Unit of Learning Title	Duration in Hours	Credit Factor
MED/CU/NUD/CC/01/6	Human anatomy	80	8
MED/CU/NUD/CC/02/6	Medical physiology	70	7
MED/CU/NUD/CC/03/6	Microbiology	90	9
MED/CU/NUD/CC/04/6	Food processing, safety and hygiene	50	5
MED/CU/NUD/CC/05/6	Nutrtition biochemistry	60	6
MED/CU/NUD/CC/06/6	Research methods and statistics	30	3
Total		**380**	**38**

Core units of learning

Unit of Learning Code	Unit of Learning Title	Duration in Hours	Credit Factor
MED/CU/NUD/CR/01/6	Nutrition in emergency	80	8
MED/CU/NUD/CR/02/6	Nutrition in life cycle	160	16
MED/CU/NUD/CR/03/6	Principles of human nutrition	200	20
MED/CU/NUD/CR/04/6	Nutrition care process	80	8
MED/CU/NUD/CR/05/6	Meal planning and management	90	9
MED/CU/NUD/CR/06/6	Maternal, infant and child nutrition	220	22
MED/CU/NUD/CR/07/6	Nutrition education and counselling	70	7
MED/CU/NUD/CR/08/6	Diet therapy I	80	8
MED/CU/NUD/CR/09/6	Diet therapy II	80	
MED/CU/NUD/CR/10/6	Dietetics	210	21
MED/CU/NUD/CR/11/6	Nutrition assessment and surveillance	70	7
MED/CU/NUD/CR/12/6	Industrial attachment	480	48
Total		**1820**	**182**
Grand total		**2620**	**262**

The total duration of the course is **2620 hours** which includes **420 hours** of basic units of learning and **480 hours** of industrial attachment.

CHAPTER 2:

DEMONSTRATE KNOWLEDGE IN HUMAN ANATOMY

2.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to understand human anatomy. It involves analyzing the scope of anatomy, identifying anatomical terminologies, demonstrating the knowledge of cell and cell division, identifying histological and cytological methods and demonstrating knowledge of types of tissues and their location.

2.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to analyse the scope of anatomy based on resource materials, identify and define anatomical terminologies as per relative position, demonstrate knowledge of the cell and cell division based on the cell physiology, identify histological and cytological methods and demonstrate knowledge of types of tissues and their location as per the scope.

2.3 Learning Outcomes

2.3.1 List of the Learning Outcomes

i) Identify anatomical terminologies

ii) Demonstrate the knowledge of cell and cell division

iii) Identify histological and cytological methods

iv) Demonstrate knowledge of types of tissues and their location

2.3.2 Learning Outcome 1: Identify Anatomical Terminologies

2.3.2.1 Learning Activities

Learning activity	Special instructions
i) Demonstrate understanding of anatomical and physiological terminologies	Define common anatomical terminologies and terms of relative position
ii) Apply relevant anatomical and physiological terminology when undertaking daily tasks	Illustrate relative position of anatomical terminologies in the human body

2.3.2.2 Information Sheet

Meaning of Human Anatomy

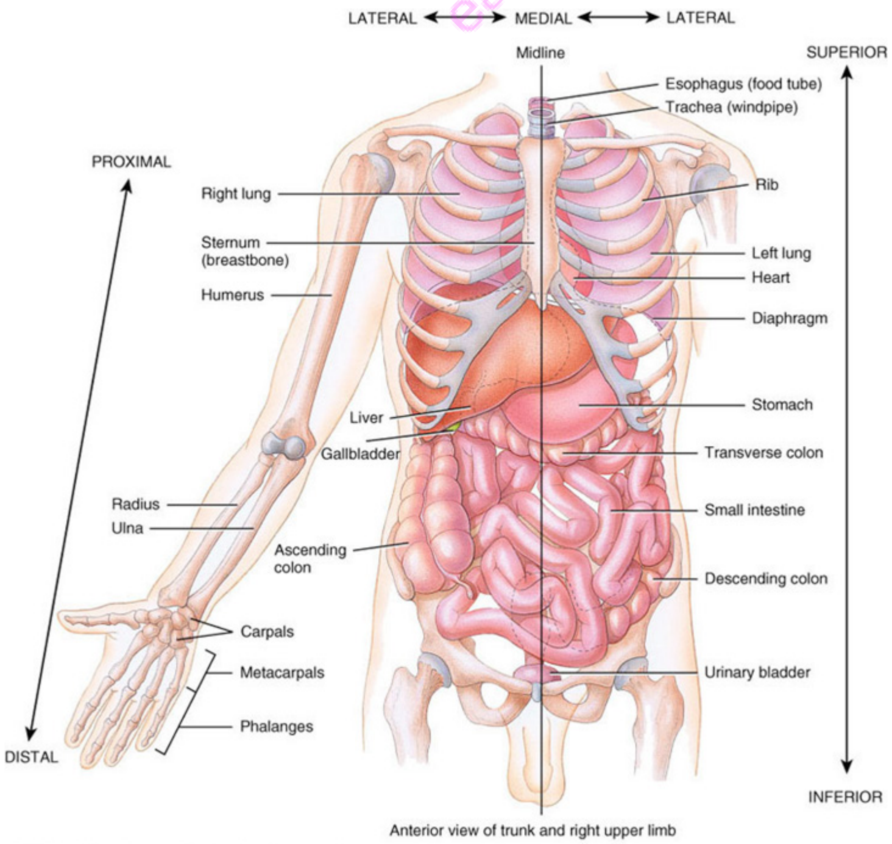
- Anatomy – Scientific study of human body structure
- Physiology – Study of human body functions
- "Structure dictates function."

Relevant Anatomical and Physiological Terminology

1. Anatomical Position – standing erect, facing forward, upper limbs at the sides, palms facing forward and thumbs out.

Orientation and Directional Terms

1. Terms of Relative Position (based on anatomical position):
   - Superior versus Inferior
   - Anterior versus Posterior
   - Medial versus Lateral
   - Proximal versus Distal (only in the extremities)
   - Superficial versus Deep
   - Internal versus External

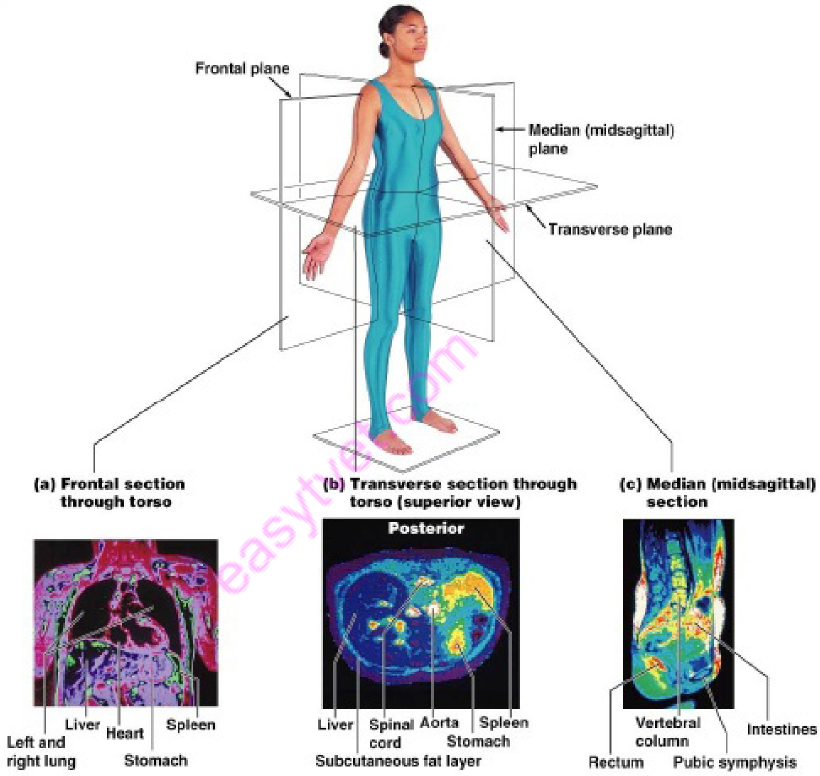


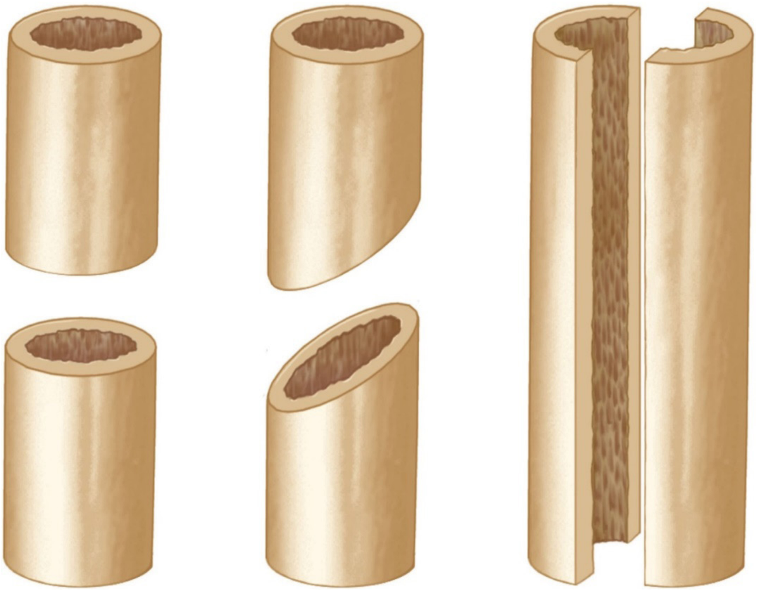
Anterior view of trunk and right upper limb

Body Sections or Planes (3)

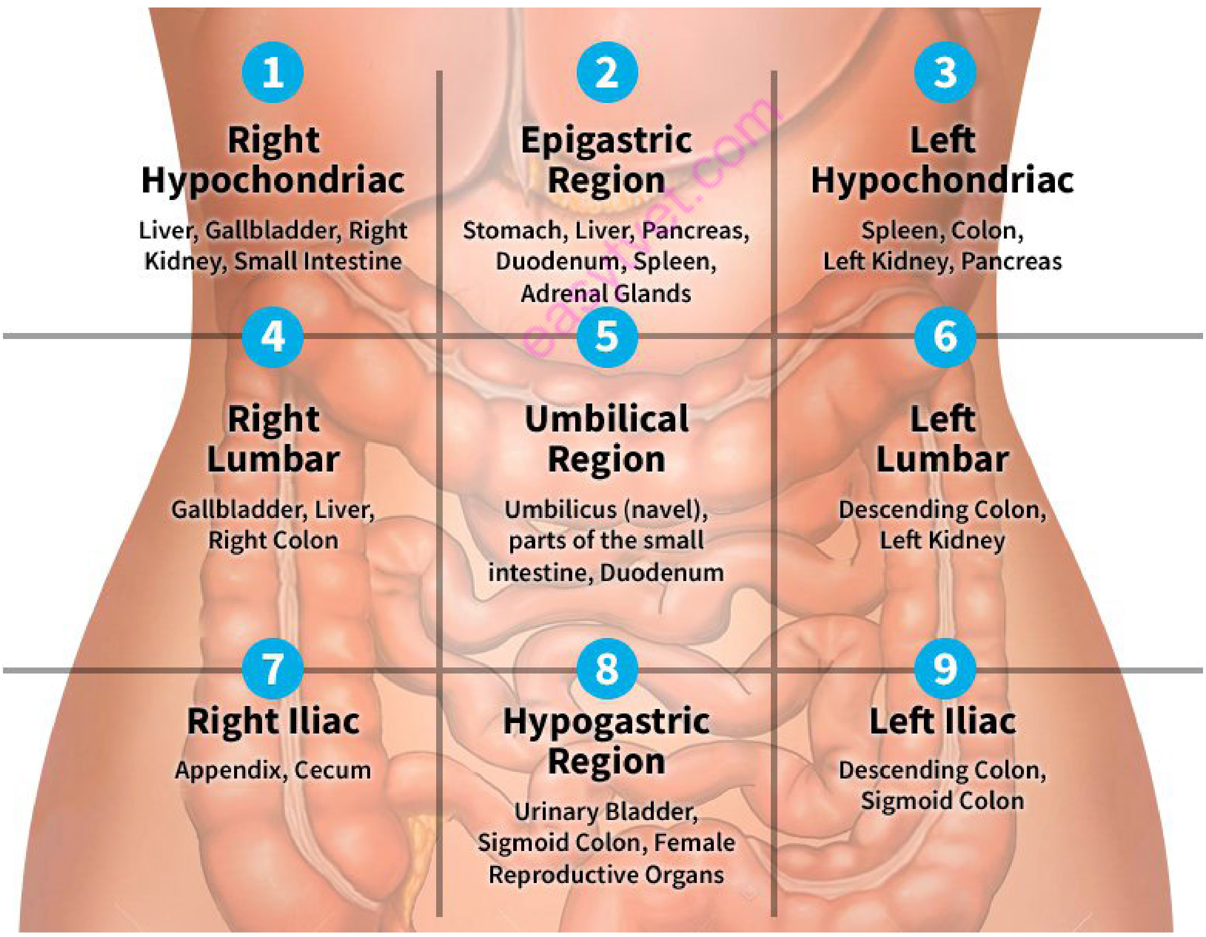
- Sagittal or Median – divides body into left and right portions
  - Mid-sagittal – divides body into equal left and right portions
- Transverse or Horizontal – divides body into superior and inferior portions
- Coronal or Frontal – divides body into anterior and posterior portions

Body Planes and Sections



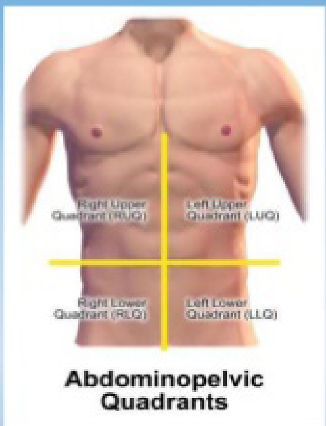


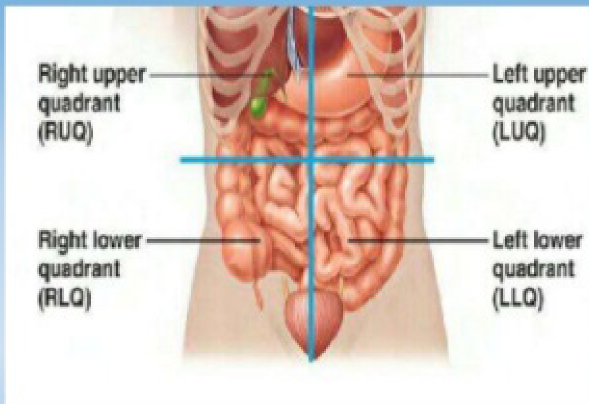
Abdominal Subdivisions (2)

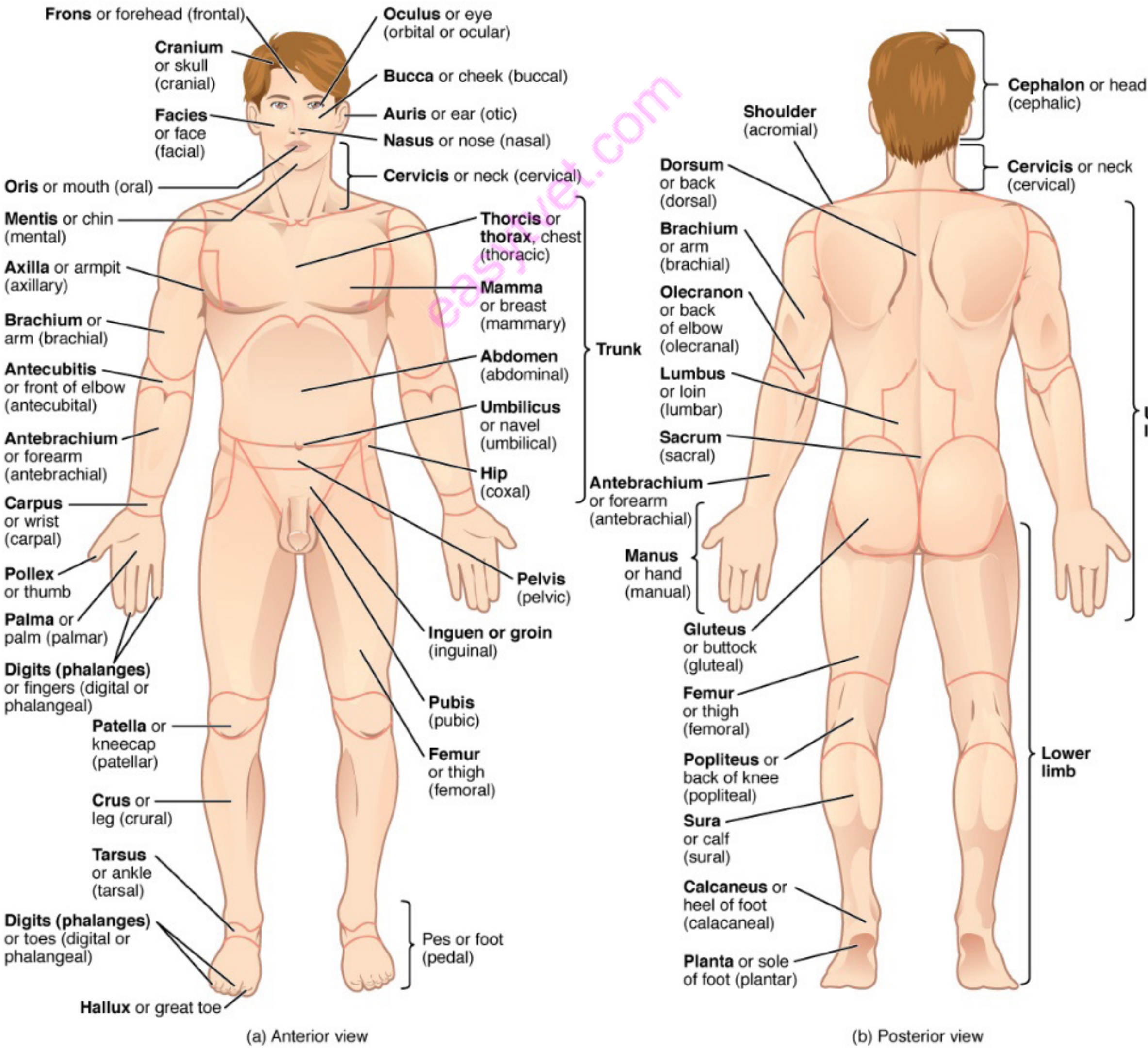


Quadrants of Abdomen

- Dividing the abdomen into various sections will help doctors determine what the cause of the illness is. The abdomen can also be divided into four quadrants:







Application of Relevant Anatomical and Physiological Terminology

Anatomical and physiological terminologies are applied in surgery and other diagnostic procedures in the hospital set up. They have enabled in the diagnosis of many medical and surgical conditions that affect human beings. These terminologies are the mainstay means of communication in the health care sector.

2.3.2.3 Self-Assessment

1. Define anatomy and physiology
2. Use a well labeled diagram to explain the nine regions of the abdomen.
3. The following organs are in the epigastric region of human abdomen which one is not
    A. Stomach
    B. Small intestine
    C. Spleen
    D. Liver
4. State and explain five terms of relative position as applied in anatomy
5. Define anatomical position
6. State whether the following statements is TRUE or FALSE
    A. Sagittal or Median body plane divides body into equal left and right portions
    B. Mid-sagittal body plane divides body into left and right portions
    C. Transverse or Horizontal body plane divides body into superior and inferior portions
    D. Coronal or Frontal body plane divides body into anterior and posterior portions

2.3.2.4 Tools, Equipment, Supplies and Materials

Dummy human body, dummy internal organs, microscope, slides, cadaver, anatomy text books, white board

2.3.2.5 References

Waugh A. & Grant A. (2016) Ross and Wilson Anatomy & Physiology 12th Edition; Churchill Livingstone

Bartholomew E.F. & Martini F.H. (2019) Essentials of Anatomy and Physiology; 8th Edition

Elaine N. & Katja H., 2016: Humana Anatomy and Physiology, 5th Edition

2.3.3 Learning Outcome 2: Demonstrate the knowledge of cell and cell division

2.3.3.1 Learning Activities

Learning activity	Special instructions
i) Identify cell types	
ii) Identify components of a human cell	Mount a pre-collected human cell on a light microscope and observe the parts Draw your observation and label the components
iii) Outline processes of cell division	Only outline cell division in eukaryotic cells
iv) Describe the composition of cytoplasm	
v) Identify type of cell division	

2.3.3.2 Information Sheet

Definition of terms

Cells are the smallest living structure

Cell = functional unit of the body

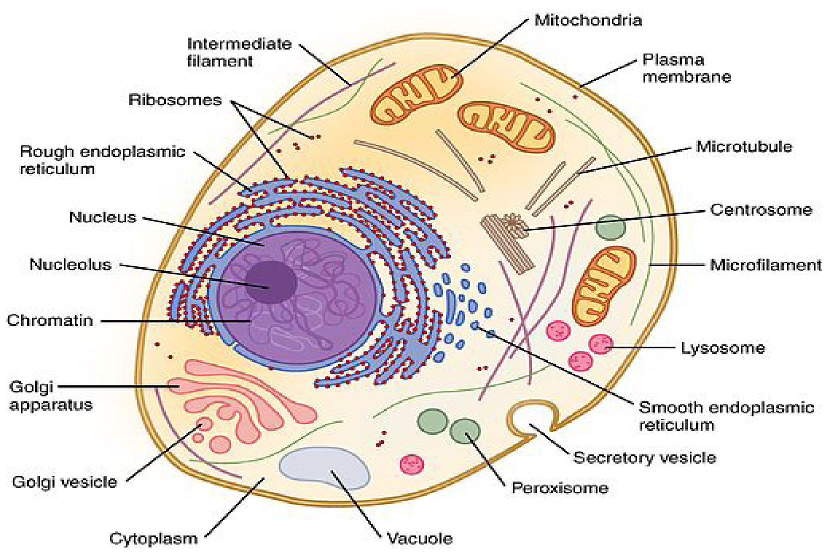
Cytology = The Study of Cells

Ultrastructural Cytology = Cytology at the Electron Microscopic level

Histology = the study of tissues

The basic organizational structure of the human body is the cell. There are 50-100 trillion cells in the human body. Differentiation is when cells specialize. As a result of differentiation, cells vary in size and shape due to their unique function.

The cell structure



- Also called a ‘typical’ cell
- Major parts include:
    - Nucleus: contains DNA
    - Cytoplasm: cellular contents between plasma membrane & nucleus
    - Cell membrane: selective barrier

Cell division

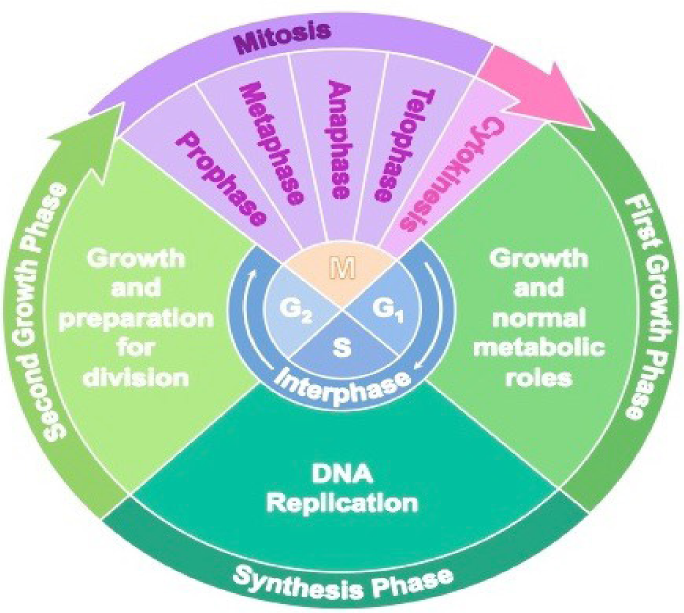
- Divides by mitosis-produces 2 new genetically identical daughter cells.
- Gametes (sex cells); division takes place by meiosis-produces four haploid cells.
- Interphase: period between cell division
- At the end of interphase the chromatin replicates and becomes tightly coiled forming a double chromosome i.e. chromatids for cell division.
- Chromatids are joined at the center by a centromere.
- Chromatid is one copy of a newly copied chromosome which is still joined to the original chromosome by a single centromere.

The Cell Cycle

Series of changes a cell undergoes from the time it forms until the time it divide.

Stages:

1. Interphase
2. Mitosis
3. Cytokinesis



Interphase

- Very active period

- Cell grows
- Cell maintains routine functions
- Cell replicates genetic material to prepare for nuclear division
- Cell synthesizes new organelles to prepare for cytoplasmic division

Phases:

1. G phases – cell grows and synthesizes structures other than DNA
2. S phase – cell replicates DNA

Mitosis

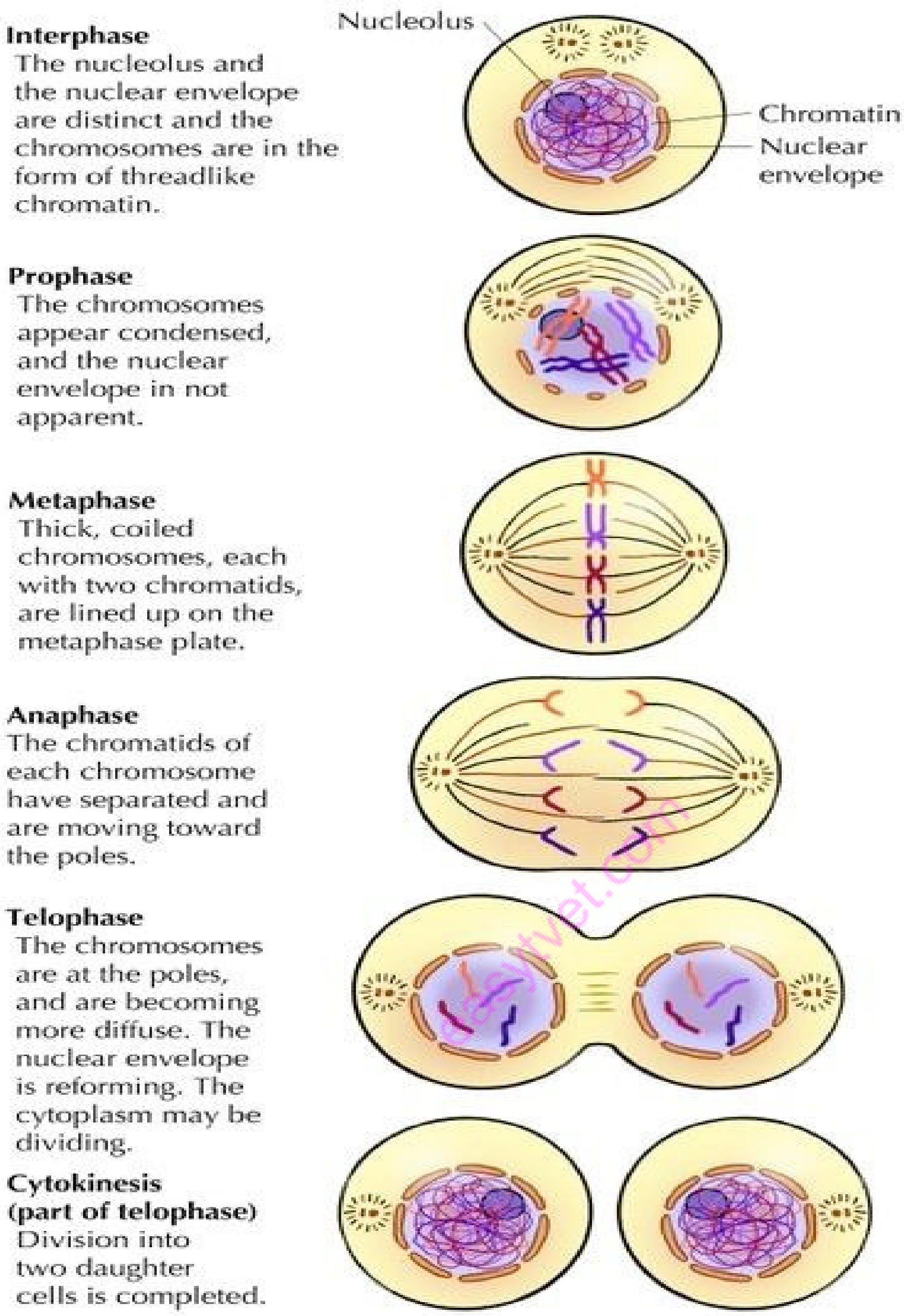
- Produces two identical daughter cells from an original somatic cell.
- Nucleus divides – karyokinesis
- Cytoplasm divides – cytokinesis
- Phases of Nuclear Division:
    1. Prophase – chromosomes form; nuclear envelope disappears
    2. Metaphase – chromosomes align midway between centrioles
    3. Anaphase – chromosomes separate and move to the opposite poles of the cell.
    4. Telophase – chromatin forms; nuclear envelope forms

Cytoplasmic Division

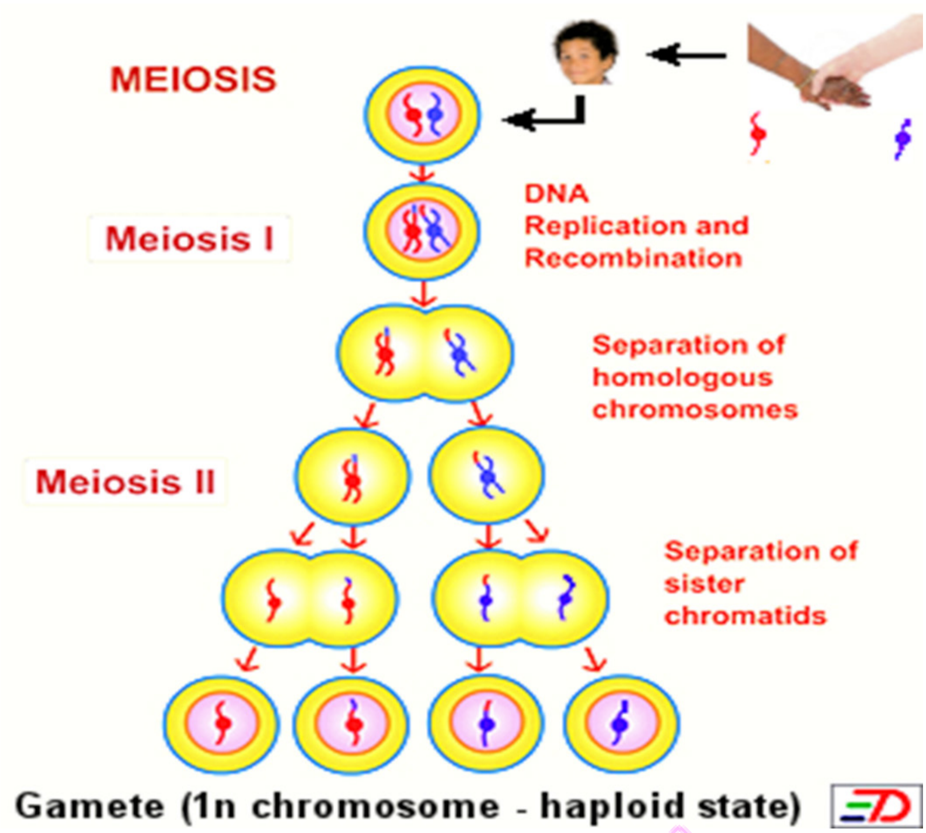
- Also known as cytokinesis
- Begins during anaphase
- Continues through telophase
- Contractile ring pinches cytoplasm in half.

Meiosis

- Is a specialized type of cell division that reduces the chromosome number by half, creating four haploid cells, each genetically distinct from the parent cell that gave rise to them.
- This type of cell division is only used to form gametes cells i.e. sperm and ovum.
- In meiosis, the chromosomes duplicate (during interphase) and homologous chromosomes exchange genetic information (chromosomal crossover) during the first division, called meiosis I. The daughter cells divide again in meiosis II, splitting up sister chromatids to form haploid gametes.
- Two gametes fuse during fertilization, creating a diploid cell with a complete set of paired chromosomes.



Differences Between Mitosis and Meiosis	
Mitosis	**Meiosis**
This type of division takes place in somatic cells	This type of division takes place in gamete cells
Two daughter cells are formed	Four daughter cells are formed
Number of chromosomes remains diploid in daughter cells	Number of chromosomes becomes haploid in daughter cells
Mitosis is necessary for growth and repair	Meiosis is necessary for sexual reproduction
Crossing over does not take place	Crossing over takes place



Control of Cell Division

- Cell division capacities vary greatly among cell types
    - Skin and blood cells divide often and continually
    - Neuron cells divide a specific number of times then cease
- Cells divide to provide a more favorable surface area to volume relationship
- Growth factors and hormones stimulate cell division
    - Hormones stimulate mitosis of smooth muscle cells in uterus
    - Epidermal growth factor stimulates growth of new skin
- Tumors are the consequence of a loss of cell cycle control.

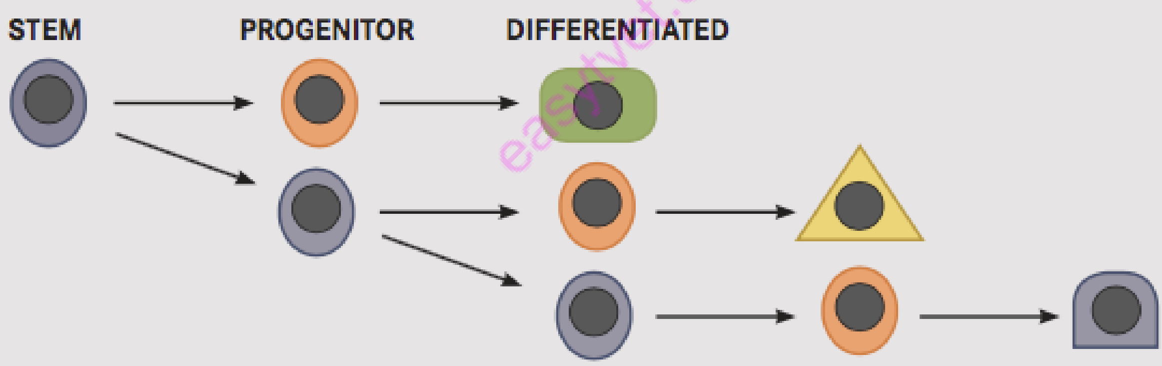
Tumors

- Two types of tumors:
    1. Benign – usually remains localized
    2. Malignant – invasive and can metastasize; cancerous
- Two major types of genes cause cancer:
    1. Oncogenes – activate other genes that increase cell division
    2. Tumor suppressor genes – normally regulate mitosis; if inactivated they are unable to regulate mitosis
        - Cells are now known as “immortal”

Stem and Progenitor Cells

- Stem cell: an undifferentiated cell of a multicellular organism which is capable of giving rise to indefinitely more cells of the same type, and from which certain other kinds of cell arise by differentiation.
    - Can divide to form two new stem cells
        - Self-renewal
    - Can divide to form a stem cell and a progenitor cell
    - Totipotent – can give rise to every cell type
    - Pluripotent – can give rise to a restricted number of cell types
- Progenitor cell:
    - Committed cell that can divide into restricted specific cells.
    - Can divide to become any of a restricted number of cells
    - Pluripotent

Upon injury, adult stem cells divide into a daughter stem cell and a progenitor cell. The progenitor cell transforms into a fully differentiated cell (eg, bone, muscle, nerves, blood vessels), and the daughter stem cell divides into another daughter cell and another progenitor cell to continue the process of healing.

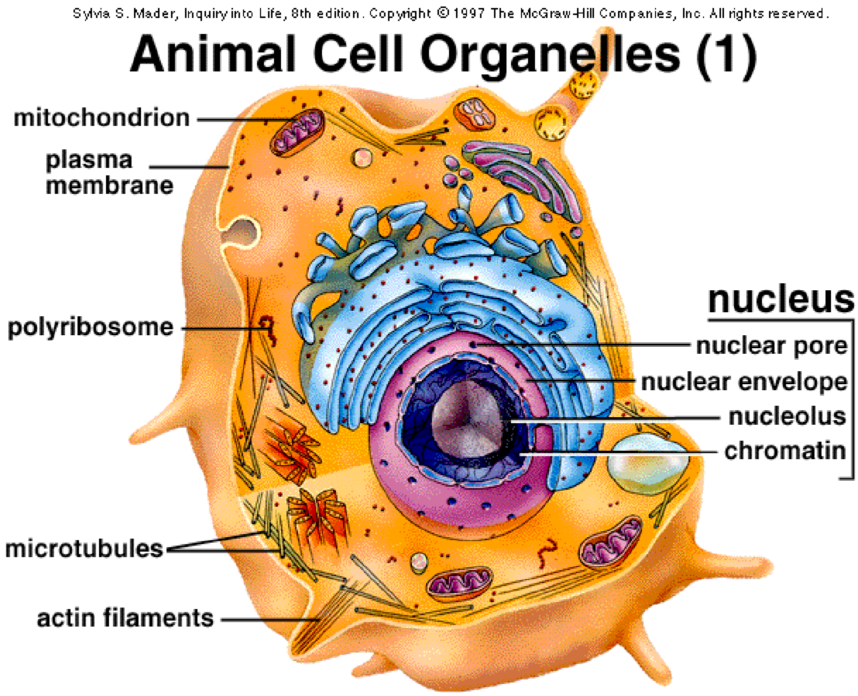


Cell Death

Apoptosis:

- Programmed cell death
- Acts as a protective mechanism
- Is a continuous process

Components of a human cell



- The composition of cytoplasm
  - Cytoplasm is the Cellular content between plasma membrane & nucleus Cytoplasm=cytosol + organelles
  - Cytosol = watery fluid
  - Organelles = solids small organs; highly specialized functions

- Roles and functions of cell components

  Organelles

  - Structures INSIDE a cell that have specific functions.

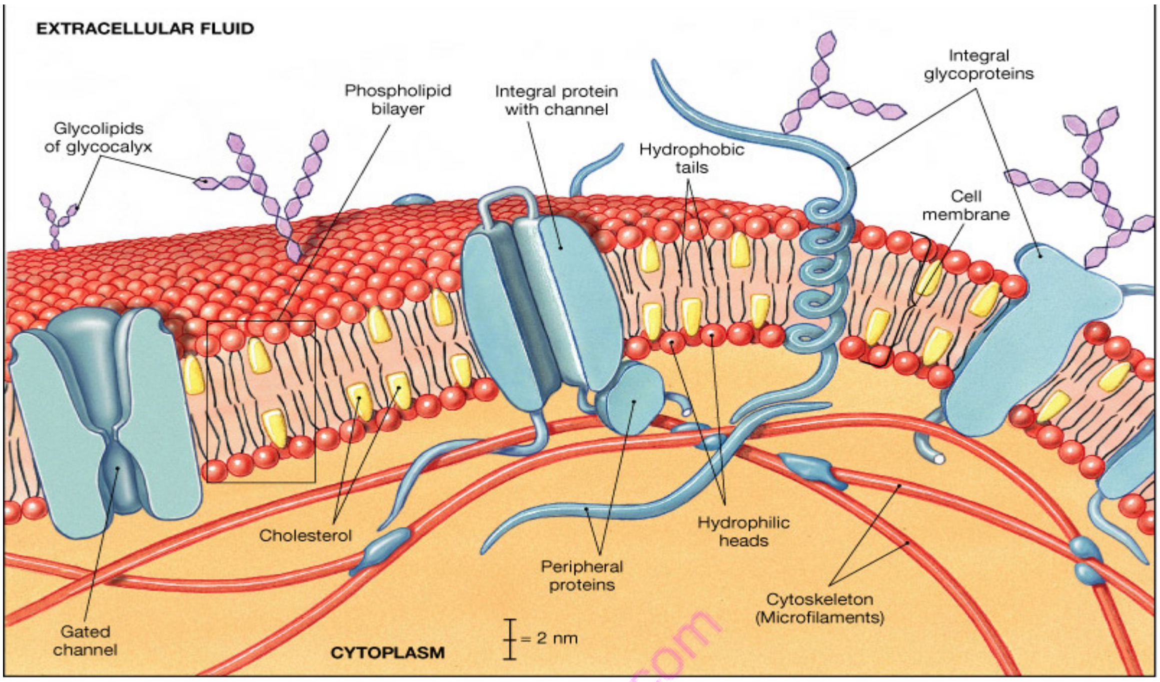
    Membranous

    - Nucleus
    - Golgi apparatus
    - Endoplasmic reticulum
    - Mitochondria
    - Vesicles and lysosomes

    Non-membranous

    - Ribosomes
    - Microtubules (cytoskeleton)
    - Actin/Myosin in muscle cells

1. Cell membrane
   - It consists of a lipid bilayer with embedded proteins.
   - Outer limit of the cell
   - Controls what moves in and out of the cell



2. Endoplasmic Reticulum (ER)
   - Connected, membrane-bound sacs, canals, and vesicles
   - Transport system
   - Rough ER--Studded with ribosomes (protein synthesis)
   - Smooth ER--Lipid synthesis

3. Ribosomes
   - Free floating or connected to ER
   - protein synthesis

4. Golgi apparatus
   - Stack of flattened, membranous sacs
   - Modifies, packages and delivers proteins

5. Vesicles
   - Membranous sacs
   - Store substances

6. Mitochondria
    - Membranous sacs with inner partitions
    - Generate energy
7. Lysosomes
    - Enzyme-containing sacs
    - Digest worn out cell parts or unwanted substances
8. Centrosome
    - Directs organisation of microtubules
    - Two rod-like centrioles (cell division.)
    - Used to produce cilia and flagella
    - Distributes chromosomes during cell division
9. Peroxisomes
    - Enzyme-containing sacs
    - Break down organic molecules
10. Cilia
    - Short hair-like projections
    - Propel substances on cell surface
11. Flagellum
    - Long tail-like projection
    - Provides motility to sperm
12. Microfilaments and microtubules
    - Thin rods and tubules
    - Support cytoplasm
    - Allows for movement of Organelles
13. Cell nucleus
    - It is found in the center of the cell. It contains the genetic material that is DNA and RNA
    - It controls all the activities of the cell.

2.3.3.3 Self-Assessment

1. Draw a well labeled diagram of a typical cell showing the various cell organelles
2. State five cell organelles and their functions
3. Differentiate between mitosis and meiosis
4. State whether the following statement in cell division is TRUE or FALSE
    a) Skin and blood cells divide often and then cease
    b) Neuron cells divide a specific number of times then cease
5. State whether the following statement on cell division is TRUE or FALSE
    a) In meosis cell division, the cell division takes place in the somatic cells
    b) In mitosis cell division, crossing over takes place
    c) In meosis cell division, cell division four daughter cell are formed
    d) The Mitosis cell division is necessary for growth and repair
6. Outline the steps in mitosis cell division.
7. Differentiate between a stem cell and a progenitor cell.

2.3.3.4 Tools, Equipment, Supplies and Materials

- Microscope

2.3.3.5 References

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2.3.4 Learning Outcome 3: Identify histological and cytological methods

2.3.4.1 Learning Activities

Learning activity	Special instructions
i) Perform direct observation	➢ Demonstrate knowledge of observation method as a means of getting anatomical information
ii) Identify histochemical methods	➢ Illustrate knowledge of histochemical methods
iii) Identify chemical methods	➢ Demonstrate the ability to identify the different chemical methods
iv) Identify physical methods	➢ Demonstrate the knowledge of physical methods based on the available materials
v) Identify staining methods	➢ Illustrate knowledge of different staining methods as per the workplace procedures
vi) Identify immunohistochemical methods	➢ Describe the different immunohistochemical methods based on the available materials
vii) Perform X-ray diffraction	➢ Demonstrate the ability to perform X-ray diffraction as per the workplace procedures

2.3.4.2 Information Sheet

Direct observation process

Direct observation, also known as observational study, is a method of collecting evaluative information in which the evaluator watches the subject in his or her usual environment without altering that environment. This method help the student observe events as they happen in their natural settings without interfering with their natural habitat. This process enable the students to capture first-hand information that act as baseline information for gathering useful anatomical information. A direct observation usually refers to observing a behaviour and knowing exactly what is happening. For example, if I see a pigeon peck at some bread, I have observed it pecking

Histochemical methods

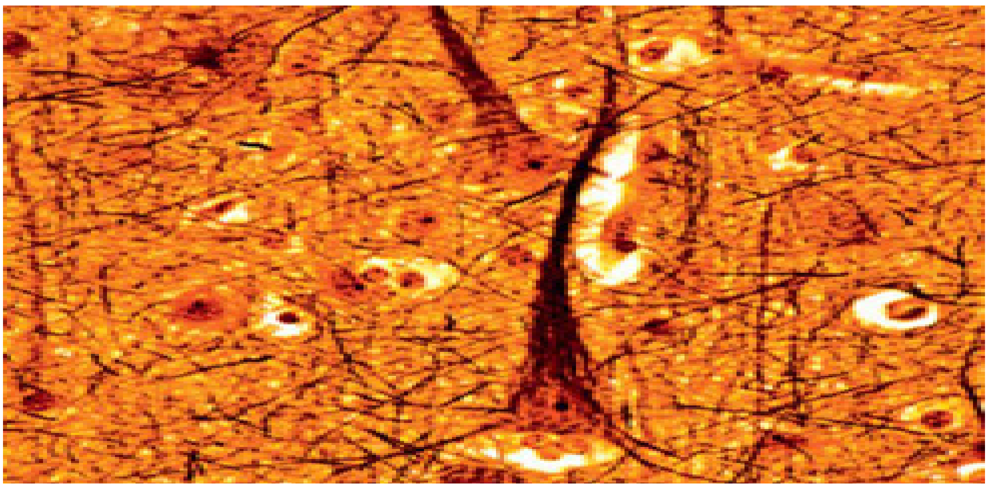
3 Histochemical Techniques

Since most cell structures are transparent, very little detail of the structure can be seen, unless the cells are stained. The same is true of components of the extracellular matrix. Because different parts of the cell are biochemically different, they take up specific stains to varying degrees. For example, haematoxylin binds strongly to acids and consequently binds to nuclear DNA and stains nuclei blue. Histologists have developed many stains which are suited to particular purposes, allowing cell structures to be differentiated. It is important to remember that the colours of stains are not the real colour of a particular tissue, and that a structure that appears as one colour using one stain, may be a quite different colour using another stain.

The great majority of routine histology is done with haematoxylin and eosin (H&E) staining, because it is quick, cheap and informative. Staining with H&E is very reliable although it does show some variation depending on the exact formulation of the stain, and the stain density is considerably affected by the thickness of the sections - thicker sections take up more stain. It is also generally done before any additional staining techniques, because histology with H&E can confirm the basic tissue type and help to localise the lesion. (The term lesion is used by pathologists to indicate any area of damage, infection, inflammation, tumour, necrosis or otherwise abnormal tissue.) For example, to diagnose a lymphoma within a lymph node, one would initially carry out H&E staining to confirm the basic diagnosis and localise the affected cells, before doing immunohistochemistry to identify exactly which type of lymphocyte was present.

A wide variety of other histochemical stains are also available, each of which can help identify particular structures. Some are relatively simple to perform, merely requiring that the section is dipped in the stain for a set time. Others require a number of sequential steps, and in some cases the results can be surprisingly variable or unpredictable. For example, the silver staining technique originally developed by Camillo Golgi (he of the Golgi apparatus) is notably temperamental (See Figure below). Some of the more commonly used techniques are outlined below:

1. Giemsa stain consists of a mixture of methylene-blue and eosin. It is mostly used on methanol-fixed blood films, where it stains erythrocytes pink and the different types of leukocyte, allowing their identification according to size and shape of their nucleii. It also binds to some pathogens, including spirochaetes (syphilis), trypanosomes (sleeping sickness and Chagas disease) and plasmodium (malarial parasites). In addition it can also be used to stain some bacteria in tissue sections pink, and it is therefore particularly useful if infection is suspected.
2. Gram stain is used to identify and differentiate bacteria. For example, staphylococci, streptococci and pneumocci are Gram-positive and stain a deep blue, whereas coliforms and neisseria are Gram-negative and stain pink.
3. Ziehl Nielsen stain is used to identify ‹acid-fast› bacilli, including mycobacteria (tuberculosis and leprosy), which appear as black rods.



Axons and dendrites of a neuron - Bielchowsky silver stain, a development of the Golgi silver staining method.

Note that identification of the bacteria requires that the shape of the bacteria can be distinguished as well as their ability to take up stain, so sections have to be observed using the highest magnification possible.

Many stains are useful because they can differentiate elements in the tissue. They include:

- Luxol fast blue/Cresyl violet is used to identify myelin which stains blue, while other elements of the nervous system stain pink or violet.
- Oil red O is a dye that is more soluble in fat than in water or alcohols, hence it is used as a stain for neutral lipids. For example when myelin is broken down in the CNS, in diseases such as multiple sclerosis, macrophages take up the lipid-rich debris and stain strongly with this dye.
- Masson's trichrome stain, covers a variety of different techniques that developed from Masson›s original formulation, each of which uses three dyes to stain different structures. It is valuable for distinguishing elements of connective tissue. Typically the cell cytoplasm, muscle and keratin are stained red, nucleii are black and collagen is blue. This stain benefits from having tissue fixed using Bouin›s fixative, although formalin-fixation is still workable.
- Periodic acid Schiff (PAS) stains carbohydrates magenta, including components of the basal lamina, surface glycoproteins on cells and intracellular carbohydrates such as glycogen in hepatocytes. Cells that secrete mucus are also strongly stained.
- Alcian blue is often combined with PAS, as it stains acidic mucins blue, whereas PAS stains neutral mucins red, hence it can be used to distinguish elements of the extracellular matrix. It also stains some fungi and parasites.
- Congo red is used to identify deposits of protein in tissue called amyloid.
- Silver staining methods have a long history; they deposit silver, which appears black onto structures that reduce silver nitrate. They can be particularly valuable for identifying individual cells, such as a single nerve cell within a group of cells, because the methods do not uniformly stain every cell of a type within the tissue. The image of a single cell within a complex tissue can be very informative, but getting the precise conditions to produce this partial staining can be difficult.
- Toluidine blue is a particularly versatile dye that stains nuclei blue, and can be used to differentiate different types of granules (e.g. within mast cells). Because it can permeate the resins that are used to embed sections for electron microscopy, it is often used as a preliminary stain, to identify sections that will later be examined by EM.
- Van Gieson stain binds to collagen in the extracellular matrix, staining it pink. Often it is combined with a stain for elastic fibres (elastic van Gieson) which stain black, allowing the two major elements of connective tissue to be differentiated.

The methods described above are only a small proportion of those that are available. As can be seen in the examples of trichrome stains, dyes may be used in combination to obtain additional information from the sections. The precise methodology and timings for the staining procedure may also vary slightly between laboratories. Some laboratories regularly use high temperatures in their staining procedures (microwaving) during particular steps, either to enhance the staining or reduce the time taken. Some stains are also more labile than others, and need to be remade regularly to maintain consistent results.

Chemical methods

- Samples must be properly prepared for microscopy. This may involve staining, fixation, and/or cutting thin sections.
- A variety of staining techniques can be used with light microscopy, including Gram staining, acid-fast staining, capsule staining, endospore staining, and flagella staining.

Gram Staining

The Gram stain procedure is a differential staining procedure that involves multiple steps. It was developed by Danish microbiologist Hans Christian Gram in 1884 as an effective method to distinguish between bacteria with different types of cell walls, and even today it remains one of the most frequently used staining techniques. Gram-staining is a differential staining technique that uses a primary stain and a secondary counterstain to distinguish between gram-positive and gram-negative bacteria.

Acid-Fast Stains

Acid-fast staining is another commonly used, differential staining technique that can be an important diagnostic tool. An acid-fast stain is able to differentiate two types of gram-positive cells: those that have waxy mycolic acids in their cell walls, and those that do not. Two different methods for acid-fast staining are the Ziehl-Neelsen technique and the Kinyoun technique. Both use carbolfuchsin as the primary stain. The waxy, acid-fast cells retain the carbolfuchsin even after a decolorizing agent (an acid-alcohol solution) is applied. A secondary counterstain, methylene blue, is then applied, which renders non–acid-fast cells blue.

Capsule Staining

Certain bacteria and yeasts have a protective outer structure called a capsule. Since the presence of a capsule is directly related to a microbe's virulence (its ability to cause disease), the ability to determine whether cells in a sample have capsules is an important diagnostic tool. Capsules do not absorb most basic dyes; therefore, a negative staining technique (staining around the cells) is typically used for capsule staining. The dye stains the background but does not penetrate the capsules, which appear like halos around the borders of the cell. The specimen does not need to be heat-fixed prior to negative staining.

Endospore Staining

Endospores are structures produced within certain bacterial cells that allow them to survive harsh conditions. Gram staining alone cannot be used to visualize endospores, which appear clear when Gram-stained cells are viewed. Endospore staining uses two stains to differentiate endospores from the rest of the cell. The Schaeffer-Fulton method (the most commonly used endospore-staining technique) uses heat to push the primary stain (malachite green) into the endospore. Washing with water decolorizes the cell, but the endospore retains the green stain. The cell is then counterstained pink with safranin. The resulting image reveals the shape and location of endospores, if they are present. The green endospores will appear either within the pink vegetative cells or as separate from the pink cells altogether. If no endospores are present, then only the pink vegetative cells will be visible

Flagella Staining

Flagella (singular: flagellum) are tail-like cellular structures used for locomotion by some bacteria, archaea, and eukaryotes. Because they are so thin, flagella typically cannot be seen under a light microscope without a specialized flagella staining technique. Flagella staining thickens the flagella by first applying mordant (generally tannic acid, but sometimes potassium alum), which coats the flagella; then the specimen is stained with pararosaniline (most commonly) or basic fuchsin

Physical methods

Fixation is the essential first step in preserving cellular structures with the goal of keeping them as "lifelike" as possible. ... Physical fixation can include microwaving and cryopreserving samples to rapidly inactivate cellular activity.

Staining methods

A variety of staining techniques can be used with light microscopy, including Gram staining, acid-fast staining, capsule staining, endospore staining, and flagella staining.

Immunohistochemical methods

The Enzymatic method for immunohistochemistry uses reagents like Calcium Chloride, Sodium Hydroxide, Hydrochloric Acid solutions, Xylenes for dewaxing, and Methanol. Immunohistochemistry use different staining procedures such as one step direct method, ABC methods, two-step indirect method and Tyramide signal amplification.

Direct Method: Direct method is one step staining method, and involves a labeled antibody (i.e. FITC conjugated antiserum) reacting directly with the antigen in tissue sections. This technique utilizes only one antibody and the procedure is short and quick. However, it is insensitive due to little signal amplification and rarely used since the introduction of indirect method.

Indirect Method: Indirect method involves an unlabeled primary antibody (first layer) which react with tissue antigen, and a labeled secondary antibody (second layer) react with primary antibody (Note: The secondary antibody must be against the IgG of the animal species in which the primary antibody has been raised). This method is more sensitive due to signal amplification through several secondary antibody reactions with different antigenic sites on the primary antibody. In addition, it is also economy since one labeled second layer antibody can be used with many first layer antibodies (raised from the same animal species) to different antigens. The second layer antibody can be labeled with a fluorescent dye such as FITC, rhodamine or Texas red, and this is called indirect immunofluorescence method. The second layer antibody may be labeled with an enzyme such as peroxidase, alkaline phosphatase or glucose oxidase, and this is called indirect immunoenzyme method.

PAP Method (peroxidase anti-peroxidase method): PAP method is a further development of the indirect technique and it involves a third layer which is a rabbit antibody to peroxidase, coupled with peroxidase to make a very stable peroxidase anti-peroxidase complex. The complex, composed of rabbit gaba-globulin and peroxidase, acts as a third layer antigen and becomes bound to the unconjugated goat anti-rabbit gaba-globulin of the second layer. The sensitivity is about 100 to 1000 times higher since the peroxidase molecule is not chemically conjugated to the anti IgG but immunologically bound, and loses none of its enzyme activity. It also allows for much higher dilution of the primary antibody, thus eliminating many of the unwanted antibodies and reducing non-specific background staining.

Avidin-Biotin Complex (ABC) Method: ABC method is standard IHC method and one of widely used technique for immunhistochemical staining. Avidin, a large glycoprotein, can be labeled with peroxidase or fluorescein and has a very high affinity for biotin. Biotin, a low molecular weight vitamin, can be conjugated to a variety of biological molecules such as antibodies. The technique involves three layers. The first layer is unlabeled primary antibody. The second layer is biotinylated secondary antibody. The third layer is a complex of avidin-biotin peroxidase. The peroxidase is then developed by the DAB or other substrate to produce different colorimetric end products.

Labeled StreptAvidin Biotin (LSAB) Method: Streptavidin, derived from streptococcus avidini, is a recent innovation for substitution of avidin. The streptavidin molecule is uncharged relative to animal tissue, unlike avidin which has an isoelectric point of 10, and therefore electrostatic binding to tissue is eliminated. In addition, streptavidin does not contain carbohydrate groups which might bind to tissue lectins, resulting in some background staining. LSAB is technically similar to standard ABC method. The first layer is unlabeled primary antibody. The second layer is biotinylated secondary antibody. The third layer is Enzyme-Streptavidin conjugates (HRP-Streptavidin or AP-Streptavidin) to replace the complex of avidin-biotin peroxidase. The enzyme is then visualized by application of the substrate chromogen solutions to produce different colorimetric end products. The third layer can also be Fluorescent dye-Streptavidin such as FITC-Streptavidin if fluorescence labeling is preferred. A recent report suggests that LSAB method is about 5 to 10 times more sensitive than standard ABC method.

- X-ray diffraction

  X-Ray Diffraction (XRD) is a laboratory-based technique commonly used for identification of crystalline materials and analysis of unit cell dimensions.

2.3.4.3 *Self-Assessment*

1. Briefly explain three histochemical techniques
2. The following staining techniques can be used with light microscopy which one is not
   A. Gram staining
   B. Acid-fast staining
   C. Capsule staining
   D. Plasma staining
3. Briefly explain five immunohistochemical methods

2.3.4.4 *Tools, Equipment, Supplies and Materials*

- Microscope
- Carbolfuchsin stain
- Heating apparatus

2.3.4.5 References

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2.4.4 Learning outcome 4: Demonstrate knowledge of types of tissues and their location

2.4.4.1 Learning Activities

Learning activity	Special instructions
i) Identify and describe the various types of tissue	Name the tissues of the body
ii) Identify and describe the location of different tissues within the human body	Demonstrate knowledge in the location of different tissues within the human body
iii) Identify and describe the functions of tissues	

2.4.4.2 Information Sheet

Types of tissues

- Epithelial tissues
- Connective tissues
- Nervous tissue
- Muscular tissue

Intercellular Junctions

Tight junctions

- Close the space between cells
- Located among cells that form linings

Desmosomes

- Form "spot welds" between cells
- Located among outer skin cells

Gap junctions

- Tubular channels between cells
- Links cytoplasm of 2 cells
- Located in cardiac muscle cells

Location of tissues

2.Epithelial Tissue

General Characteristics

- Cover organs and the body
- Line body cavities
- Line hollow organs
- Have a free surface (apical)
- Have a basement membraneAre avascular
- Cells readily divide
- Cells tightly packed
- Cells often have desmosomes
- Function in protection, secretion, absorption, and excretion
- Classified according to cell shape and number of cell layers

Simple Epithelium

- Single layer of identical cell
- Found on the absorptive and secretory surfaces
- Named according to the shapes of the cells
- The more active the tissue the taller the cells.

Stratified Epithelia

- Several layers of cells of various shapes
- Superficial layers grow up from below
- Basement membrane absent
- Protects the underlying structures from mechanical wear and tear

Simple Squamous:

- Single layer of flat cells; tightly packed, forms smooth & thin membrane
- Substances pass easily through
- Line air sacs, heart
- Line blood vessels
- Line lymphatic vessels-endothelium

Simple Cuboidal:

- Single layer of cube-shaped cells
- Line kidney tubules
- Cover ovaries
- Line ducts of some glands
- Involved in secretion, absorption and excretion

Simple Columnar:

- Single layer of elongated cells
- Nuclei usually near the basement membrane at same level
- Sometimes possess cilia
- Sometimes possess microvilli
  - Often have goblet cells
  - Line uterus, stomach, intestines

Pseudostratified Columnar:

- Single layer of elongated cells
- Nuclei at two or more levels
- Appear striated
- Often have cilia
- Often have goblet cells
- Line respiratory passageways

Stratified Squamous:

- o Many cell layers
- o Top cells are flat (shed), deepest layers columnar
- o Outer layer of skin
- o Line oral cavity, vagina, and anal canal

Stratified Cuboidal:

- o 2-3 layers
- o Cube-shaped cells
- o Line ducts of mammary glands, sweat glands, salivary glands, and the pancreas

Stratified Columnar:

- o Top layer of elongated cells
- o Cube-shaped cells in deeper layers
- o Line part of male urethra and part of pharynx
- o Keratinised:-wear & tear, dry -skin
- o Non-keratinised:-wear & tear, wet surfaces-mouth

Transitional Epithelium:

- Many cell layers
- Cube-shaped and elongated cells.
- Stretches--Change shape

• Line urinary bladder, ureters, and part of urethra

GLANDULAR EPITHELIUM

- Composed of cells that are specialized to produce and secrete substances
- There are two (2) types:
    - Endocrine glands are ductless (key word: hormone)
    - Exocrine glands have ducts.

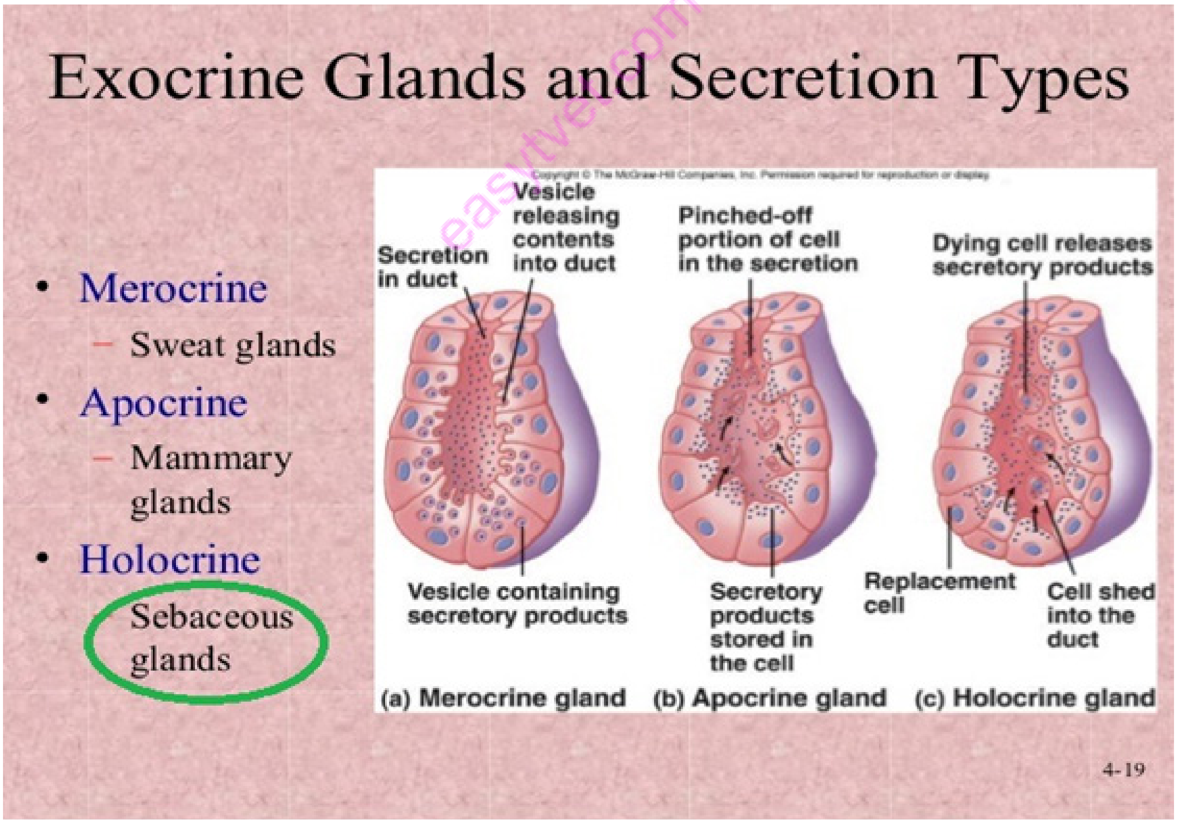
Unicellular exocrine gland:

- o Composed of one cell
- o Goblet cell

Multicellular exocrine gland:

- o Composed of many cells
- o Sweat glands, salivary glands, etc.
- o Simple and compound

Types of Glandular Secretions



Merocrine Glands

- Fluid product
- Salivary glands

- Pancreas gland
- Sweat glands

Apocrine Glands

- Portions of cells
- Mammary glands
- Ceruminous glands

Holocrine Glands

- Whole cells
- Sebaceous glands

3. Connective Tissues

General Characteristics:

- Most abundant tissue type
- Many functions:
- Bind structures
- Provide support and protection
- Serve as frameworks
- Fill spaces
- Store fat
- Produce blood cells
- Protect against infections
- Help repair tissue damage
- Have a matrix (intercellular substance)-
- Connective fibres are present in the matrix; semi solid, dense and rigid
- Have varying degrees of vascularity
- Have cells that usually divide

Major Cell Types Present in Connective Tissue

1. Fibroblasts

- Fixed cell
- Large, star-shaped
- Most common cell
- Produce fibers

2. Mast cells

- Fixed cell
- Release heparin
- Release histamine

3. Macrophages

- Wandering cell
- Phagocytic
- Important in injury or infection

4. Fat Cells

- Form the adipose tissue

Types of Fibers in Connective Tissue

- There are three types of fibers in connective tissue

1. Collagenous fibers

- Thick
- Great tensile strength
- Hold structures together
- Composed of collagen
- Abundant in dense CT
- Tendons, ligaments

2. Reticular fibers

- Very thin collagenous fibers
- Highly branched
- Form supportive networks

3. Elastic fibers

- Bundles of microfibrils embedded in elastin
- Fibers branch
- Elastic
- Vocal cords, air passages

Types of Connective Tissues

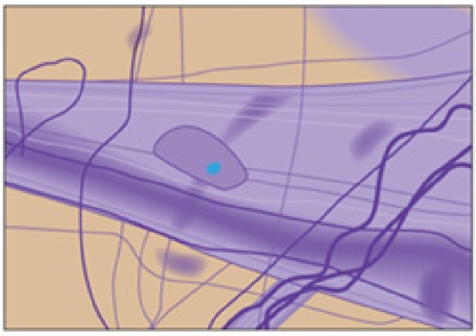
Connective Tissue Proper:

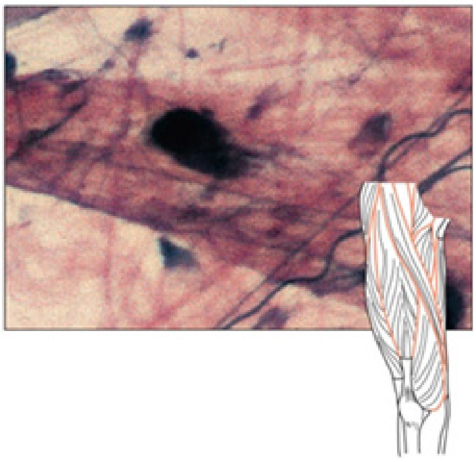
1. Loose connective tissue
2. Adipose tissue
3. Reticular connective tissue
4. Dense connective tissue
5. Elastic connective tissue

Specialized Connective Tissue:

1. Cartilage
2. Bone
3. Blood

1. Loose Connective Tissue





Mainly fibroblasts

- Fluid to gel-like matrix
- Collagenous fibers
- Elastic fibers
- Bind skin to structures
- Beneath most epithelia
- Blood vessels nourish nearby epithelial cells
- Between muscles.

2. Adipose Tissue

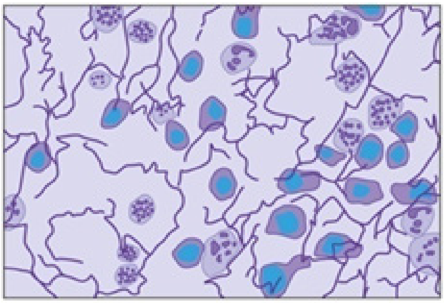
- Adipocytes
- Insulates
- Beneath skin
- Around kidneys and heart
- Cushions
- Store fats
- Behind eyeballs

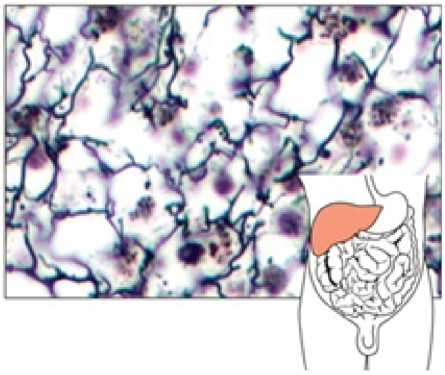
3. Reticular Connective Tissue

a. Composed of reticular fibers

b. Supports internal organ walls

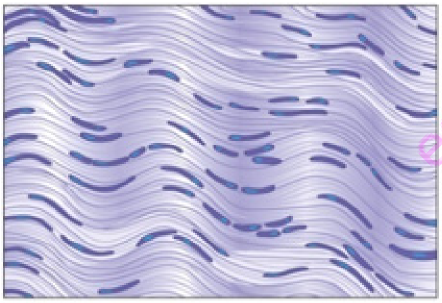
c. Walls of liver, spleen, lymphatic organs.

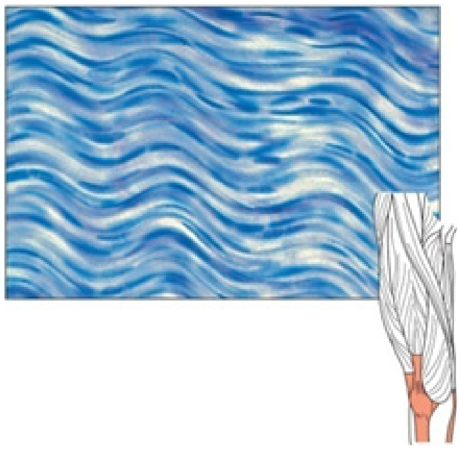




4. Dense Connective Tissue

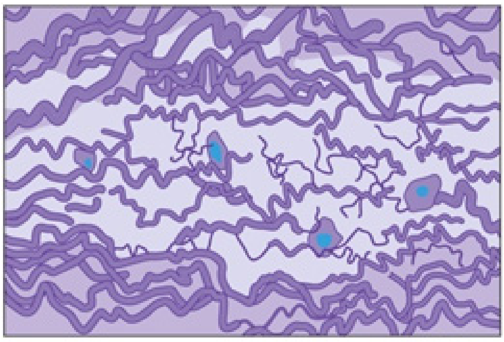
- Packed collagenous fibers
- Few fibroblasts
- Tendons, ligaments, dermis
- Elastic fibers
- Bind body parts together
- Poor blood supply

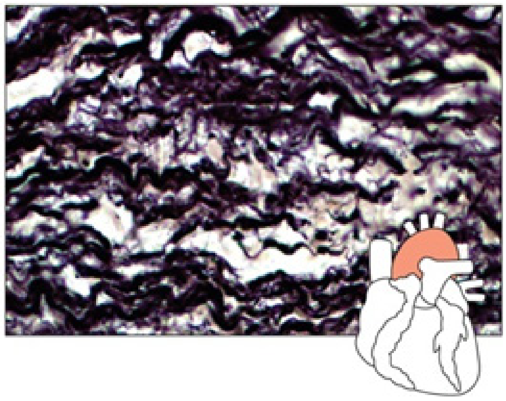




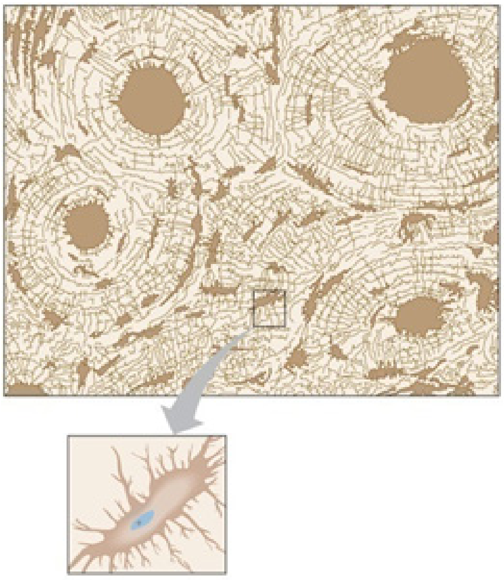
5. Elastic Connective Tissue

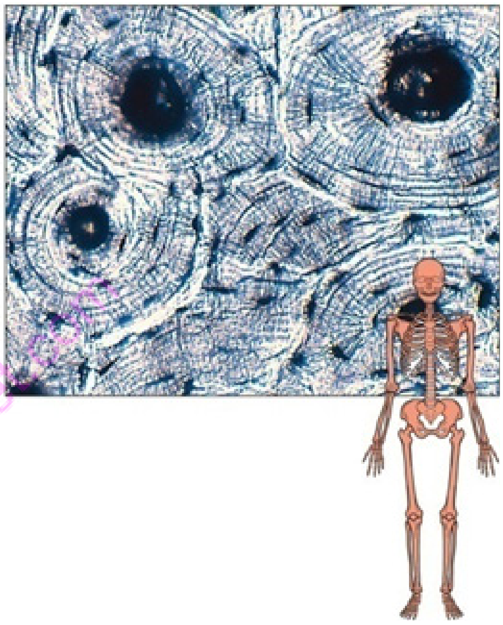
- Abundant in elastic fibers
- Some collagenous fibers
- Fibroblasts
- Attachments between bones
- Walls of large arteries, airways, heart





6. Bone (Osseous Tissue)





- Solid matrix
- Protects
- Attachment for muscles
- Osteocytes in lacunae
- Supports
- Forms blood cells
- Skeleton

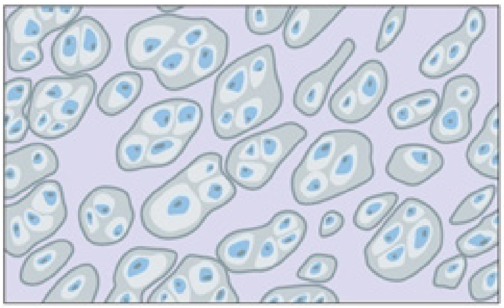
7. Cartilage

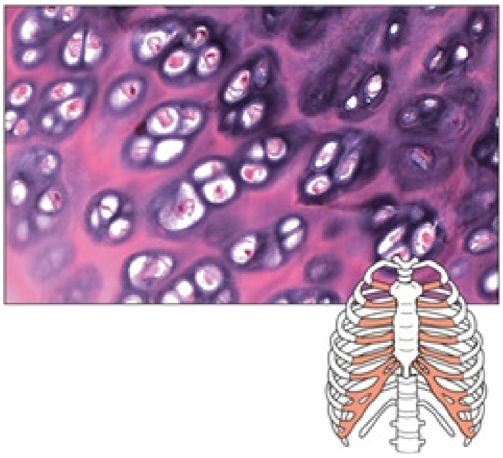
- Rigid matrix
- Chondrocytes in lacunae
- Poor blood supply

Three (3) types:

- 1) Hyaline Cartilage
- 2) Elastic Cartilage
- 3) Fibrocartilage

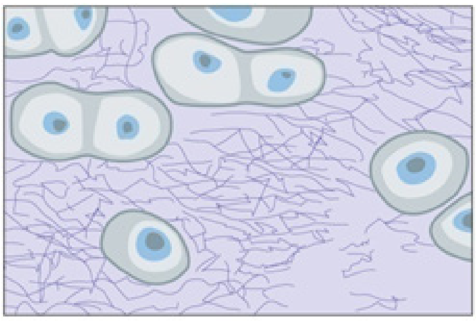
Hyaline cartilage

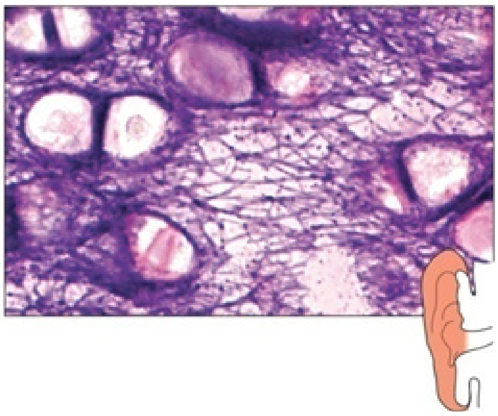




- Most abundant
- Ends of bones
- Nose, respiratory passages
- Embryonic skeleton

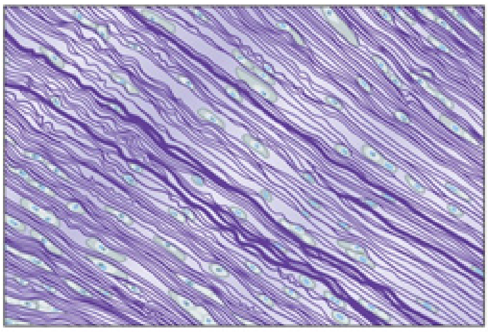
Elastic cartilage





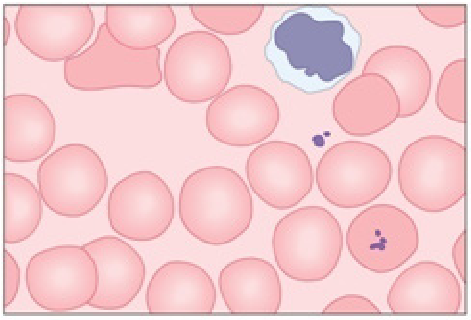
- Flexible
- External ear, larynx

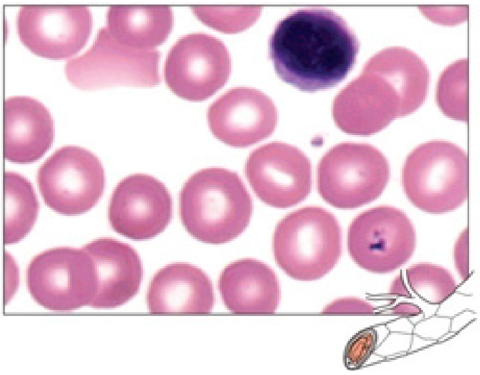
Fibrocartilage



- Very tough
- Shock absorber
- Intervertebral discs
- Pads of knee and pelvic girdle

8. Blood





- Fluid matrix called plasma
- White blood cells
- Transports
- Involved in clotting
- Heart

- Red blood cells
- Platelets
- Defends
- Throughout body in blood vessels

Types of Membranes

There are four (4) types of epithelial membranes:

1. Serous Membranes

- Line body cavities that do not open to the outside
- Reduce friction
- Inner lining of thorax and abdomen
- Cover organs of thorax and abdomen
- Secrete serous fluid

2. Mucous Membranes

- Line tubes and organs that open to outside world
- Lining of mouth, nose, throat, etc.
- Secrete mucus

3. Cutaneous Membranes

- Covers body
- Skin

4. Synovial Membranes

- Composed entirely of connective tissue
- Lines joints

3. Muscle Tissues

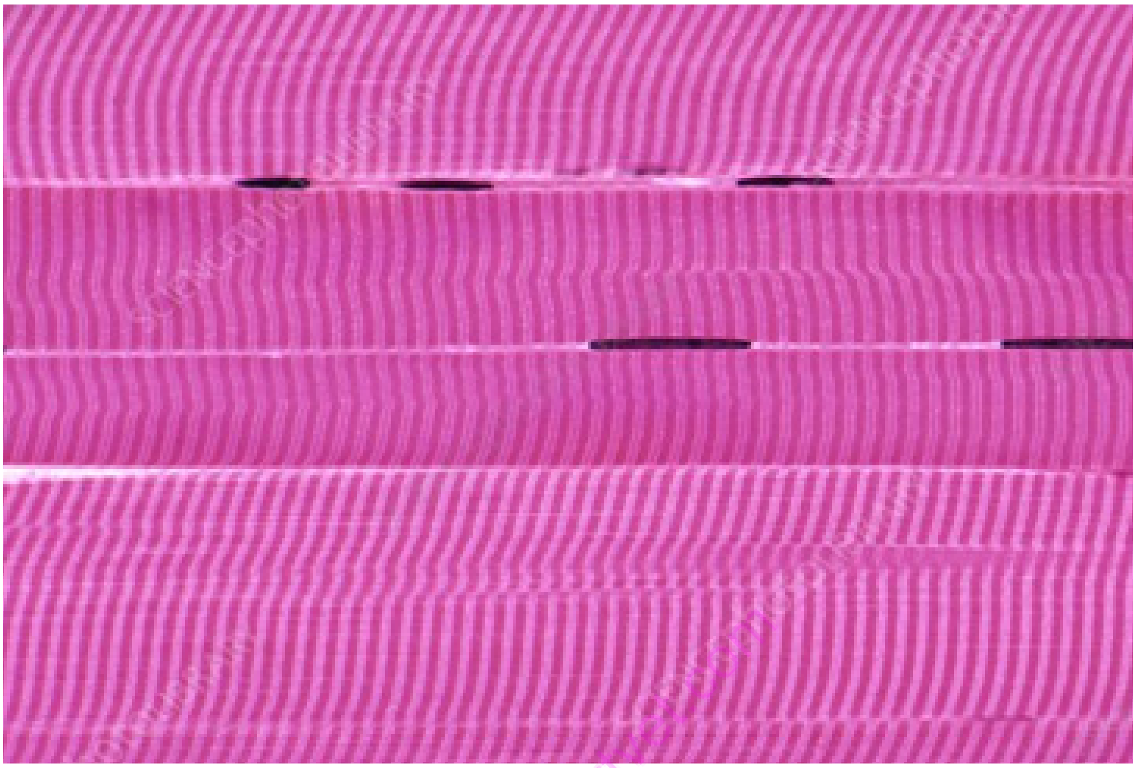
- General characteristics:
- Muscle cells also called muscle fibers
- Contractile

Three (3) types:

1. Skeletal muscle
2. Smooth muscle
3. Cardiac muscle

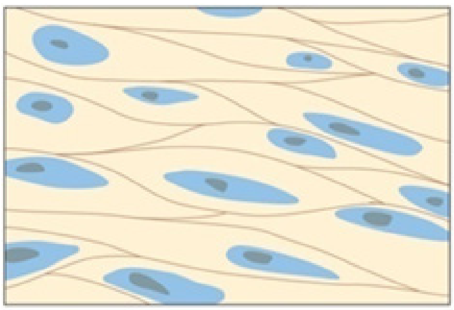
Skeletal muscle

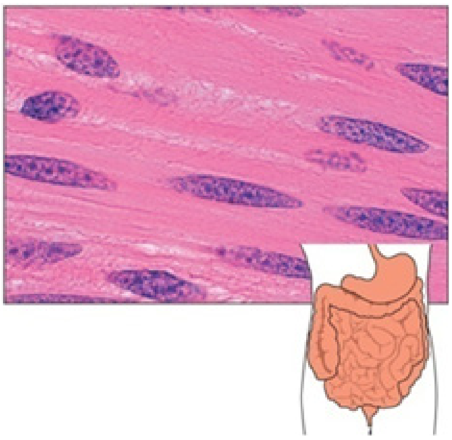
- Attached to bones
- Striated
- Voluntary



Smooth muscle

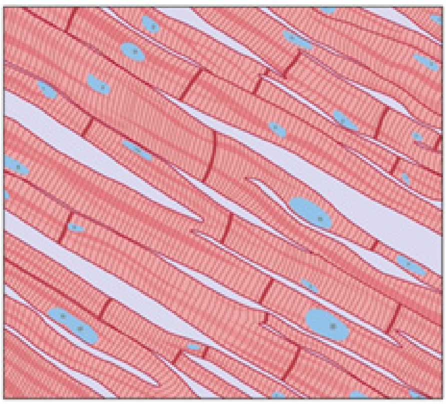
- Walls of organs
- Walls of blood vessels
- Non-striated
- Skin
- Involuntary

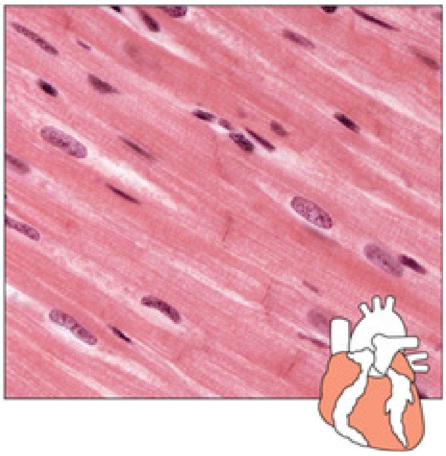




Cardiac muscle

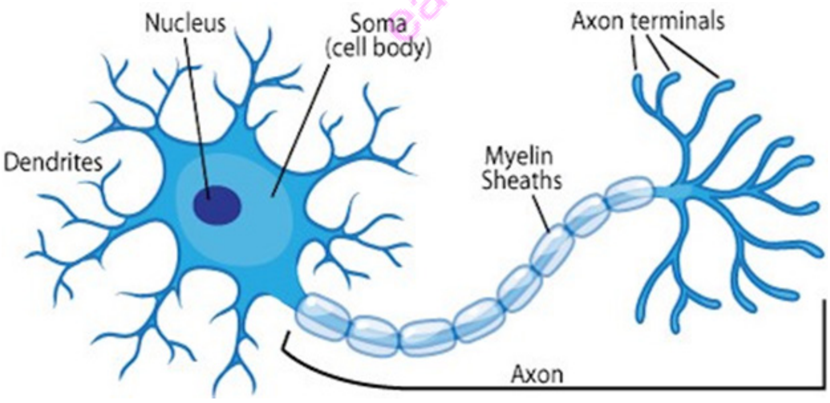
- Heart wall
- Striated
- Involuntary
- Intercalated discs





9. Nervous Tissue

- Found in brain, spinal cord, and peripheral nerves
- Functional cells are neurons
- Neuroglial cells support and bind nervous tissue components
- Sensory reception
- Conduction of nerve impulses



THE PROCESS OF ORGANOGENESIS

Early Embryonic Development

Fertilization is the process in which gametes (an egg and sperm) fuse to form a zygote (Figure 13.8). To ensure that the offspring has only one complete diploid set of chromosomes, only one sperm must fuse with one egg. In mammals, a layer called the zona pellucida protects the egg. At the tip of the head of a sperm cell is a structure like a lysosome called the acrosome, which contains enzymes. When a sperm binds to the zona pellucida, a series of events, called the acrosomal reactions, take place. These reactions, involving enzymes from the acrosome, allow the sperm plasma membrane to fuse with the egg plasma membrane and permit the sperm nucleus to transfer into the ovum. The nuclear membranes of the egg and sperm break down and the two haploid nuclei fuse to form a diploid nucleus or genome.

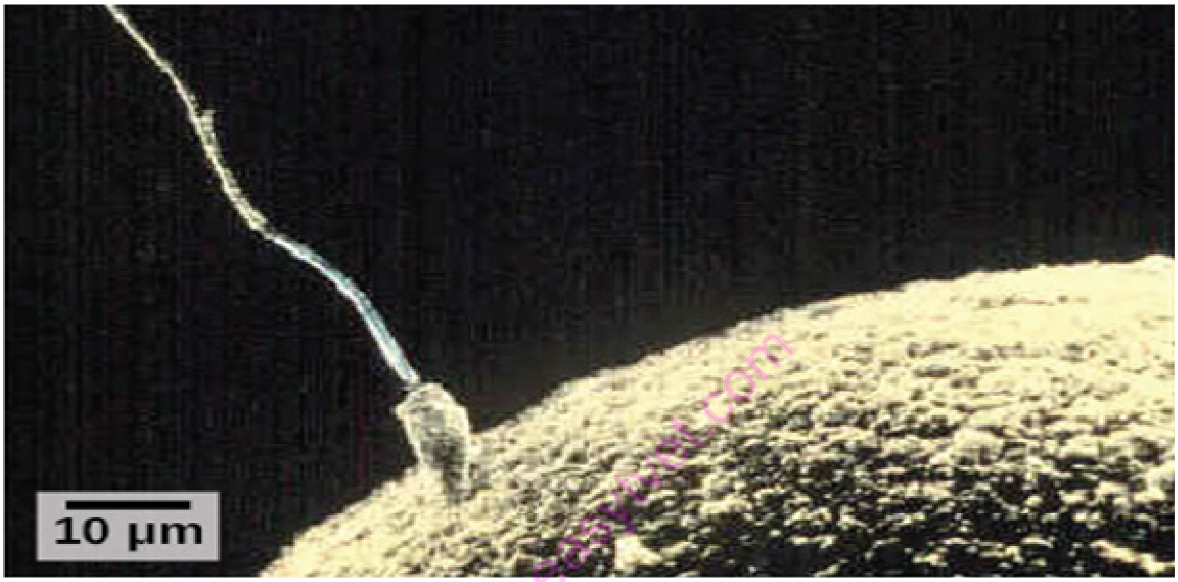
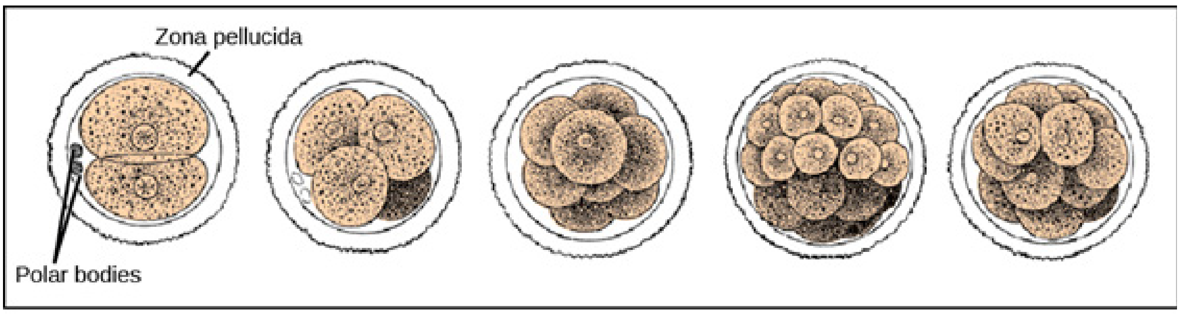


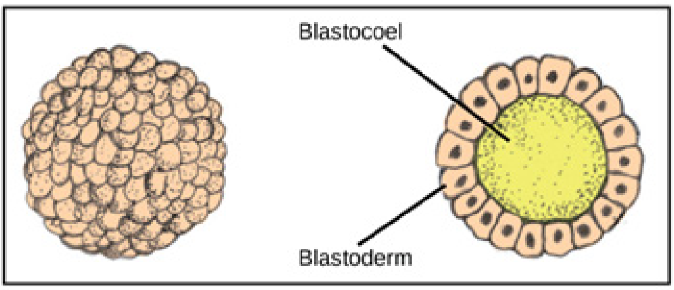
Figure 13.8 Fertilization is the process in which sperm and egg fuse to form a zygote. (credit: scale-bar data from Matt Russell)

To ensure that no more than one sperm fertilizes the egg, once the acrosomal reactions take place at one location of the egg membrane, the egg releases proteins in other locations to prevent other sperm from fusing with the egg.

The development of multi-cellular organisms begins from this single-celled zygote, which undergoes rapid cell division, called cleavage (Figure 13.9 a), to form a hollow ball of cells called a blastula (Figure 13.9 b).



(a)



(b)

Figure 13.9 (a) During cleavage, the zygote rapidly divides into multiple cells. (b) The cells rearrange themselves to form a hollow ball called the blastula. (credit a: modification of work by Gray's Anatomy; credit b: modification of work by Pearson Scott Foresman; donated to the Wikimedia Foundation)

In mammals, the blastula forms the blastocyst in the next stage of development. Here the cells in the blastula arrange themselves in two layers: the inner cell mass, and an outer layer called the trophoblast. The inner cell mass will go on to form the embryo. The trophoblast secretes enzymes that allow implantation of the blastocyst into the endometrium of the uterus. The trophoblast will contribute to the placenta and nourish the embryo.

Concept in Action

Visit the Virtual Human Embryo project at the Endowment for Human Development site to click through an interactive of the stages of embryo development, including micrographs and rotating 3-D images.

The cells in the blastula then rearrange themselves spatially to form three layers of cells. This process is called gastrulation. During gastrulation, the blastula folds in on itself and cells migrate to form the three layers of cells (Figure 13.10) in a structure, the gastrula, with a hollow space that will become the digestive tract. Each of the layers of cells is called a germ layer and will differentiate into different organ systems.

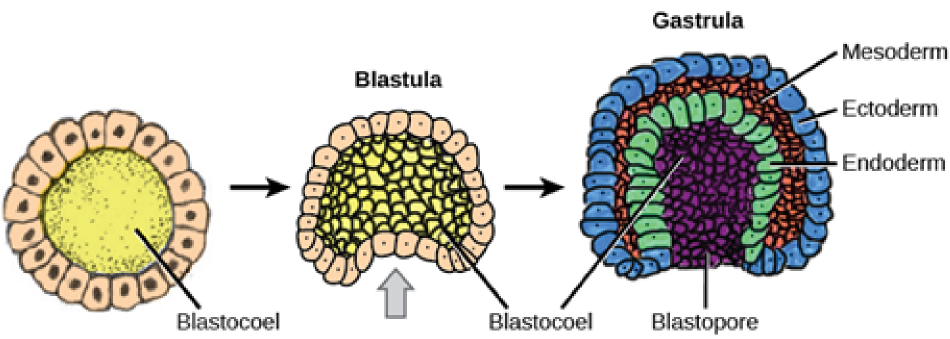


Figure 13.10 Gastrulation is the process wherein the cells in the blastula rearrange themselves to form the germ layers. (credit: modification of work by Abigail Pyne).

The three germ layers are the endoderm, the ectoderm, and the mesoderm. Cells in each germ layer differentiate into tissues and embryonic organs. The ectoderm gives rise to the nervous system and the epidermis, among other tissues. The mesoderm gives rise to the muscle cells and connective tissue in the body. The endoderm gives rise to the gut and many internal organs.

Organogenesis

Gastrulation leads to the formation of the three germ layers that give rise during further development to the different organs in the animal body. This process is called **organogenesis**.

Organs develop from the germ layers through the process of differentiation. During differentiation, the embryonic stem cells express specific sets of genes that will determine their ultimate cell type. For example, some cells in the ectoderm will express the genes specific to skin cells. As a result, these cells will take on the shape and characteristics of epidermal cells. The process of differentiation is regulated by location-specific chemical signals from the cell's embryonic environment that sets in play a cascade of events that regulates gene expression.

Vertebrate Axis Formation

Through the expression patterns of different genes, the three axes of the body are established, aiding in tissue and organ development.

Key Points

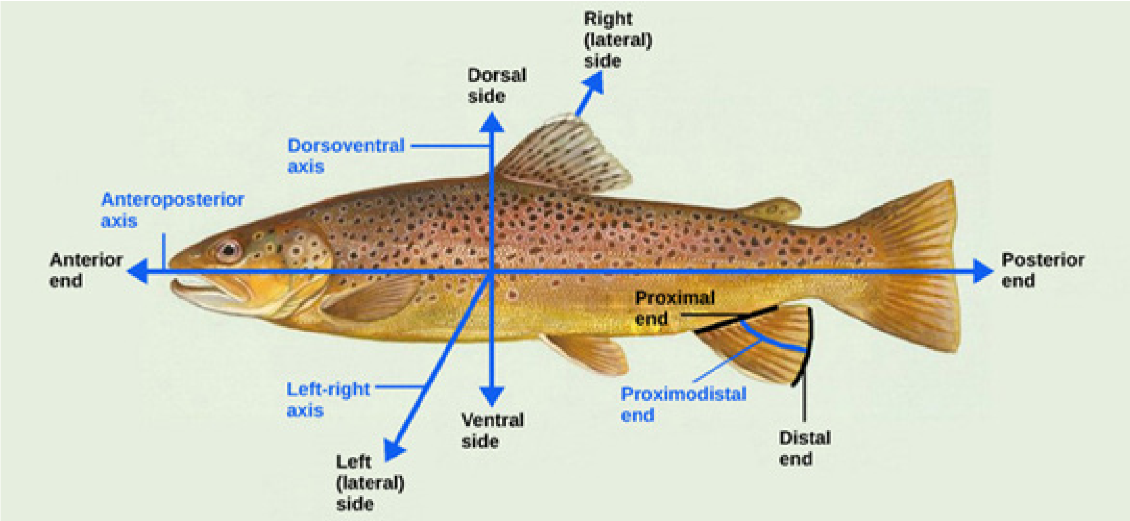
- As an animal develops, it must organize its internal and external structures such that the anterior/posterior (forward/backward), dorsal / ventral (back/belly), and lateral/medial (side/middle) axes are correctly determined.
- Proteins that are part of the Wnt signaling pathway help determine the anterior/posterior axis by guiding the axons of the spinal cord in an anterior/posterior direction.
- Together with the sonic hedgehog (Shh) protein, Wnt determines the dorsal/ventral axis; Wnt levels are highest in the dorsal region and lessen toward the ventral region, while Shh levels are highest in the ventral region and lessen toward the dorsal region.

Key Terms

- **dorsal**: with respect to, or concerning the side in which the backbone is located, or the analogous side of an invertebrate
- **ventral**: on the front side of the human body, or the corresponding surface of an animal, usually the lower surface
- **notochord:** a flexible rodlike structure that forms the main support of the body in the lowest chordates; a primitive spine
- **Wnt signaling pathway**: a group of signal transduction pathways made of proteins that pass signals from outside of a cell through cell surface receptors to the inside of the cell.

Vertebrate Axis Formation

Even as the germ layers form, the ball of cells still retains its spherical shape. However, animal bodies have lateral-medial (toward the side-toward the midline), dorsal-ventral (toward the back-toward the belly), and anterior-posterior (toward the front-toward the back) axes. As the body forms, it must develop in such a way that cells, tissues, and organs are organized correctly along these axes.



Body axes: *Animal bodies have three axes for symmetry: anterior/posterior (front/behind), dorsal/ventral (back/belly), and lateral/medial (side/middle).*

How are these established? In one of the most seminal experiments ever to be carried out in developmental biology, Spemann and Mangold took dorsal cells from one embryo and transplanted them into the belly region of another embryo. They found that the transplanted embryo now had two notochords: one at the dorsal site from the original cells and another at the transplanted site. This suggested that the dorsal cells were genetically programmed to form the notochord and define the dorsal-ventral axis. Since then, researchers have identified many genes that are responsible for axis formation. Mutations in these genes leads to the loss of symmetry required for organism development. Many of these genes are involved in the Wnt signaling pathway.

In early embryonic development, the formation of the primary body axes is a crucial step in establishing the overall body plan of each particular organism. Wnt signaling can be implicated in the formation of the anteroposterior and dorsoventral axes. Wnt signaling activity in anterior-posterior development can be seen in several organisms including mammals, fish, and frogs. Wnt signaling is also involved in the axis formation of specific body parts and organ systems that are a part of later development. In vertebrates, sonic hedgehog (Shh) and Wnt morphogenetic signaling gradients establish the dorsoventral axis of the central nervous system during neural tube axial patterning. High Wnt signaling establishes the dorsal region while high Shh signaling indicates in the ventral region. Wnt is also involved in the dorsal-ventral formation of the central nervous system through its involvement in axon guidance. Wnt proteins guide the axons of the spinal cord in an anterior-posterior direction. Wnt is also involved in the formation of the limb dorsal-ventral axis. Specifically, Wnt7a helps produce the dorsal patterning of the developing limb.

Section Summary

The early stages of embryonic development begin with fertilization. The process of fertilization is tightly controlled to ensure that only one sperm fuses with one egg. After fertilization, the zygote undergoes cleavage to form the blastula. The blastula, which in some species is a hollow ball of cells, undergoes a process called gastrulation, during which the three germ layers form. The ectoderm gives rise to the nervous system and the epidermal skin cells, the mesoderm gives rise to the muscle cells and connective tissue in the body, and the endoderm gives rise to the digestive system and other internal organs. Organogenesis is the formation of organs from the germ layers. Each germ layer gives rise to specific tissue types.

2.4.4.3 Self-Assessment

1. The process of gastrulation forms the _______.

   A. Blastula B. Zygote

   C. Organs D. Germ layers

2. Which of the following gives rise to the skin cells?

   A. Ectoderm B. Endoderm

   C. Mesoderm D. None of the above

3. Which one of the following characteristic does not describe collagenous fibers

   A. Thick

   B. Composed of collagen

   C. Great tensile strength

   D. Very thin collagenous fibers

4. What do you think would happen if multiple sperm fused with one egg?

2.4.4.4 Tools, Equipment, Supplies and Materials

Dummy human body, microscope, slides, cadaver, anatomy text books, white board, mark pen, skills laboratory

2.4.4.5 References

Sadler T. W. (2014) Langman's Medical Embryology 13th Edition, Kindle Edition. Wolters Kluwer Health

Cochard L.R. (2012) Netter's Atlas of Human Embryology E-Book: Updated Edition (Netter Basic Science) 1st Edition, Kindle Edition: Saunders

Moore K.L., Persaud T.V.N. & Torchia M.G. (2015) The Developing Human E-Book: Clinically Oriented Embryology 10th Edition, Kindle Edition: Saunders

CHAPTER 3:

DEMONSTRATE KNOWLEDGE IN MEDICAL PHYSIOLOGY

3.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to demonstrate the knowledge of medical physiology. It involves demonstrating the knowledge of physiologic principles, demonstrating the knowledge of human body systems, integumentary system.

3.2 Performance Standard

By the end of this unit of learning/competency, the trainee should demonstrate understanding in the structure and functions of the cell based on resource materials, the functioning of human body and its relation to nutrition, health and diseases as per the cellular inclusions and workplace procedures.

3.3 Learning Outcomes

3.3.1 List of the Learning Outcomes

1. Demonstrate the knowledge of physiologic principles
2. Demonstrate the knowledge of the human body systems

3.3.2 Learning Outcome 1: Demonstrate the knowledge of physiologic principles

3.3.2.1 Learning Activities

Learning activity	Special instructions
Analyse the structure of the normal cell	Draw a normal cell showing all the orga-nelles
Identify functions of ***cellular organelles*** as per the structure	
Describe types of cell division	Differentiate between Mitosis & Meiosis
Identify types of mammalian cells	Use of a light microscope
Identify the organization, size and compo-sition of body fluids	Differentiate between intracellular and ex-tracellular fluids
Identify Units of measurement of the physiochemical constituent in cells identified	
Identify forces producing movement of substances between body fluid com-partments	Illustrate knowledge of passive and active processes
Analyse maintenance and variations in cell membrane potential	
Outline the buffering system of the body	

3.3.2.2 Information Sheet

Structure of the Normal Cell

Types of cells

Cells are the smallest living structure

Cell = functional unit of the body

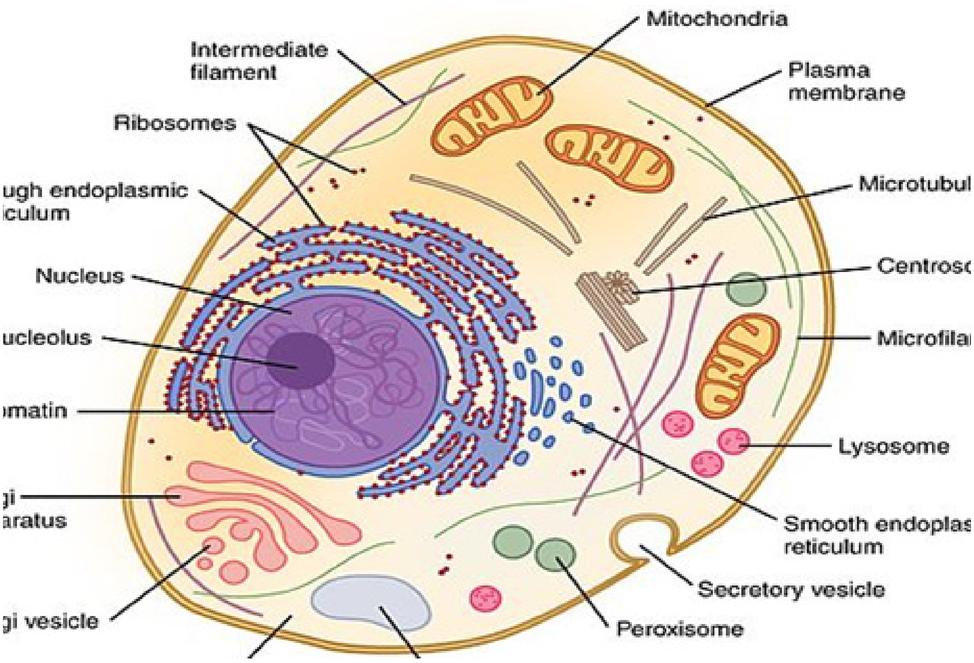
Cytology = The Study of Cells

Ultrastructural Cytology = Cytology at the Electron Microscopic level

Histology = the study of tissues

The basic organizational structure of the human body is the cell. There are 50-100 trillion cells in the human body. Differentiation is when cells specialize. As a result of differentiation, cells vary in size and shape due to their unique function.

The cell structure



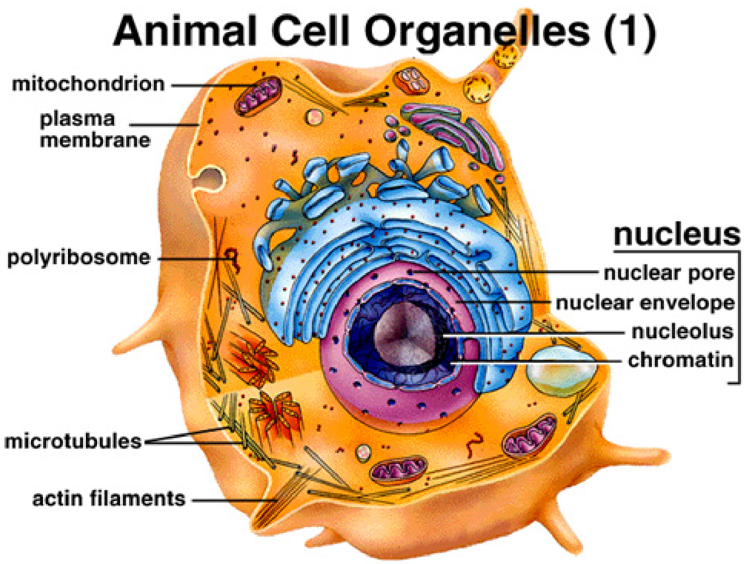
To learn more about the cell structure and the nucleus, follow the link below:

https://www.youtube.com/watch?v=URUJD5NEXC8

Also called a 'typical' cell. Major parts include:

- Nucleus--contains DNA
- Cytoplasm--cellular contents between plasma membrane & nucleus
- Cell membrane---selective barrier

Functions of Cellular Organelles



The composition of cytoplasm

Cytoplasm is the Cellular content between plasma membrane & nucleus Cytoplasm=cytosol + organelles

Cytosol = watery fluid

Organelles = solids small organs; highly specialized functions

Roles and functions of cell components

Organelles

Structures INSIDE a cell that have specific functions.

Membranous

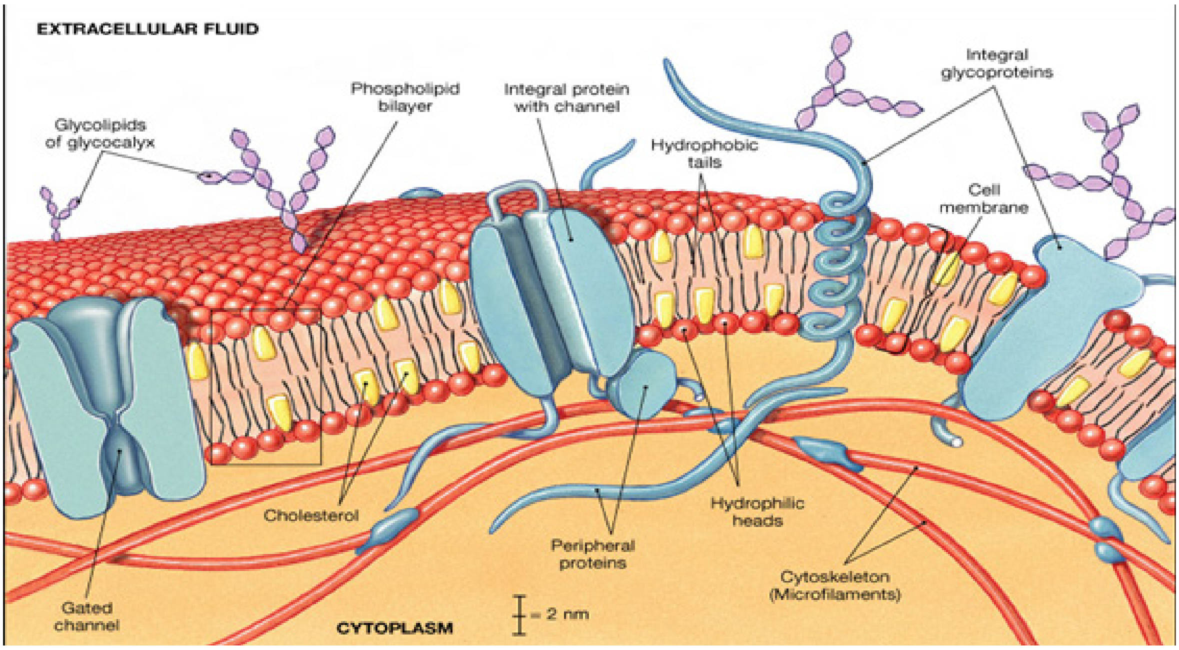
- Nucleus
- Golgi apparatus
- Endoplasmic reticulum
- Mitochondria
- Vesicles and lysosomes

Non-membranous

- Ribosomes
- Microtubules (cytoskeleton)
- Actin/Myosin in muscle cells

Cell membrane

- It consists of a lipid bilayer with embedded proteins.
- Outer limit of the cell
- Controls what moves in and out of the cell.



Follow this link to learn more on the cell membrane and its functions:
https://www.youtube.com/watch?v=UxvFdW9aO0s

Endoplasmic Reticulum (ER)

- Connected, membrane-bound sacs, canals, and vesicles
- Transport system
- Rough ER--Studded with ribosomes (protein synthesis)
- Smooth ER--Lipid synthesis

Ribosomes

- Free floating or connected to ER
- Protein synthesis

Golgi apparatus

- Stack of flattened, membranous sacs
- Modifies, packages and delivers proteins

Vesicles

- Membranous sacs
- Store substances

Mitochondria

- Membranous sacs with inner partitions
- Generate energy

Lysosomes

- Enzyme-containing sacs
- Digest worn out cell parts or unwanted substances

Centrosome

- Directs organisation of microtubules
- Two rod-like centrioles (cell division.)
- Used to produce cilia and flagella
- Distributes chromosomes during cell division

Peroxisomes

- Enzyme-containing sacs
- Break down organic molecules

Cilia

- Short hair-like projections
- Propel substances on cell surface

Flagellum

- Long tail-like projection
- Provides motility to sperm

Microfilaments and microtubules

- Thin rods and tubules
- Support cytoplasm
- Allows for movement of Organelles

Cell nucleus

- It is found in the center of the cell. It contains the genetic material that is DNA and RNA
- It controls all the activities of the cell.

Process of cell division

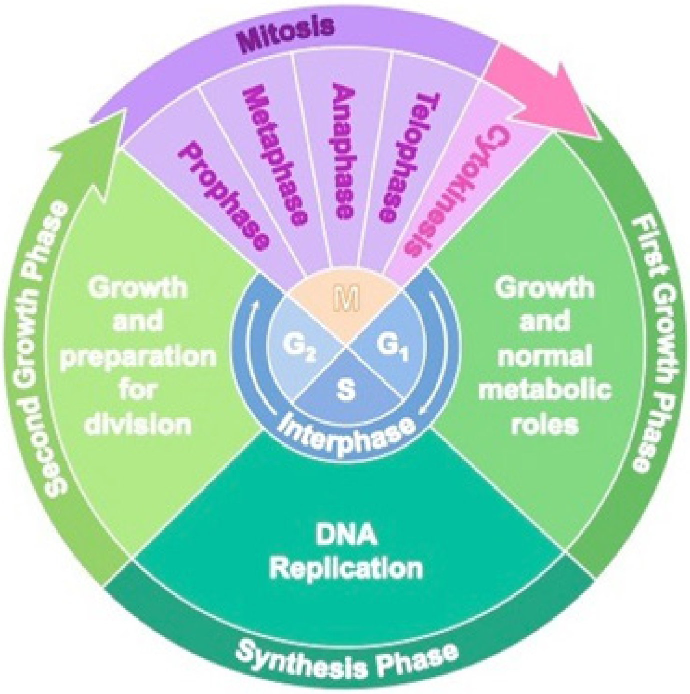
- Division by mitosis-produces two new genetically identical daughter cells.
- Gametes (sex cells); division takes place by meiosis-produces four haploid cells.
- Interphase: period between cell division
- At the end of interphase the chromatin replicates and becomes tightly coiled forming a double chromosome i.e. chromatids for cell division.
- Chromatids are joined at the center by a centromere.
- Chromatid is one copy of a newly copied chromosome which is still joined to the original chromosome by a single centromere.

The Cell Cycle

Series of changes a cell undergoes from the time it forms until the time it divide

Stages:

- Interphase
- Mitosis
- Cytokinesis



Interphase

- Very active period
- Cell grows
- Cell maintains routine functions
- Cell replicates genetic material to prepare for nuclear division
- Cell synthesizes new organelles to prepare for cytoplasmic division

Phases:

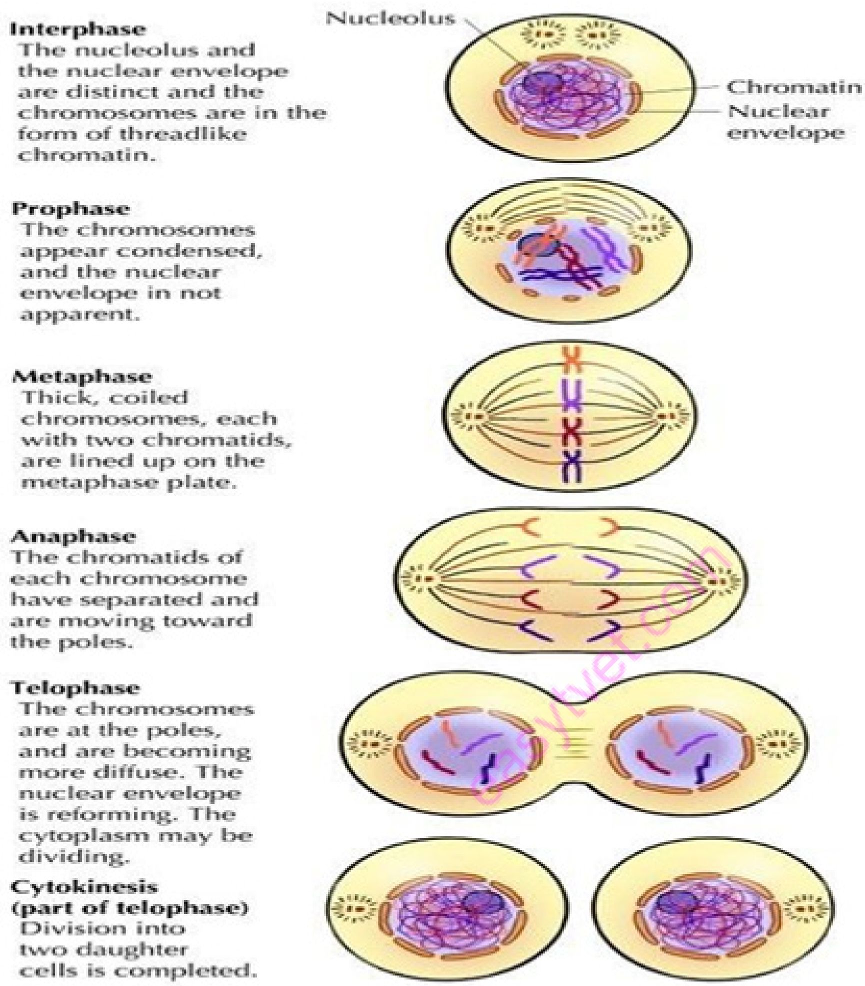
- G phases – cell grows and synthesizes structures other than DNA
- S phase – cell replicates DNA

Mitosis

- Produces two identical daughter cells from an original somatic cell.
- Nucleus divides – karyokinesis
- Cytoplasm divides – cytokinesis

Phases of Nuclear Division:

- Prophase – chromosomes form; nuclear envelope disappears
- Metaphase – chromosomes align midway between centrioles
- Anaphase – chromosomes separate and move to the opposite poles of the cell.
- Telophase – chromatin forms; nuclear envelope forms



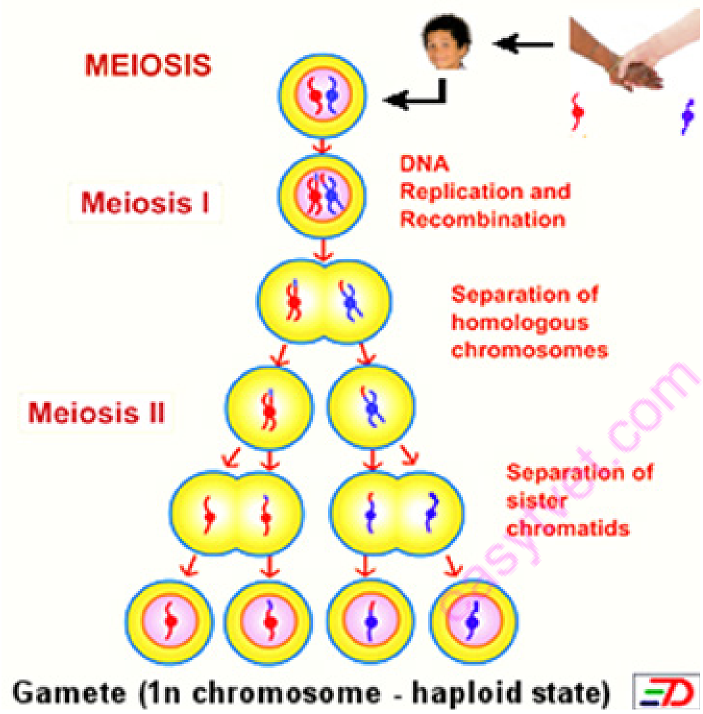
Follow this link to learn more on the process of mitosis:
https://www.youtube.com/watch?v=xsrH050wnIA

Cytoplasmic Division

- Also known as ***cytokinesis***
- Begins during anaphase
- Continues through telophase
- Contractile ring pinches cytoplasm in half.

Meiosis

- Is a specialized type of cell division that reduces the chromosome number by half, creating four haploid cells, each genetically distinct from the parent cell that gave rise to them.
- This type of cell division is only used to form gametes cells i.e. sperm and ovum.
- In meiosis, the chromosomes duplicate (during interphase) and homologous chromosomes exchange genetic information (chromosomal crossover) during the first division, called meiosis I. The daughter cells divide again in meiosis II, splitting up sister chromatids to form haploid gametes.
- Two gametes fuse during fertilization, creating a diploid cell with a complete set of paired chromosomes.



Follow this link to learn more on the process of meiosis:
https://www.youtube.com/watch?v=c5hA0WCv1lg

Differences Between Mitosis and Meiosis	
Mitosis	**Meiosis**
This type of division takes place in somatic cells	This type of division takes place in gamete cells
Two daughter cells are formed	Four daughter cells are formed
Number of chromosomes remains diploid in daughter cells	Number of chromosomes becomes haploid in daughter cells
Mitosis is necessary for growth and repair	Meiosis is necessary for sexual reproduction
Crossing over does not take place	Crossing overtakes place

Control of Cell Division

- Cell division capacities vary greatly among cell types
  - o Skin and blood cells divide often and continually
  - o Neuron cells divide a specific number of times then cease
- Cells divide to provide a more favorable surface area to volume relationship
- Growth factors and hormones stimulate cell division
  - o Hormones stimulate mitosis of smooth muscle cells in uterus
  - o Epidermal growth factor stimulates growth of new skin
- Tumors are the consequence of a loss of cell cycle control

Tumors

Two types of tumors:

- **Benign** – usually remains localized
- **Malignant** – invasive and can metastasize; cancerous

Two major types of genes cause cancer:

- Oncogenes – activate other genes that increase cell division
- Tumor suppressor genes – normally regulate mitosis; if inactivated they are unable to regulate mitosis

Cells are now known as "immortal".

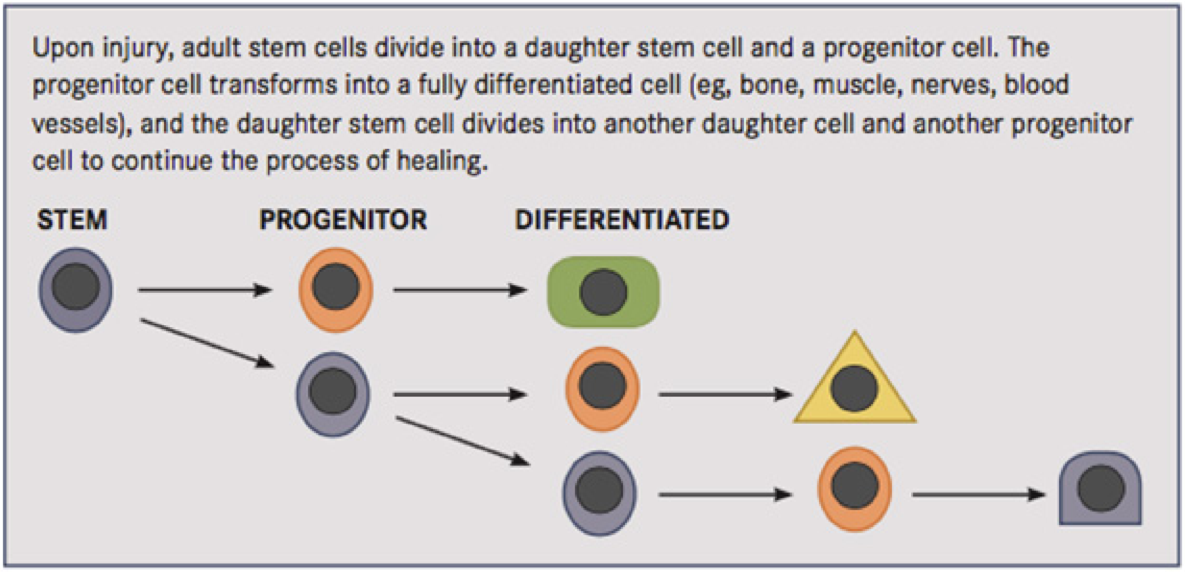
Stem and Progenitor Cells

Stem cell: An undifferentiated cell of a multicellular organism which is capable of giving rise to indefinitely more cells of the same type, and from which certain other kinds of cell arise by differentiation.

- Can divide to form two new stem cells
- Self-renewal
- Can divide to form a stem cell and a progenitor cell
- Totipotent – can give rise to every cell type
- Pluripotent – can give rise to a restricted number of cell types.

Progenitor cell:

- Committed cell that can divide into restricted specific cells.
- Can divide to become any of a restricted number of cells
- Pluripotent



Cell Death

Apoptosis:

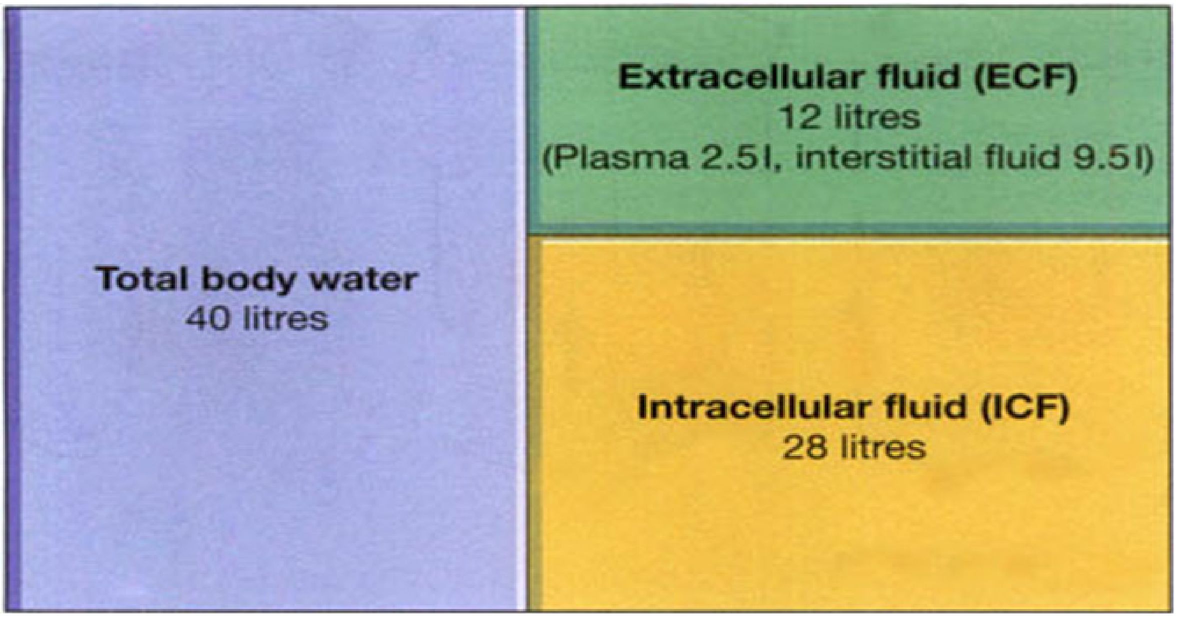
- Programmed cell death
- Acts as a protective mechanism
- Is a continuous process

Body Fluids Composition

- Total body water in adults is about 60% of body weight.
  - o Extracellular water…..about 22% of body weight
  - o Intracellular water……about 38% of body weight
- Proportion is higher in
  - o Young people and adults below average weight.
- It is lower in:

o The elderly

o Obesity



Distribution of body water in a 70 kg person

Importance of Water

- It makes up part of all body fluids
- It protects cells from outside pressure
- It helps in the regulation of body temperature
- It maintains intracellular pressure
- It is involved in chemical reactions
- It washes out wastes and is, therefore, a medium of excretion

Extracellular Fluid (ECF)

- Consists of
  - o blood,
  - o plasma,
  - o lymph,
  - o cerebrospinal fluid
  - o fluid in the interstitial spaces of the body.
  - o Others (synovial fluid, pericardial fluid, pleural fluid)
- Interstitial or intercellular fluid (tissue fluid) bathes all the cells of the body except the outer layers of skin.
- It is the medium through which substances pass from blood to the body cells, and from the cells to blood.

INTRACELLULAR FLUID (ICF)

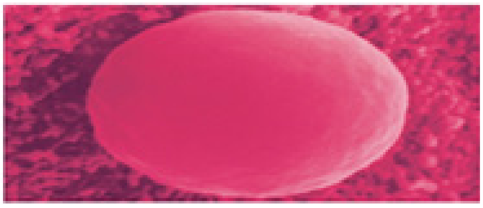
- Its composition is largely controlled by the cell itself, because there are selective uptakes and discharge mechanisms present in the cell membrane.
- Thus, sodium levels are nearly ten times higher in the ECF than in the ICF.
- This concentration difference occurs because although sodium diffuses into the cell down its concentration gradient there is a pump in the membrane which selectively pumps it back out again.

Units of measurement of the physiochemical constituent in cells identified as per the concentration

Isotonic – same osmotic pressure

Hypertonic – is one where the concentration of solutes is greater outside the cell than inside it.

Hypotonic – is one where the concentration of solutes is lower outside the cell than inside it.



Forces Producing Movement of Substances between Body Fluid Compartments

Movements Into and Out of the Cell

Passive (Physical) Processes

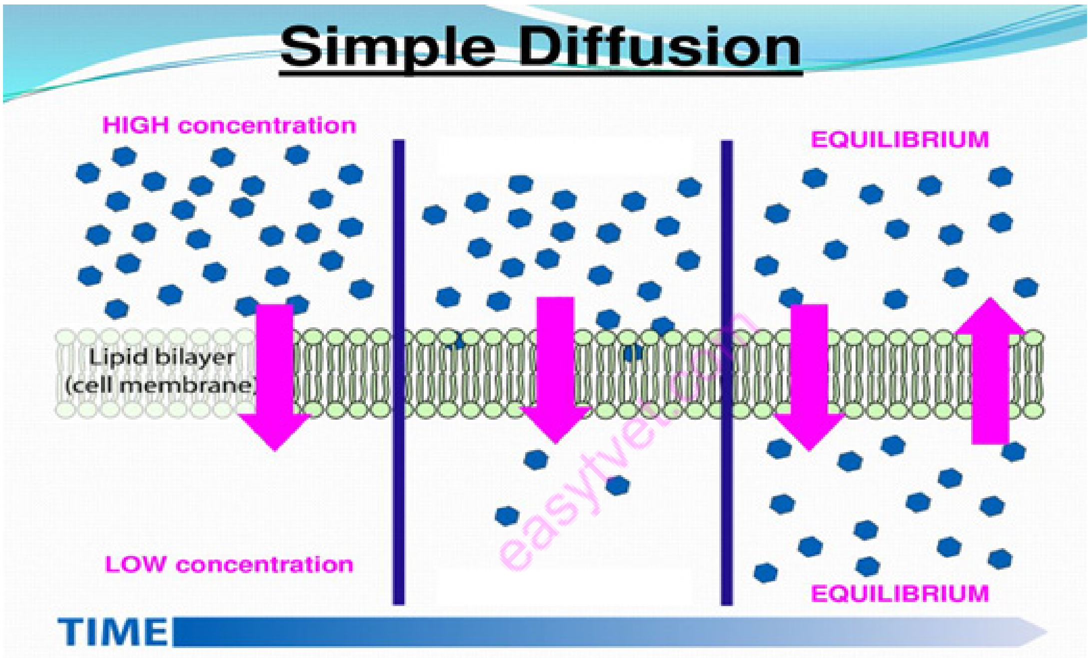
- Substances cross the semipermeable membrane down the concentration gradient.
- Require no cellular energy and include:
    - o Simple diffusion
    - o Facilitated diffusion
- o Osmosis
- o Filtration

Active (Physiological) Processes

- Require cellular energy and include:
  - o Active transport
  - o Endocytosis
  - o Exocytosis
  - o Transcytosis

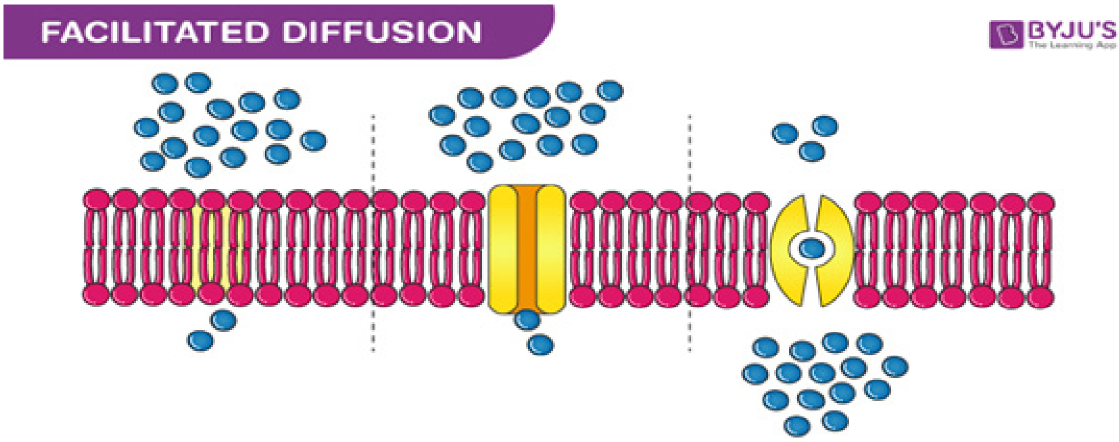
Simple Diffusion

- Movement of substances from regions of higher concentration to regions of lower concentration.
- Oxygen, carbon dioxide and lipid-soluble substances.



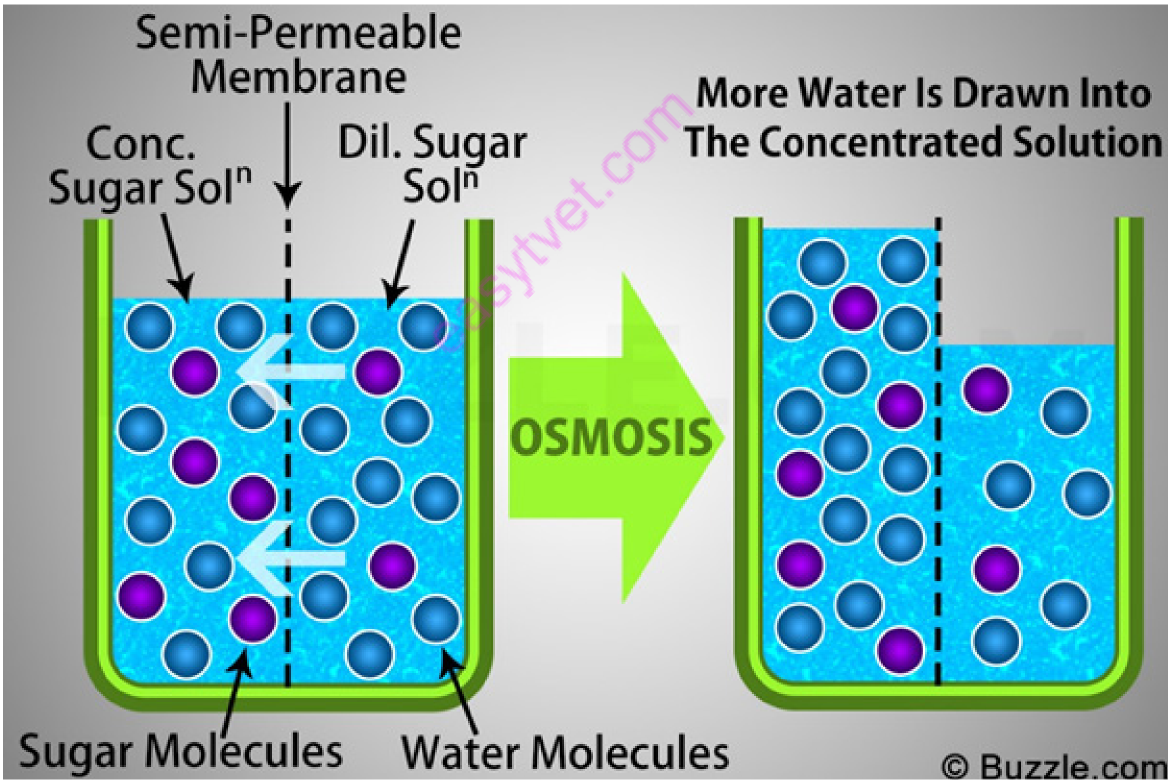
Facilitated Diffusion Facilitated Diffusion

- Diffusion across a membrane with the help of a channel or carrier molecule.
- Carrier molecule are site specific, limited in number therefore transports a limited amount of substances at any time.-transport maximum.
- Glucose and amino acids.



Osmosis

Movement of water, from a region of lower solute concentration to a region of higher solute concentration through a semi permeable membrane. Water moves toward a higher concentration of solutes.



Osmosis and Osmotic Pressure

Osmotic Pressure – ability of osmosis to generate enough pressure to move a volume of water

Osmotic pressure increases as the concentration of solutes increases.

Isotonic – same osmotic pressure

Hypertonic – is one where the concentration of solutes is greater outside the cell than inside it.

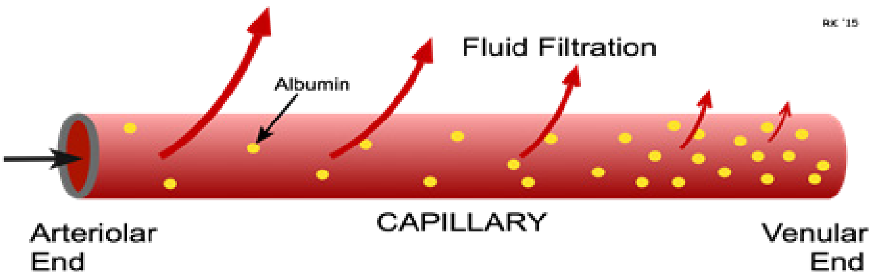
Hypotonic – is one where the concentration of solutes is lower outside the cell than inside it.

Filtration

Smaller molecules are forced through porous membranes

Hydrostatic pressure important in the body

Molecules leaving blood capillaries

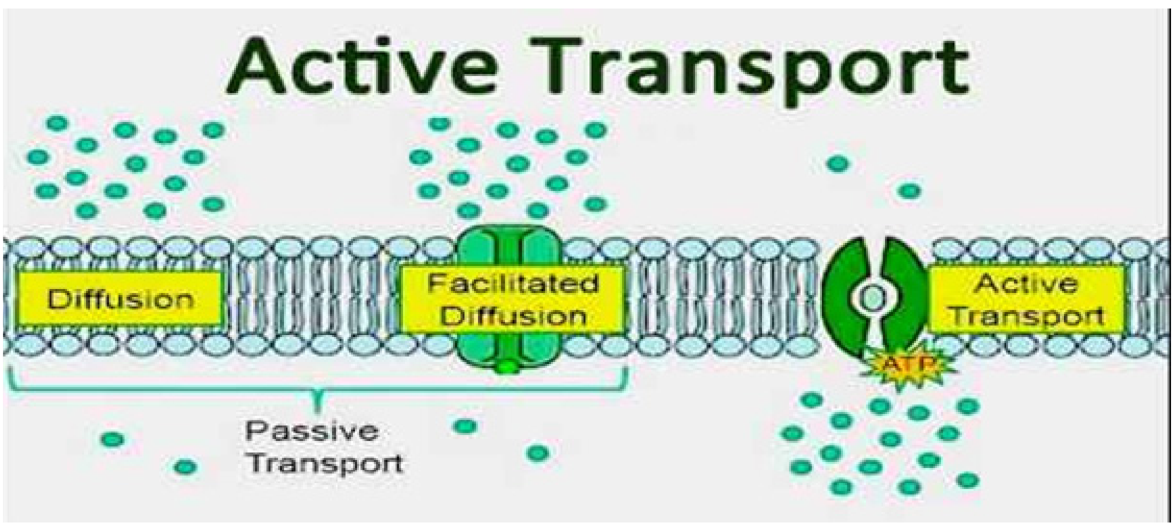


Active Transport

Carrier molecules transport substances across a membrane from regions of lower concentration to regions of higher concentration

Primary Active Transport—It uses energy in form of ATP to move molecules from a region of lower concentration to region of higher concentration.

Sugars, amino acids, sodium ions, potassium ions, etc. uses ATP Moves in both directions Site specificity.



Active Transport: Sodium-Potassium Pump

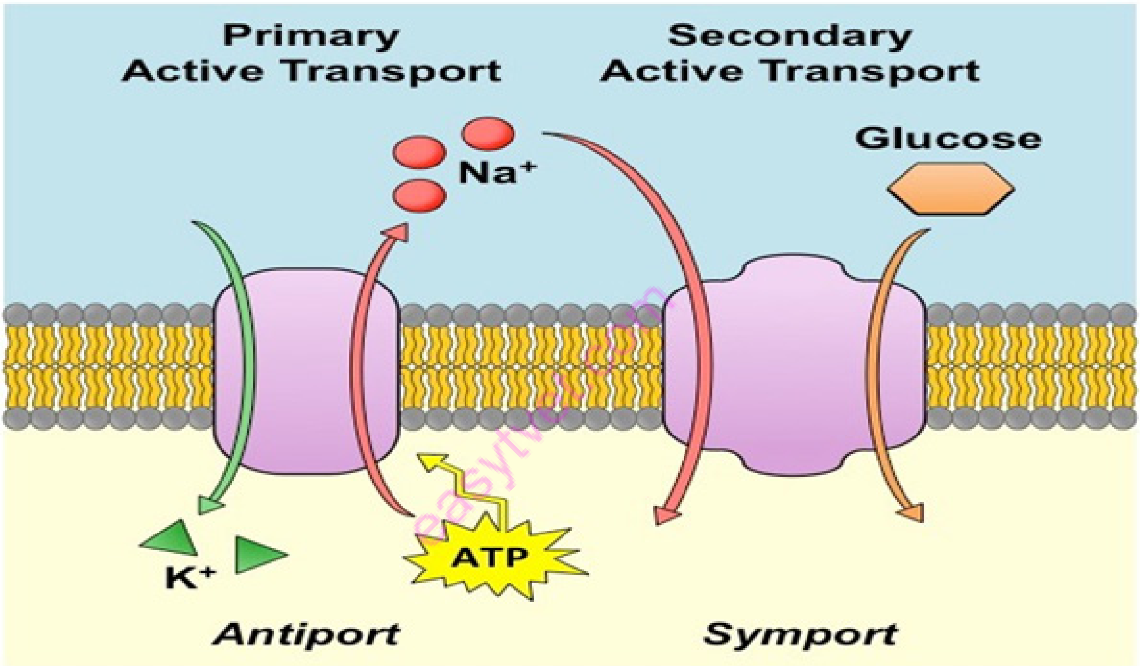
Active transport mechanism

Creates balance by "pumping" three (3) sodium (Na+) OUT and two (2) potassium (K+) INTO the cell 3:2 ratio K+ is intracellular and Na + extracellular and they diffuse down the concentration gradient. Na+ constantly pumped out of the cell in exchange for K +

Secondary Active Transport

Also called **co-transport**. Uses the energy stored in a concentration gradient. The gradient is established through active transport.

Symporters move substances in the same direction while **Antiporters** move substances in opposite directions.

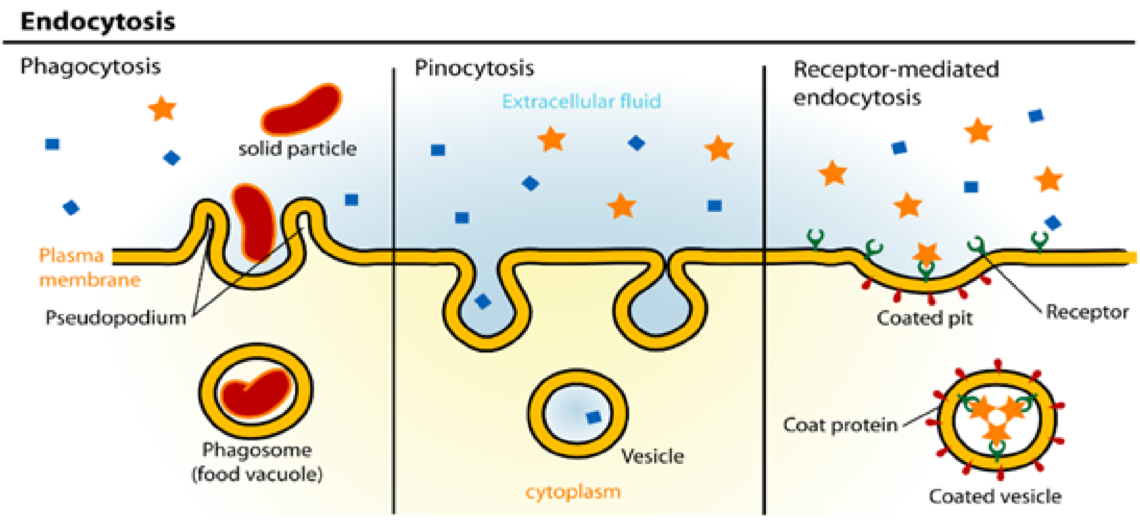


Endocytosis

Cell engulfs a substance by forming a vesicle around the substance

Three types:

- Pinocytosis – substance is mostly water
- Phagocytosis – substance is a solid
- Receptor-mediated endocytosis – requires the substance to bind to a membrane-bound receptor.



Exocytosis

Reverse of endocytosis

- Substances in a vesicle fuse with cell membrane
- Contents released outside the cell
- Release of neurotransmitters from nerve cells

Transcytosis

Endocytosis is followed by exocytosis

- Transports a substance rapidly through a cell
- HIV crossing a cell layer.

Maintenance and Variations in Membrane Potentials

Action Potential Definition of Terms

Action potential is a change in electrical potential associated with the passage of an impulse along the membrane of a muscle cell or a nerve cell.

Excitable membrane cell membrane that regulates the movement of ions so that an electrical signal can be generated.

An **action potential** is generated by the rapid influx of Na+ ions followed by a slightly slower efflux of K+ ions.

Membrane potential distribution of charge across the cell membrane, based on the charges of ions.

Resting membrane potential the difference in voltage measured across a cell membrane under steady-state conditions, it is typically -70 mV.

Depolarization change in a cell membrane potential from rest toward zero. Also defined as a change within a cell, during which the cell undergoes a shift in electric charge distribution, resulting in less negative charge inside the cell.

Repolarization is the return of the membrane potential to its normally negative voltage at the end of the action potential.

Refractory period time after the initiation of an action potential when another action potential cannot be generated

Hyperpolarization is a change in a cell's membrane potential that makes it more negative.

Relative refractory period time during the refractory period when a new action potential can only be initiated by a stronger stimulus than the current action potential because voltage-gated K+ channels are not closed.

Absolute refractory period time during an action period when another action potential cannot be generated because the voltage-gated Na+ channel is inactivated.

Electrochemical exclusion principle of selectively allowing ions through a channel on the basis of their charge.

Size exclusion principle of selectively allowing ions through a channel on the basis of their relative size

Gated property of a channel that determines how it opens under specific conditions, such as voltage change or physical deformation.

Inactivation gate part of a voltage-gated Na+ channel that closes when the membrane potential reaches +30 mV

Leakage channel ion channel that opens randomly and is not gated to a specific event, also known as a non-gated channel.

Ligand-gated channels another name for an ionotropic receptor for which a neurotransmitter is the ligand.

Voltage-gated channel—is an ion channel that opens because of a change in the charge distributed across the membrane where it is located

Mechanically gated channel ion channel that opens when a physical event directly affects the structure of the protein.

Ionotropic receptor neurotransmitter receptor that acts as an ion channel gate, and opens by the binding of the neurotransmitter.

Nonspecific channel a channel that is not specific to one ion over another, such as a nonspecific cation channel that allows any positively charged ion across the membrane.

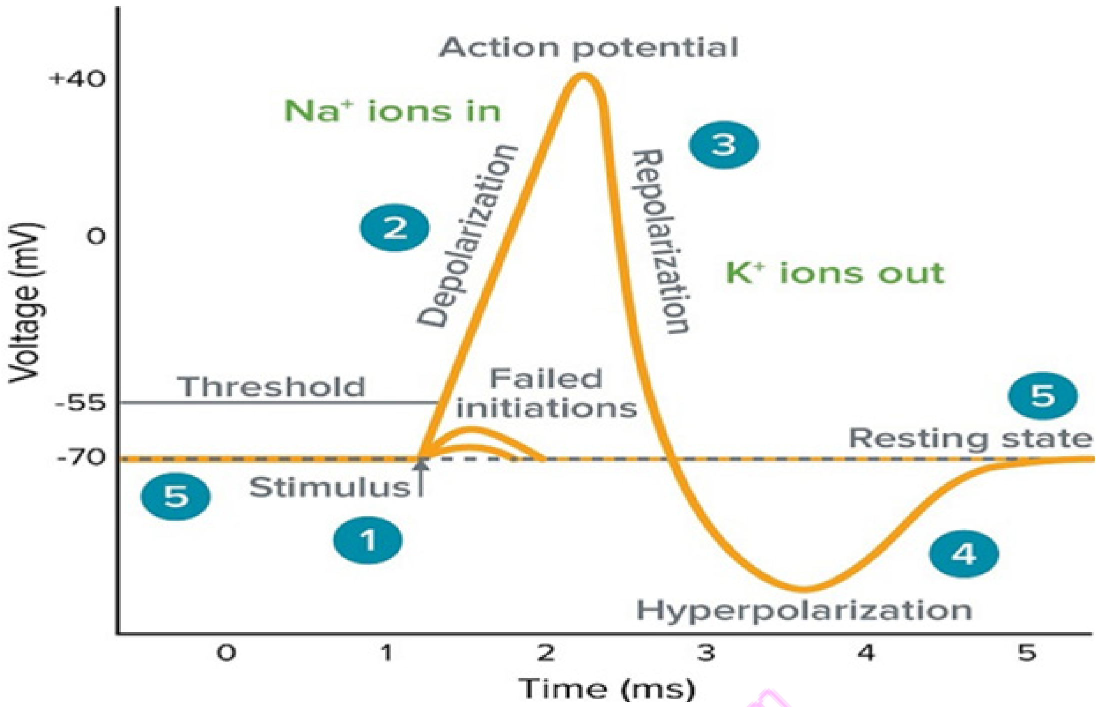
Inactivation gate part of a voltage-gated Na+ channel that closes when the membrane potential reaches +30 mV

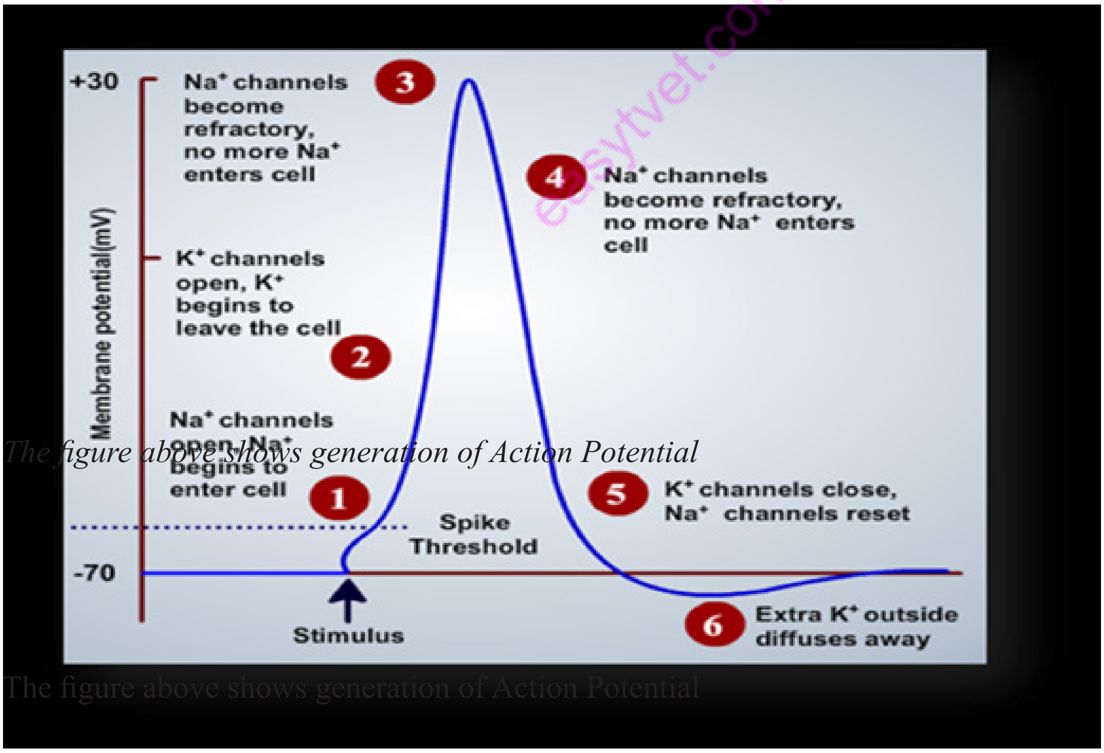
Continuous conduction slow propagation of an action potential along an unmyelinated axon owing to voltage-gated Na+ channels located along the entire length of the cell membrane.

Saltatory conduction quick propagation of the action potential along a myelinated axon owing to voltage-gated Na+ channels being present only at the nodes of Ranvier.

Resistance property of an axon that relates to the ability of particles to diffuse through the cytoplasm; this is inversely proportional to the fiber diameter

Action Potential

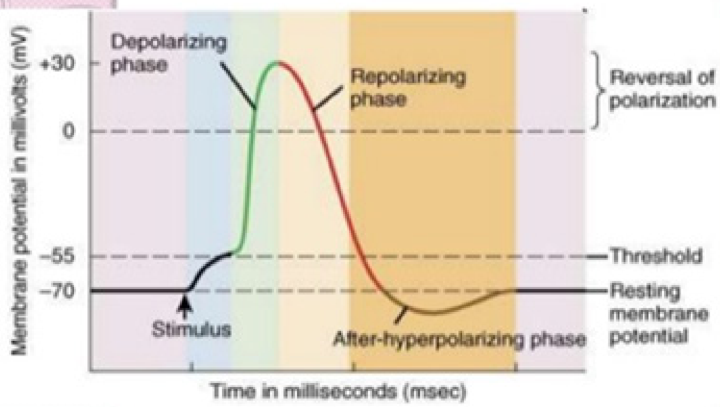




The figure above shows generation of Action Potential

The figure above shows generation of Action Potential

Action Potential



- Resting membrane potential is -70mV
- triggered when the membrane potential reaches a threshold usually -55 MV
- if the graded potential change exceeds that of threshold – Action Potential
- Depolarization is the change from -70mV to +30 mV
- Repolarization is the reversal from +30 mV back to -70 mV)

- action potential = nerve impulse
- takes place in two stages: ***depolarizing phase*** (more positive) and ***repolarizing phase*** (more negative - back toward resting potential)
- followed by a ***hyperpolarizing phase*** or refractory period in which no new AP
  can be generated

The Buffering System of the Body

Acids, Alkalis and pH

An acid: a substance that produces hydrogen ions when dissolved. Acids act as electrolytes in water. They neutralize bases to produce salt and water. Common acids are hydrochloric acid and carbonic acid.

A base: a substance that reacts with acid to form salt and water by acepting hydrogen ions and oftenly releasing hydroxyl (OH-) ions.

Common bases are magnesium hydroxide and aluminium hydroxide.

The balance between acids and bases must be maintained for the various processes in the body to take place optimally.

Number of H+ present in a solution is a measure of the acidity of the solution.

Maintenance of the normal H+ concentration within the body is an important factor in maintaining homeostasis.

The pH scale

Def: A standard scale for the measurement of the hydrogen ion concentration in solution.

Not all acids ionize completely when dissolved in water. The hydrogen ion concentration is a measure, therefore, of the amount of dissociated acid (ionized acid) rather than of the total amount of acid present. Strong acids dissociate more freely than weak acids, e.g. hydrochloric acid dissociates freely into H+ and Cl~, while carbonic acid dissociates much less freely into H+ and HCO3-.

Alkalinity of a solution depends on the number of hydroxyl ions (OH-). Water is a neutral solution because every molecule contains one hydrogen ion and one hydroxyl radical.

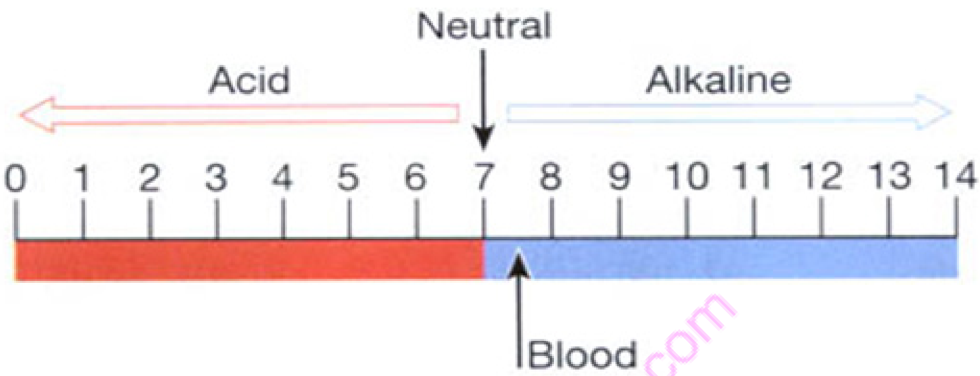
pH scale was developed taking water as the standard.

In a neutral solution such as water, where the number of hydrogen ions is balanced by the same number of hydroxyl ions, the pH = 7.

A pH reading below 7 indicates an acid solution, while readings above 7 indicate alkalinity.

A change of one whole number on the pH scale indicates a tenfold change in [H+]. Therefore, a solution of pH 5 contains ten times as many hydrogen ions as a solution of pH 6.

Ordinary litmus paper colors blue for alkalinity and red for acidity.



PH Values of Body Fluids

Vary.

pH value in an organ is produced by its secretion of acids or alkalis which establishes the optimum level.

Body fluid	pH
Blood	7.35 to 7.45
Saliva	5.4 to 7.5
Gastric juice	1.5 to 3.5
Bile	6 to 8.5
Crossing over does not take place	4.5 to 8.0

Buffering Systems in the Body

Buffering mechanisms temporarily neutralize fluctuations in pH thus keeping it stable within its normal limits.

The lungs and the kidney are the most active organs in buffering.

Lungs regulate CO2 levels in the body by either ↑ or ↓ breathing.

Kidneys regulate pH by either ↑ or ↓ excretion of hydrogen and bicarbonate ions as required.

Other buffer systems include **body proteins** and **phosphate**.

Buffer substances/systems help maintain the Acid-Base balance so that the pH remains within normal, but narrow, limits

Acidosis and Alkalosis

When the pH is below 7.35, and all the reserves of alkaline buffer are used up, the condition of **acidosis exists** (**Acidosis** is an increased acidity in the blood and other body tissue).

When the reverse situation persists and the pH is above 7.45, and the increased alkali uses up all the acid reserve, the state of **alkalosis exists** (**Alkalosis** refers to a condition reducing hydrogen ion concentration of arterial blood plasma)

3.3.2.3 Self-Assessment

1. Differentiate between a stem cell and a progenitor cell.
2. State four buffering mechanisms in the body.
3. The following bases take part in buffering human body. Which one is not?

   A. Magnesium hydroxide　　B. Aluminum hydroxide.

   C. Sodium hydroxide　　D. Potassium hydroxide
4. Briefly explain four physical processes that are used to move substances in and out of the cell.
5. Define the following terms; action potential, depolarization, repolarization and refractory period.

3.3.2.4 Tools, Equipment, Supplies and Materials

Slides, anatomy textbooks, white board, mark pen, skills laboratory demonstration.

3.3.2.5 References

Waugh A. & Grant A. (2016) Ross and Wilson Anatomy & Physiology 12th Edition; Churchill Livingstone

Bartholomew E.F. & Martini F.H. (2019) Essentials of Anatomy and Physiology; 8th Edition

Elaine N. & Katja H., 2016: Humana Anatomy and Physiology, 5th Edition

Barrett K.E., Barman S.M., Yuan J. & Brooks H.L. (2019) Ganong's Review of Medical Physiology, Twenty sixth Edition 26th Edition; McGraw-Hill Education

3.3.3 Learning outcome 3: Demonstrate the knowledge of the human body systems

3.3.3.1 Learning Activities

Learning activity	Special instructions
Identify the components of the human body systems as per the workplace procedures	The components of the human body systems • Describe the structure of a neuron • Demonstrate knowledge of the central nervous system • Illustrate knowledge of the functions of the brain • Demonstrate knowledge of the functions of the spinal cord • Describe the peripheral nervous system • Describe the somatic and autonomic nervous system
Identify relevant principles of the body systems to performance of therapy	Demonstrate understanding of relevant principles of the body systems to performance of therapy treatment
Apply relevant principles of the body systems to performance of therapy treatment as per the workplace procedures	Relevant functions of the body systems • The nervous system • The cardiovascular system • The respiratory system • The renal system • Musculoskeletal system • Reproductive system • Skin • Gastrointestinal system • Endocrine system • Special senses

3.3.3.1 Information sheet

Relevant Functions of the Body's Systems

The Nervous System

Introduction

Nervous system detects and responds to changes inside and outside the body. Consists of the brain, the spinal cord and peripheral nerves. Nervous system is divided into two main areas:

1. Central Nervous System (CNS); the brain and the spinal cord
2. Peripheral Nervous System (PNS); all the nerves outside the brain and spinal cord.

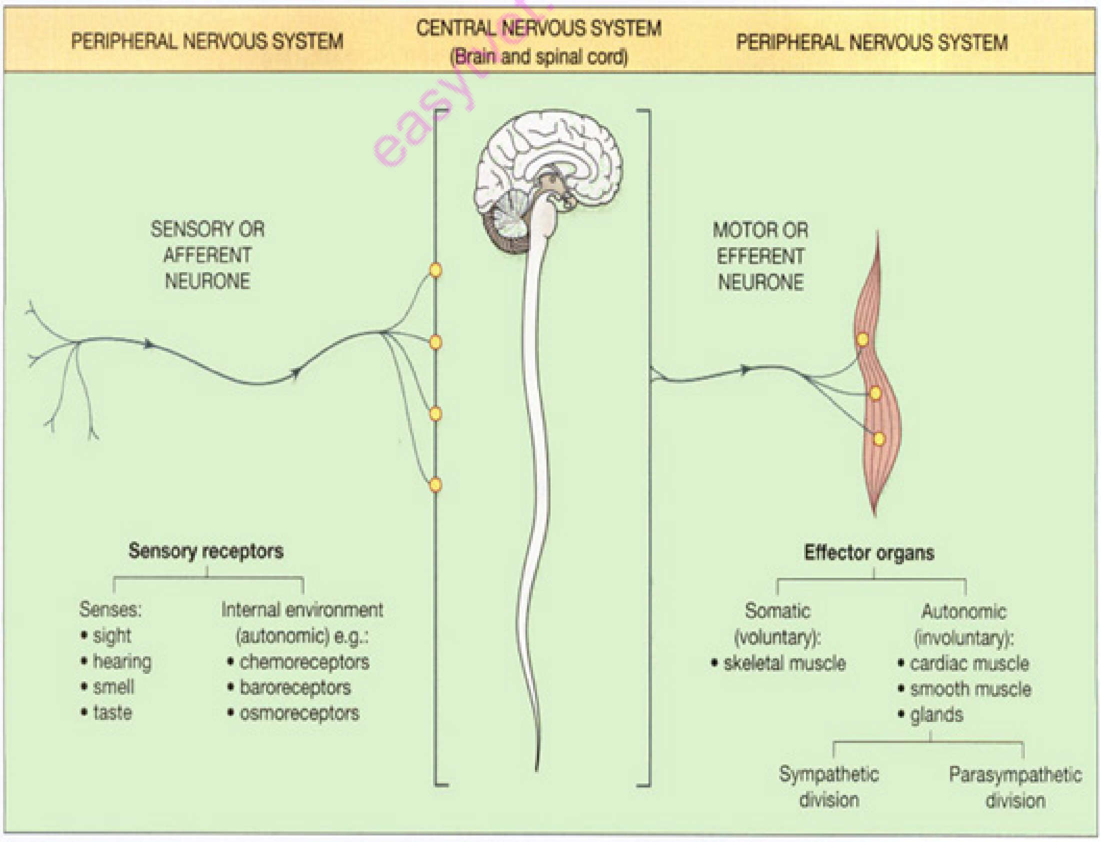
PNS has two functional parts:

1. The sensory division
2. The motor division

Motor division is involved in activities that are:

Voluntary —the **somatic nervous system** (movement of voluntary muscles)

Involuntary — the **autonomic nervous system (ANS)** (functioning of smooth and cardiac muscle and glands) which has 2 parts: ***sympathetic and parasympathetic***



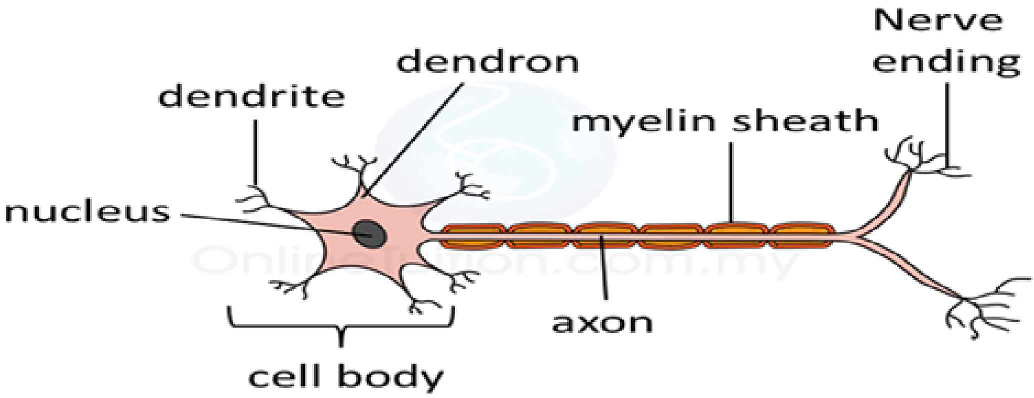
Functional components of the nervous system.

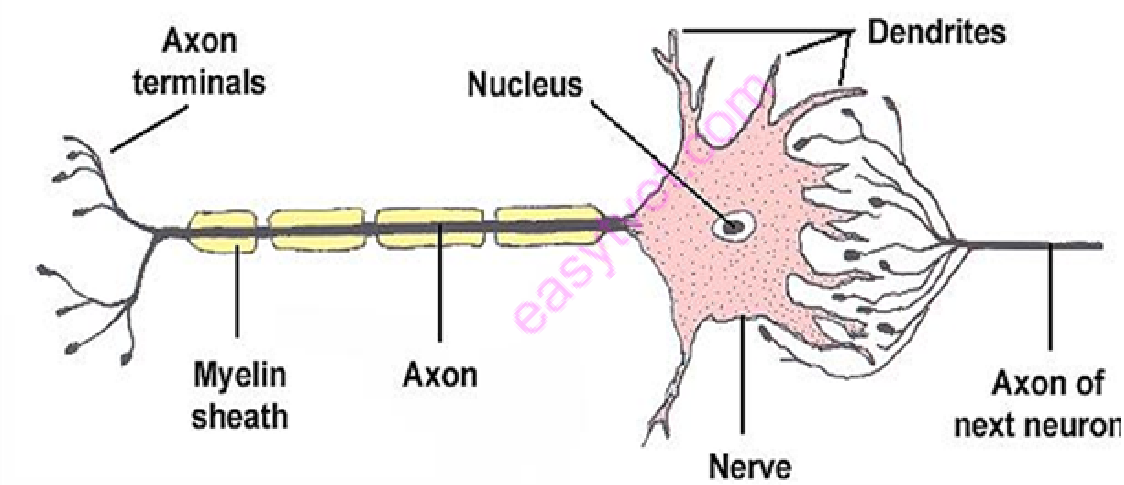
Cells and Tissues of the Nervous System

NEURONES

Neurones are nerve cells. Each neurone consists of a cell body and its processes, one axon and many dendrites.

Nerves: group/bundle of axons and/or dendrites of many neurons bound together.





Properties of Neurons

Have the characteristics of irritability and conductivity.

Irritability: ability to initiate nerve impulses in response to stimuli from: outside the body, e.g. touch, light waves Inside the body, e.g. a change in the CO_2 concentration in the blood alters respiration.

Conductivity: ability to transmit an impulse.

Neuron Anatomy

Cell body

- Nucleus
- Large nucleolus

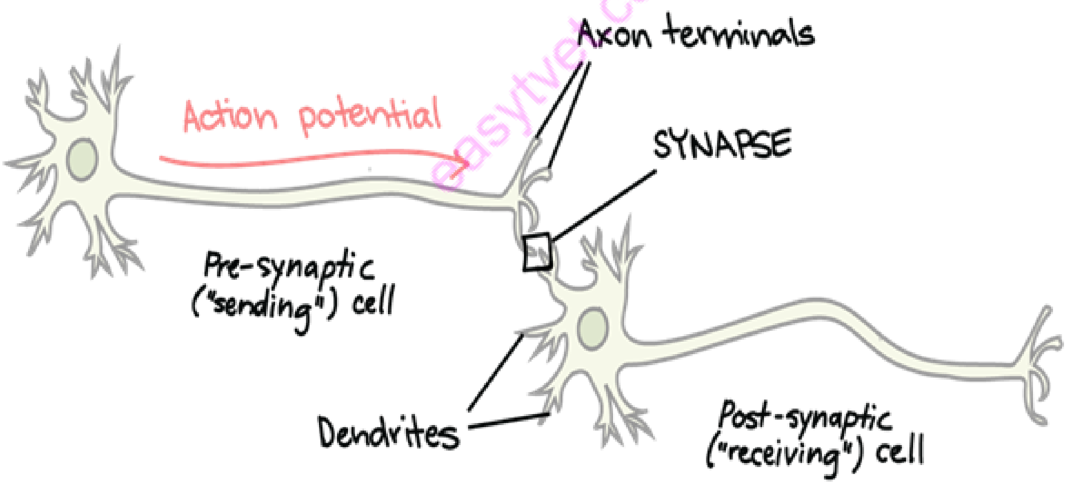
Extensions outside the cell body

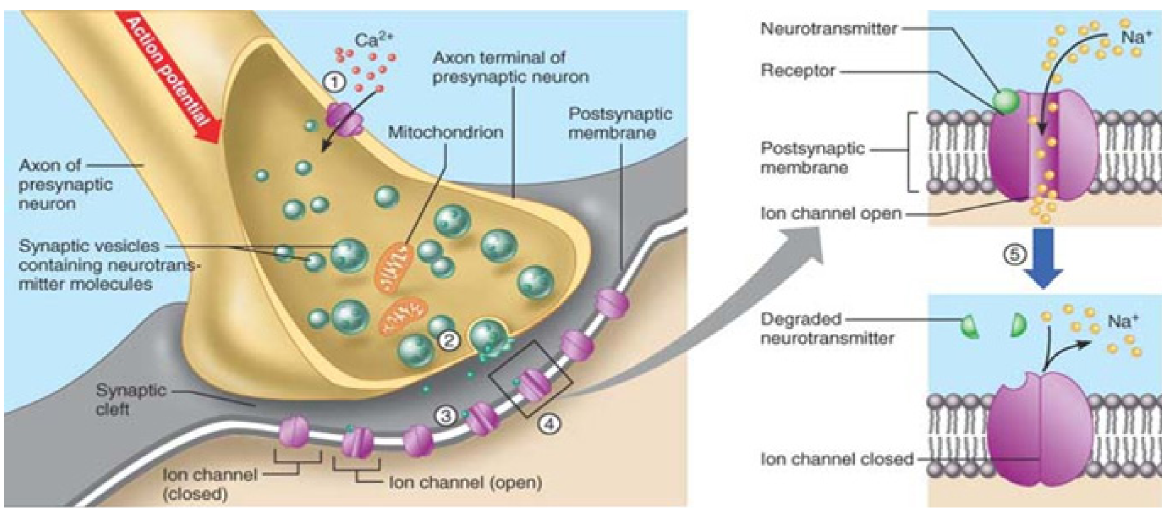
Dendrites – conduct impulses toward the cell body

Axons – conduct impulses away from the cell body

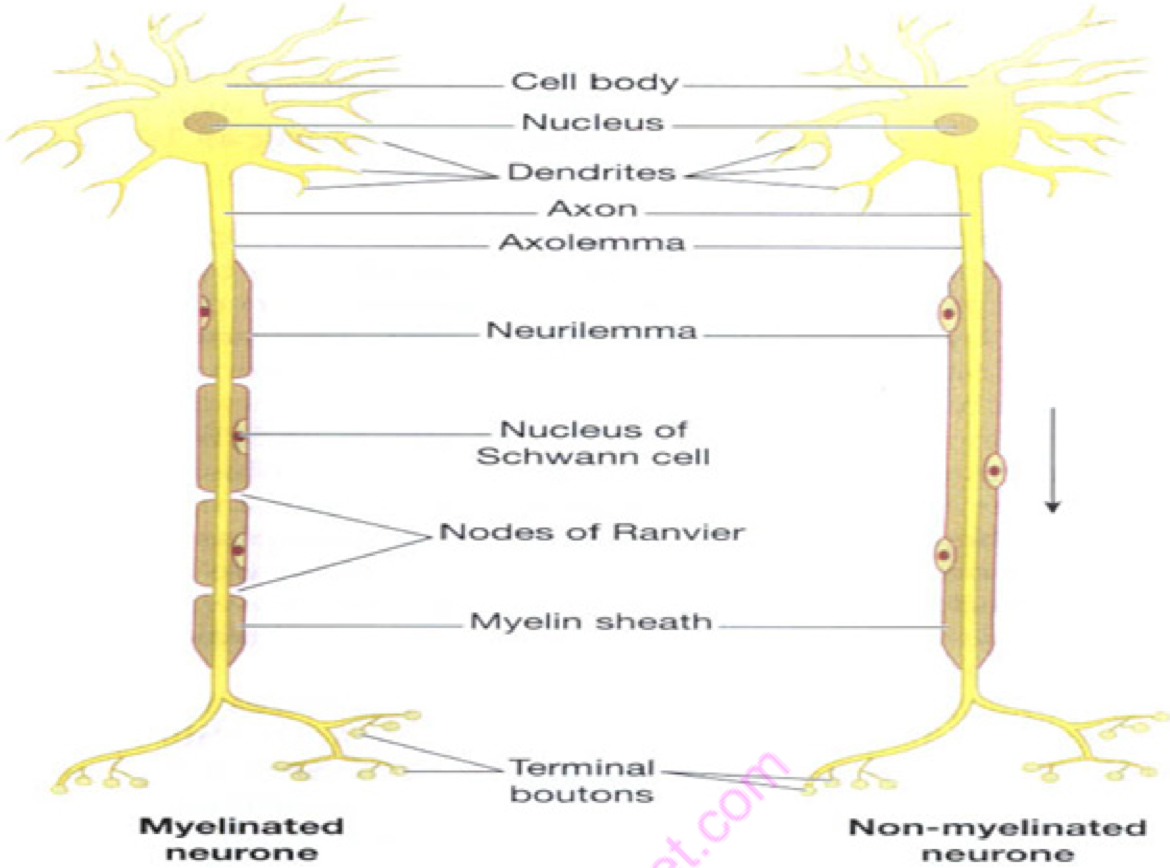
- Usually neurons have only one axon but may have many dendrites
- Axons end in axonal terminals
- Axonal terminals contain tiny vesicles or sacs which store neurotransmitters
- Axonal terminals are separated from the next neuron by a tiny gap called
- **Synaptic cleft** – gap between adjacent neurons
- **Synapse** – junction between nerves

Diagram Showing a Synapse and synaptic cleft

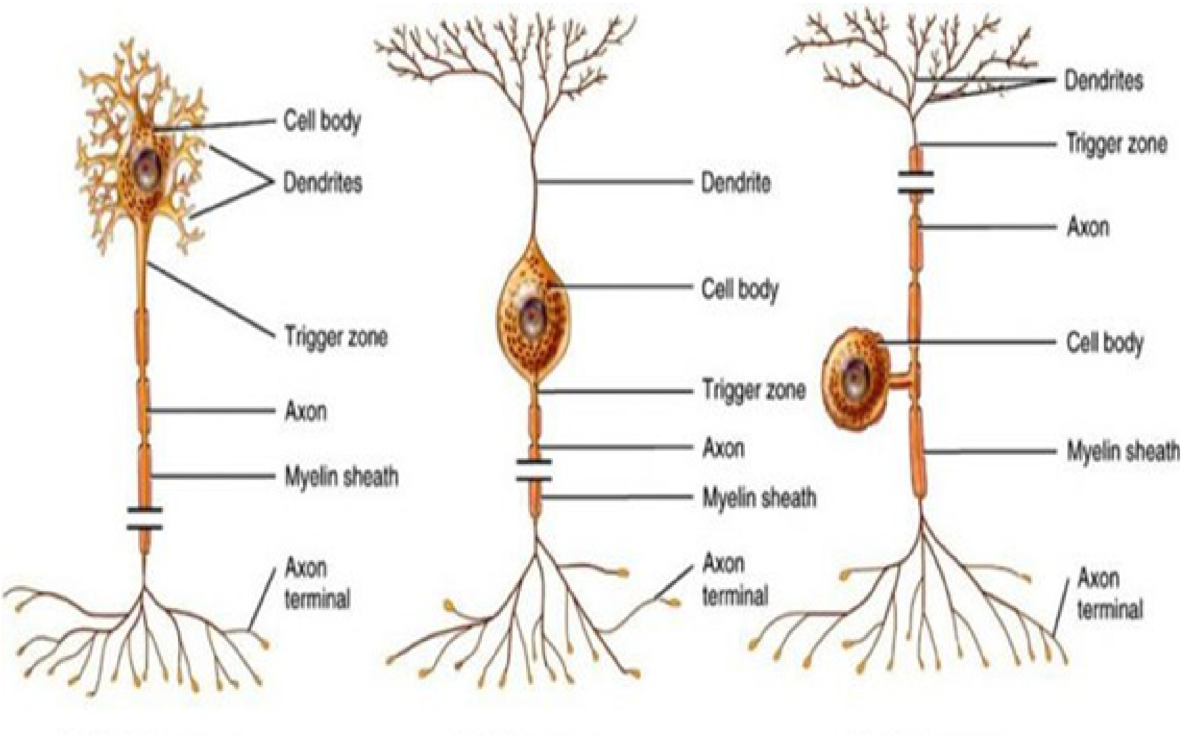




Most long **nerve fibers** (axon) are covered with a whitish fatty material **(myelin). Myelin** protects and insulates the fibers and increase the rate of transmission of the nerve impulses.



Neuron Classification by Shape



(a) Multipolar neuron (b) Bipolar neuron (c) Unipolar neuron

Nervous System Communication

Communication between neurons takes place via **electrical impulses.**

Nerve impulse propagation occurs via **action potential.**

Action potential is a change in electrical potential associated with the passage of an impulse along the membrane of a muscle cell or a nerve cell.

Excitable membrane cell membrane that regulates the movement of ions so that an electrical signal can be generated.

Neurotransmitters include:

- Noradrenaline,
- Acetylcholine,
- Serotonin (5-hydroxytryptamine),
- Endorphins
- Gamma ammo- butyric acid (gaba),
- Dopamine,
- Enkephalins,
- Substance p.

Nerves

A nerve consists of numerous neurons collected into bundles

Types of Neurons

a) Sensory or Afferent Nerves

Transmit action potentials (information) generated by sensory receptors on the body to the spinal cord which is then carried to the brain.

Sensory receptors are specialized nerve endings that respond to different stimuli (changes). Various types to include:

- *Somatic, cutaneous or common senses:* Originate in the skin. They are: pain, touch, heat and cold.
- *Proprioceptor senses.* Originate in muscles and joints and contribute to the maintenance of balance and posture.
- *Special senses.* Sight, hearing, smell, touch and taste.
- *Autonomic afferent nerves.* Originate in internal organs, glands and tissues, e.g. baroreceptors, chemoreceptors, and are associated with reflex regulation of involuntary activity and visceral pain.

b) Motor or Efferent Nerves

Originate in the brain, spinal cord and autonomic ganglia and transmit impulses to the effector organs: muscles and glands. 2 types:

- *Somatic nerves:* involved in voluntary movement and reflexes
- *Autonomic nerves:* involved in cardiac and smooth muscle contraction and glandular secretion

c) Mixed Nerves

Occur outside the spinal cord, when sensory and motor nerves are enclosed within the same sheath of connective tissue e.g. sciatic nerve.

Neuroglia

Neurones of the CNS are supported by 4 types of non-excitable glial cells that make up a quarter to a half of the volume of brain tissue.

Unlike nerve cells these continue to replicate throughout life.

They are :

- Astrocytes,
- Microglia
- Oligodendrocytes,
- Ependymal cells.

Name	Function
Astrocytes	Support neurons, help maintain K+ level, contribute to the blood-brain barrier (BBB)
Oligodendrocytes	Produce the myelin sheath to electrically insulate neurons of the CNS, provide support
Microglia	Capable of movement and phagocytosis of pathogens and damaged tissue
Ependymal cells	Line the ventricles of the brain; many of the cells have cilia; involved in circulation of CSF

Central Nervous System

The Meninges

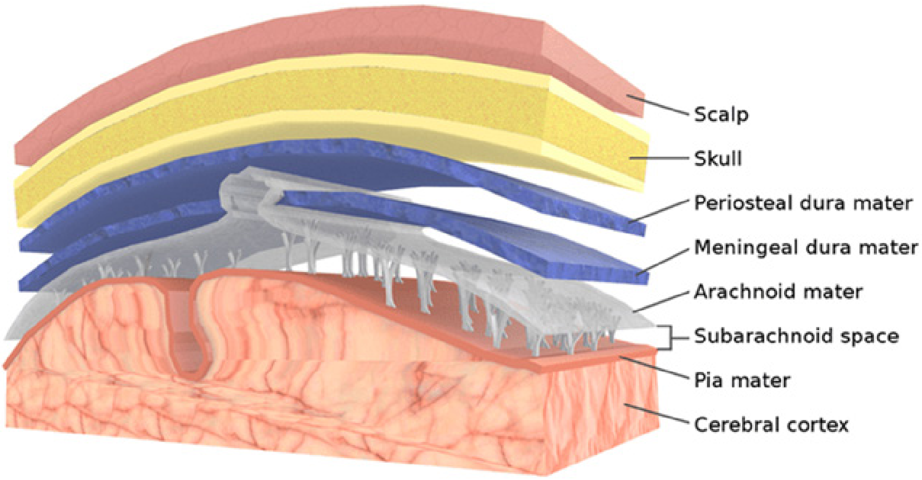
These are tissue membranes that cover the brain and spinal cord.

Has 3 layers of tissue named from outside inwards; they are:

- Dura mater
- Arachnoid mater
- Pia mater

Dura and **arachnoid** maters are separated by a potential space, the **subdural space.**

Arachnoid and **pia** maters are separated by the **subarachnoid** space, containing **cerebrospinal fluid.**



Ventricles of the Brain and the Cerebrospinal Fluid

The brain contains 4 irregular-shaped cavities called Ventricles containing **cerebrospinal fluid (CSF).**

They are:

- Right lateral ventricle
- Left lateral ventricle
- Third ventricle
- Fourth ventricle.

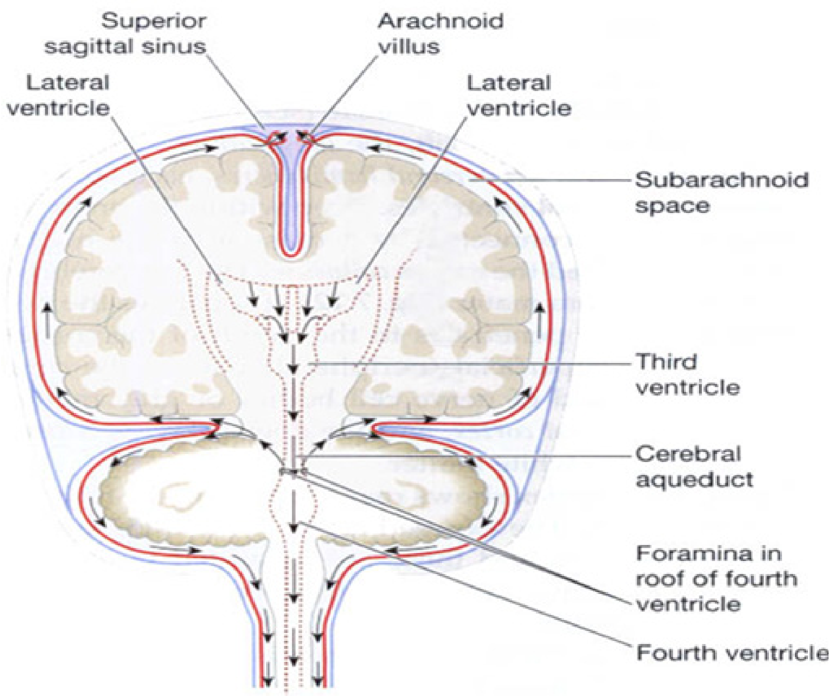
Cerebrospinal Fluid

CSF is secreted into each ventricle of the brain by **choroid plexuses**; a capillary of network that forms cerebrospinal fluid from blood plasma.

CSF passes back into the blood through tiny diverticula of arachnoid mater, called **arachnoid villi.**

CSF is a clear, slightly alkaline fluid found in the brain and spinal cord, consisting of:

- Water
- Mineral salts
- Glucose
- Plasma proteins: small amounts of albumin and globulin
- Creatinine (small amounts)
- Urea (small amounts)
- A few leukocytes.



Functions of CSF

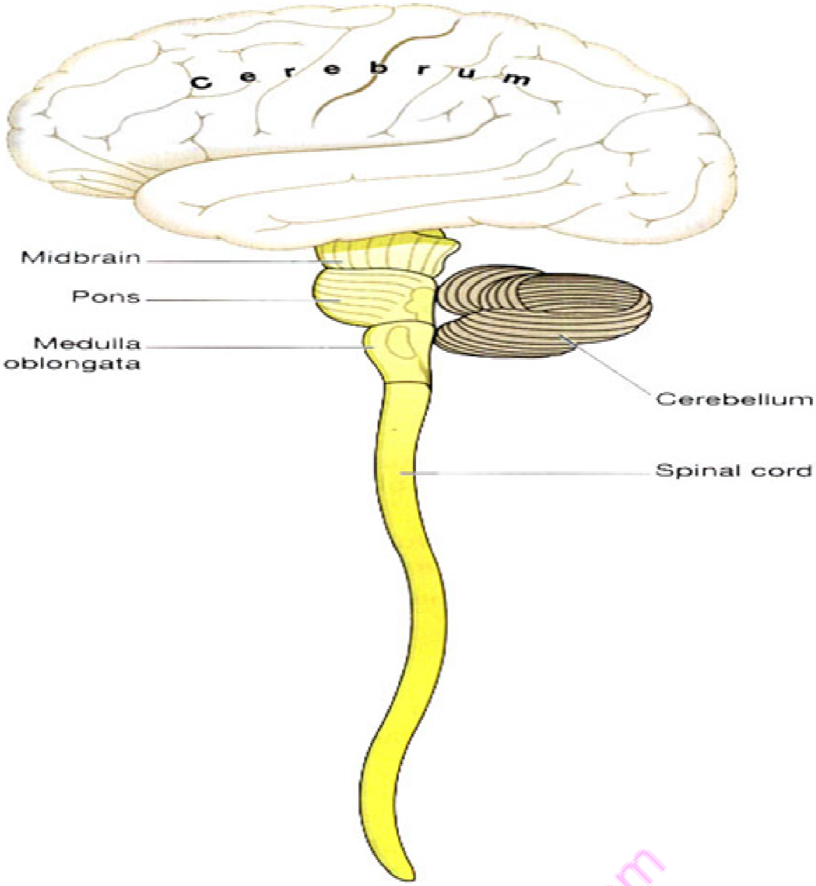
- It is involved in the exchange of substances, for example, nutrients between the CSF and the nerve cells.
- It keeps the brain and spinal cord moist.
- It is a shock absorber for the brain, spinal cord and nerves.
- It supports the brain and spinal cord and protects them by maintaining pressure around the delicate structures in a uniform manner.

The Brain

Constitutes about one-fiftieth of the body weight and lies within the cranial cavity.

The parts are

- Cerebrum
- Thalamus
- Hypothalamus
- Midbrain
- Pons
- Medulla oblongata
- Cerebellum



Cerebrum

It is the largest part of the brain & occupies the anterior and middle cranial fossae.

Cerebral cortex shows many infoldings of varying depth.

Exposed areas of the folds are the gyri or convolutions and these are separated by **sulci** or **fissures.**

Convolutions greatly increase the surface area of the cerebrum.

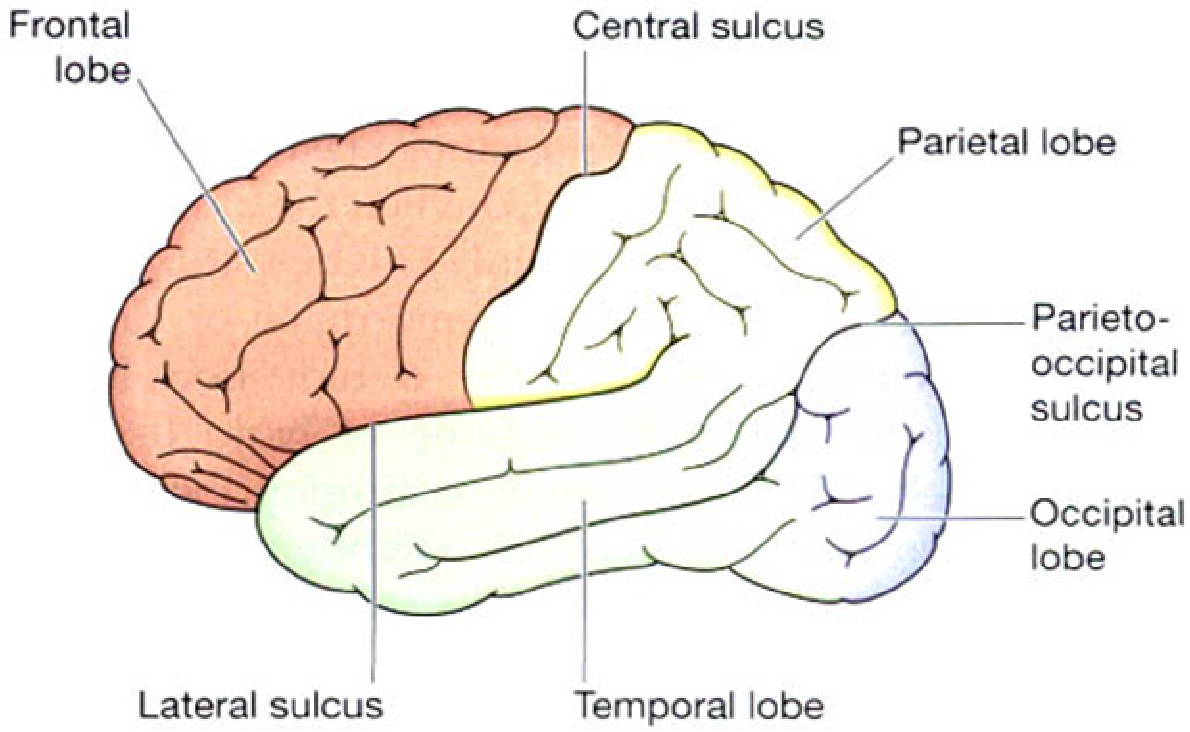
Cerebral cortex is divided into **lobes** that have the same names as the cranial bones under which they lie:

The lobes include:

- Frontal lobe
- Parietal lobe
- Temporal lobe
- Occipital lobe

Boundaries of the lobes are marked by deep sulci (fissures). They include:

- Central sulci
- Lateral sulci
- Parieto-occipital sulci



The lobes and sulci of the cerebrum

Functions of the Cerebral Cortex

- Mental activities involved in memory, intelligence, sense of responsibility, thinking, reasoning, moral sense and learning.
- Sensory perception, including the perception of pain, temperature, touch, sight, hearing, taste and smell
- Initiation and control of skeletal (voluntary) muscle contraction.

Functional Areas of the Cerebrum

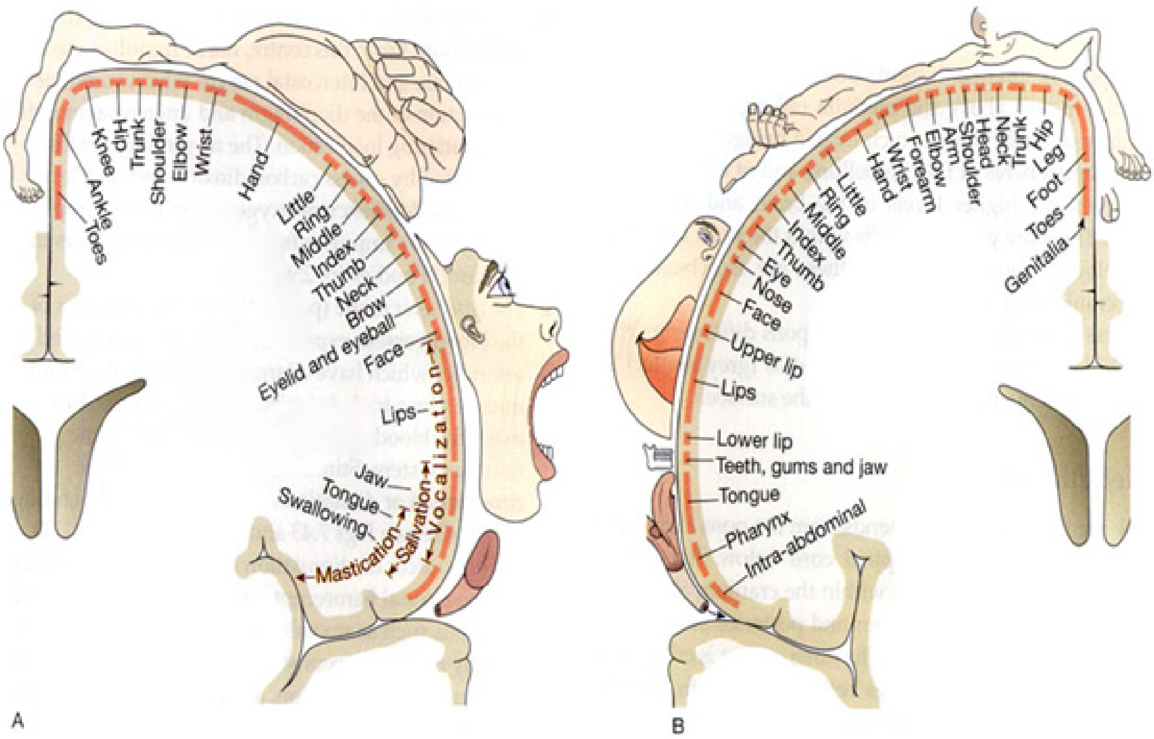
A) Motor Areas of the Cerebrum

1. The primary motor area.

Lies in the frontal lobe immediately anterior to the central sulcus. Its cell bodies control **skeletal muscle activity.**

2. The Motor Speech (Broca's area)

Lies in the frontal lobe just above the lateral sulcus and it controls the movements of muscles necessary for speech.



The motor homunculus showing body representation in the motor area of the cerebrum (A) & sensory area (B) of the cerebrum

B) Sensory Areas of the Cerebrum

1. The Somatosensory Area.

Lies behind the central sulcus.

Perceives sensations of pain, temperature, pressure and touch, knowledge of muscular movement and the position of joints (proprioception).

2. The Auditory (hearing) Area.

Lies immediately below the lateral sulcus within the temporal lobe. It is involved in hearing.

3. The Olfactory (Smell) Area

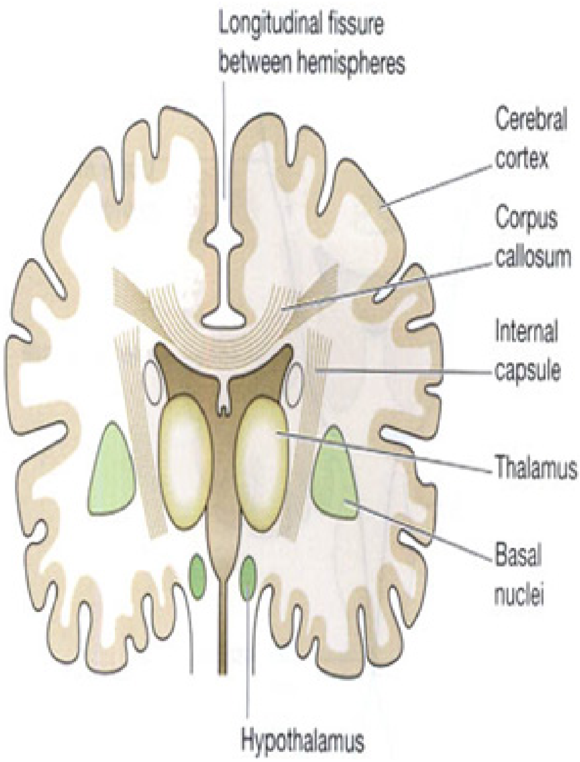
Lies deep within the temporal lobe and is involved with smell.

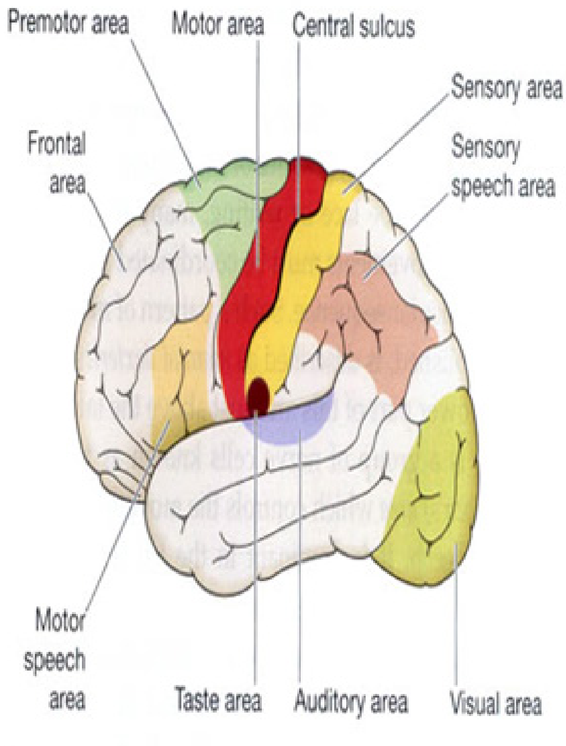
4. The Taste Area

Lies just above the lateral sulcus in the deep layers of the sensory area. Involved with taste.

5. The Visual Area

Lies behind the parieto-occipital sulcus and includes the greater part of the occipital lobe. Involved with vision.





C) Association Areas

These are areas that connected to other functional areas of the cortex and their main function is to receive, coordinate and interpret impulses from the sensory and motor areas thus permitting higher cognitive/thinking abilities.

1. The Prefrontal Area

Lies in the frontal lobe immediately anterior to the motor area. The cells exert a controlling influence over the motor area, ensuring an orderly series of movements.

2. The Frontal Area

It forms the rest of the frontal lobe. It is responsible for:

- The behavior,
- Character
- Emotional state of the individual.

3. The Sensory Speech (Wernicke's) Area

Situated in the lower part of the parietal lobe and extends into the temporal lobe. **Spoken words** are perceived here.

Diencephalon

Deep within the cerebral hemispheres there are groups of cell bodies called nuclei which act as relay stations where impulses are passed from one neurone to the next in a chain.

Important masses of grey matter include:

- Thalamus
- Hypothalamus.

Thalamus: Situated below corpus callosum. Sensory input from the skin, viscera and special sense organs is transmitted to the thalamus before redistribution to the cerebrum.

Hypothalamus: Situated below and in front of the thalamus, immediately above the ***pituitary gland.*** It controls **output of hormones** from the **pituitary gland**

- Hypothalamus also Controls:
- The autonomic nervous system
- Appetite and satiety
- Thirst and water balance
- Body temperature
- Emotional reactions, e.g. pleasure, fear, rage
- Sexual behaviour including mating and child rearing
- Biological clocks or circadian rhythms, e.g. sleeping and waking cycles, body temperature and secretion of some hormones.

Brain Stem

a) Midbrain

Situated around the cerebral aqueduct between the cerebrum above and the pons below.

Consists of nuclei and nerve fibres (tracts) which connect the cerebrum with lower parts of the brain and with the spinal cord.

The nuclei act as relay stations for the ascending and descending nerve fibres.

b) Pons

Situated in front of the cerebellum, below the midbrain and above the medulla oblongata.

Consists mainly of nerve fibres which form a bridge between the two hemispheres of the cerebellum, and of fibres passing between the higher levels of the brain and the spinal cord.

c) Medulla Oblongata

Extends from the pons above and is continuous with the spinal cord below.

Some cells constitute relay stations for sensory nerves passing from the spinal cord to the cerebrum.

The **Vital Centers**, consisting of nuclei associated with autonomic reflex activity, lie in its deeper structure. These are the:

- Cardiac center
- Respiratory center
- Vasomotor center
- Reflex center of vomiting, coughing, sneezing and swallowing.

d) Reticular Formation

A collection of neurones in the core of the brain stem.

Functions

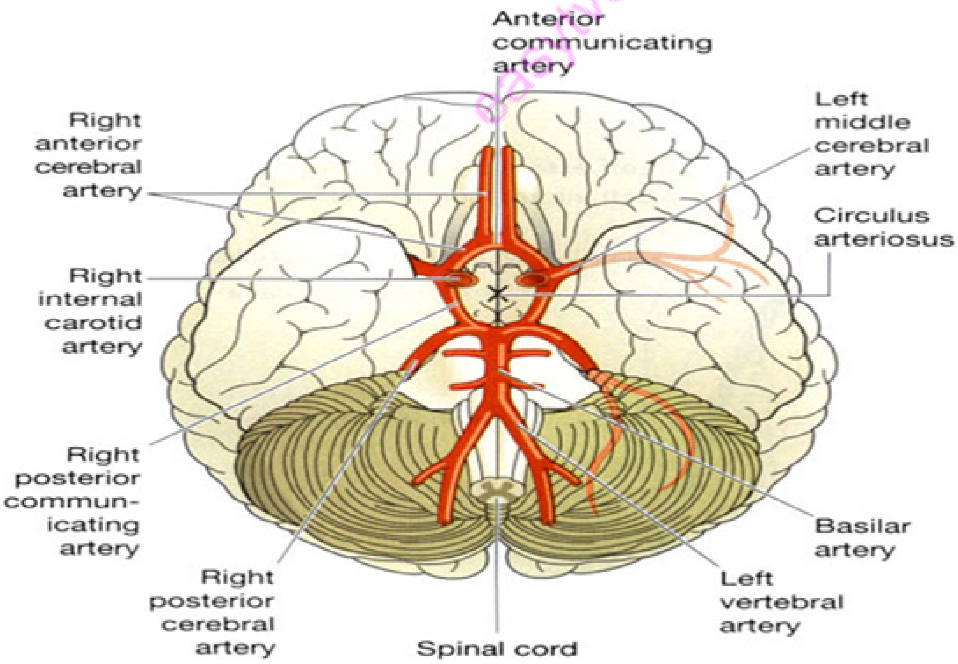
Coordination of skeletal muscle activity associated with voluntary motor movement and the maintenance of balance.

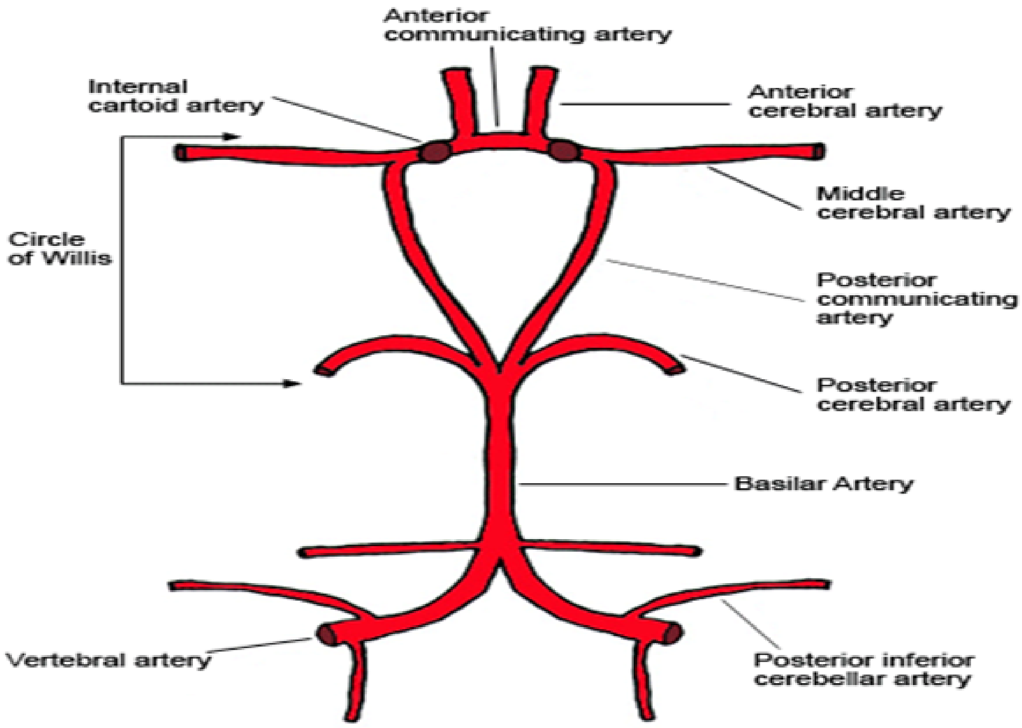
Coordination of activity controlled by the autonomic nervous system, e.g. CVS, Respiration and GIT activity.

Blood Supply to the Brain

By Circle of Willis (Circulus Arteriosus)

Receives about 15% of the cardiac output, approximately 750 ml of blood per minute.



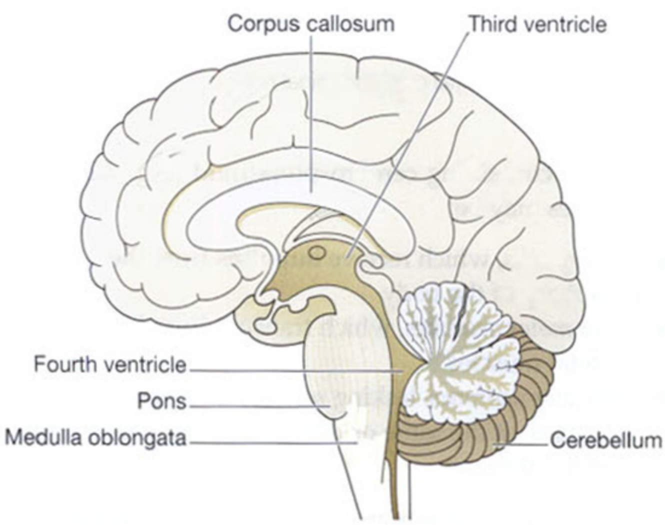


Cerebellum

Situated behind the pons and immediately below the posterior portion of the cerebrum occupying the posterior cranial fossa.

Functions

- Maintenance of balance and posture
- Coordination of voluntary movements
- Motor learning
- Cognitive functions especially language



Cerebellum and associated structures

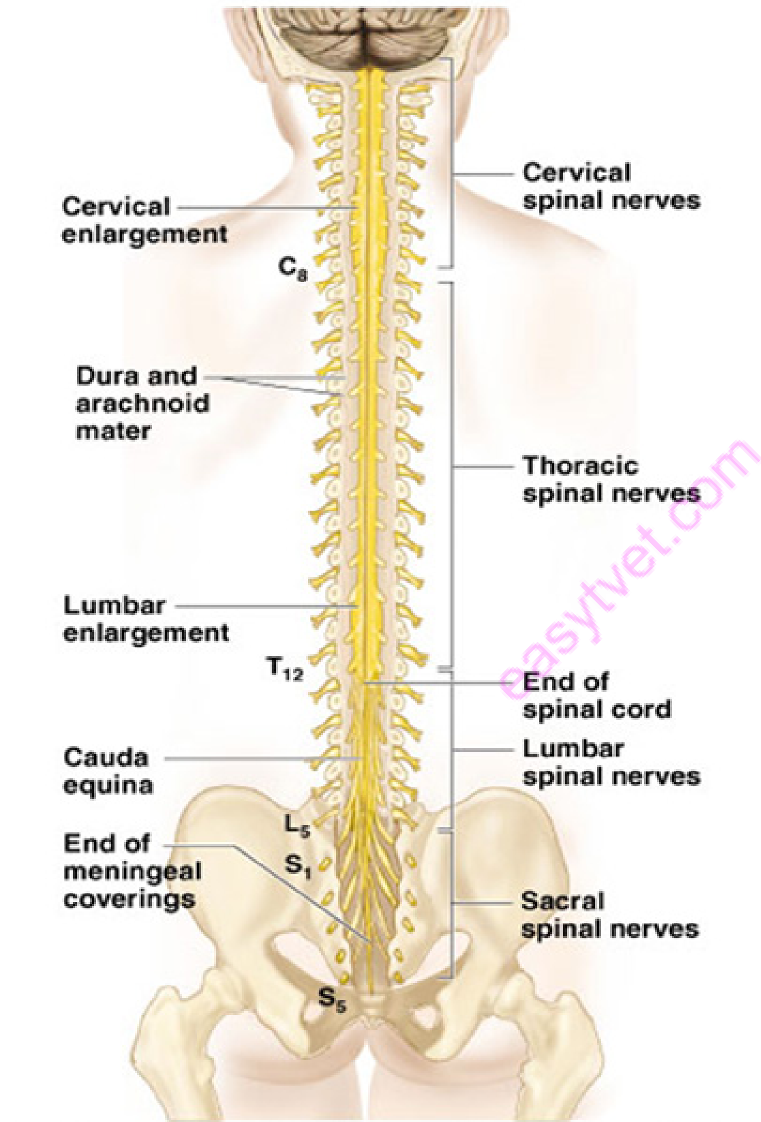
Spinal Cord

A cylindrical cord which is approximately 45cm long. It provides a two ways conduction pathways to and from the brain. It is a major reflex center, and extends from the medulla oblongata (foramen magnum) to the region of T12 or L1.

In humans 31 pairs of spinal nerves arise from it.

Enlargements occur in the cervical and lumbar regions.

Below T12 is the **cauda equina** (a collection of spinal nerves)-horses tail.



Clinical Implication

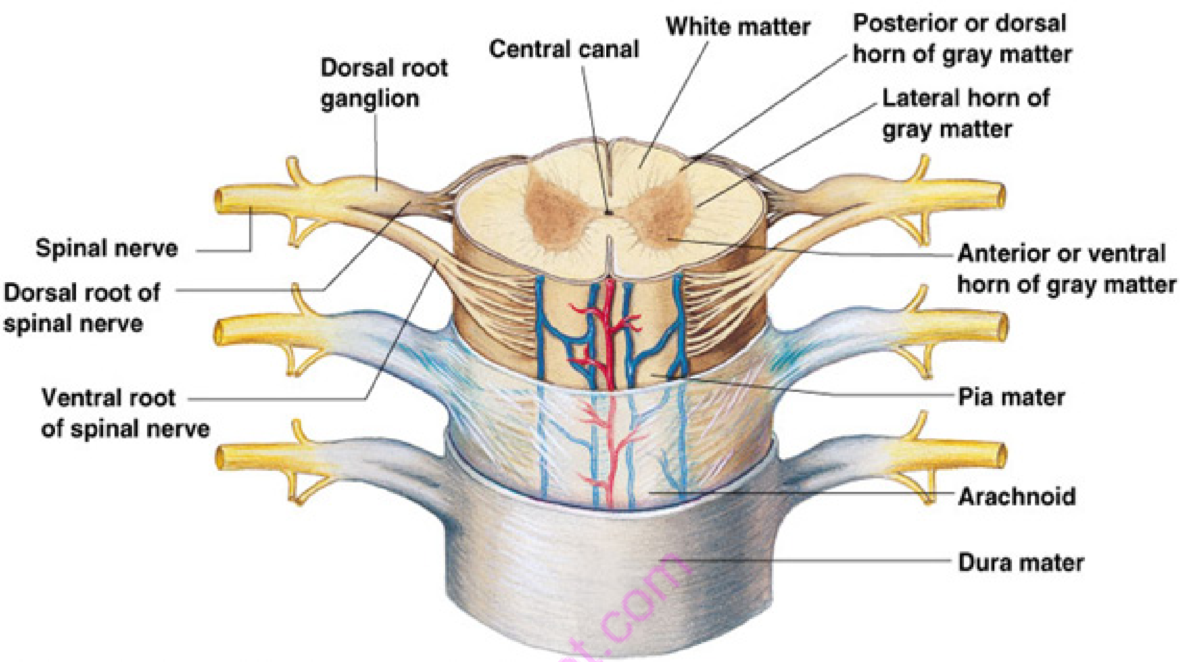
L1-L2 lumbar puncture

For clinical examination of CSF or administration of anesthetics.

Spinal Cord Anatomy

Internal gray matter - mostly cell bodies

- Dorsal (posterior) horns
- Anterior (ventral) horns
- Central canal filled with **cerebrospinal fluid**



Exterior white mater – conduction tracts

Gray matter

Arranged to resemble letter **H**.

The nerve cell bodies may be:

- Sensory neuron---receives impulses from the rest of the body
- Lower motor neurons: transmit impulses to skeletal muscles
- Connector neurons; links sensory and motor neurons to form **spinal reflex arcs.**

White matter

Anterior, lateral and posterior columns or tracts, and are formed by **motor, sensory and connector** fibers.

Tracts are named according to their points of origin and destination. e.g. spinothalamic, corticospinal.

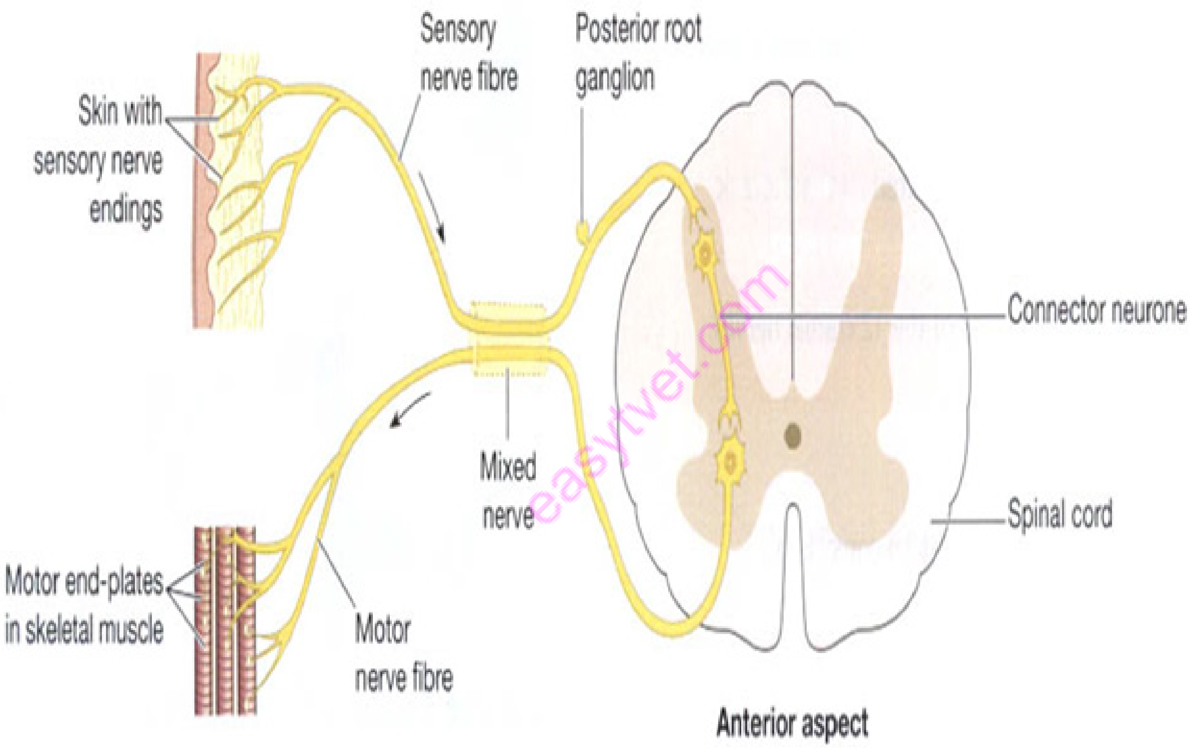
A Reflex Arc

Reflex arc – rapid, predictable, and involuntary responses to stimuli.

Reflex arc – direct route from a sensory neuron, to an interneuron, to an effector

It has 5 Essential Parts:

1. **Receptors** – detect a change (the stimulus) & generate impulses.
2. **Sensory neurons** – transmit impulses from receptors to the CNS.
3. **Central nervous system** – contains one or more synapses.
4. **Motor neurons** – transmit impulses from the CNS to the effector.
5. **Effector** – performs its characteristic action E.g. muscle contraction.



A simple reflex arc

Peripheral Nervous System

Consists of:
- 31 pairs of spinal nerves
- 12 pairs of cranial nerves
- Autonomic nervous system.

Most of PNS nerves are mixed nerves.

Spinal Nerves

Named and grouped according to the vertebrae with which they are associated.

- 8 cervical
- 12 thoracic
- 5 lumbar
- 5 sacral
- 1 coccygeal

Cranial Nerves

Def: 12 pairs of nerves originating from nuclei in the inferior surface of the brain, some sensory, some motor and some mixed. They are:

I. Olfactory
II. Optic
III. Oculomotor
IV. Trochlear
V. Trigeminal
VI. Abducent
VII. Facial
VIII. Vestibulocochlear (auditory)
IX. Glossopharyngeal
X. Vagus
XL. Accessory
XII. Hypoglossal

Name	Function	
Motor Cranial nerves	Sensory cranial nerves	Mixed cranial nerves
III -Oculomotor IV -Trochlear VI -Abducent XI -Accessory XII -Hypoglossal	I --Olfactory II --Optic VIII --Auditory	V -Trigeminal VII -Facial IX -Glossopharyngeal X -Vagus

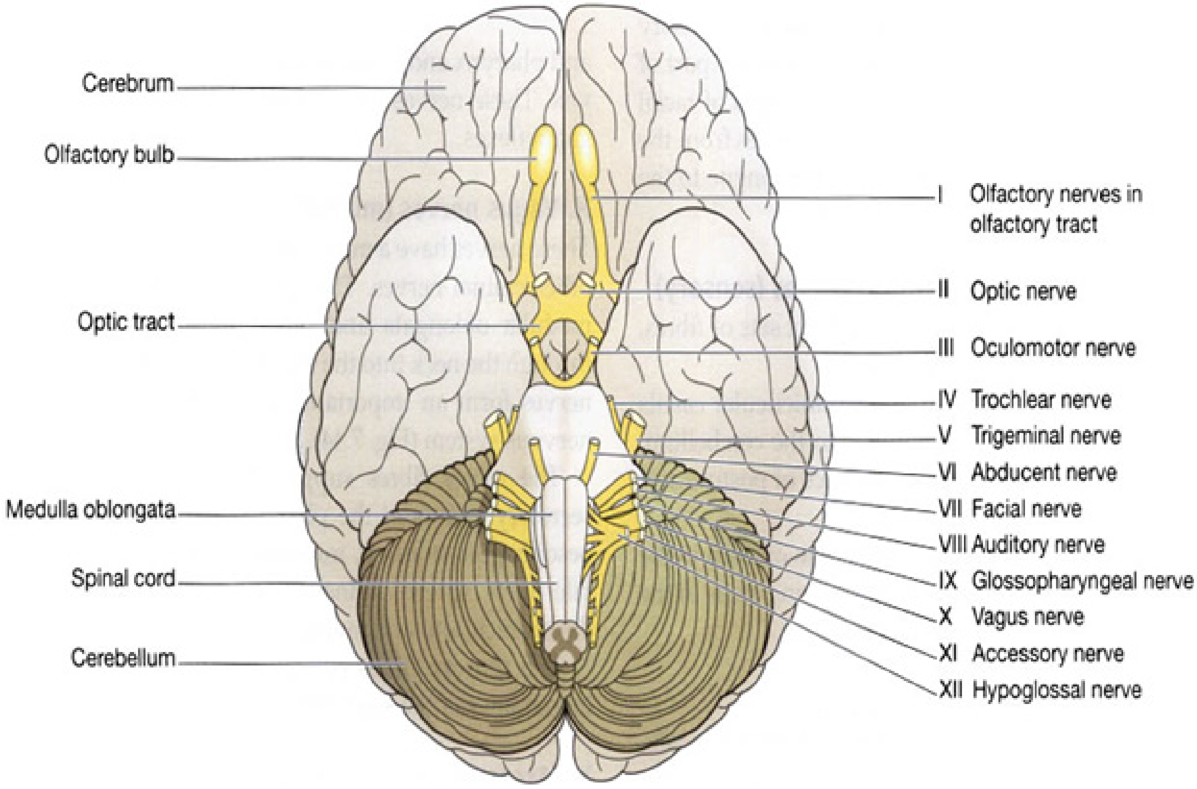
Functional Types

Cranial Nerves and Associated structures

Autonomic Nervous System

This is the involuntary branch of the nervous system. It consists of only motor nerves, and is divided into two divisions

- Sympathetic division
- Parasympathetic division



Anatomy of the Sympathetic Division

Originates from T1 through L2.

Norepinephrine and epinephrine are neurotransmitters to the effector organs

Anatomy of the Parasympathetic Division.

Cranial Nerves and Associated structures

Autonomic Nervous System

This is the **involuntary branch** of the nervous system, and consists of only **motor nerves**. It is divided into two divisions:

- Sympathetic division
- Parasympathetic division

Anatomy of the Sympathetic Division

Originates from T_1 through L^2

Norepinephrine and epinephrine are neurotransmitters to the effector organs

Anatomy of the Parasympathetic Division

Originates from the brain stem and S_1 through S_4

Always uses **acetylcholine** as a neurotransmitter.

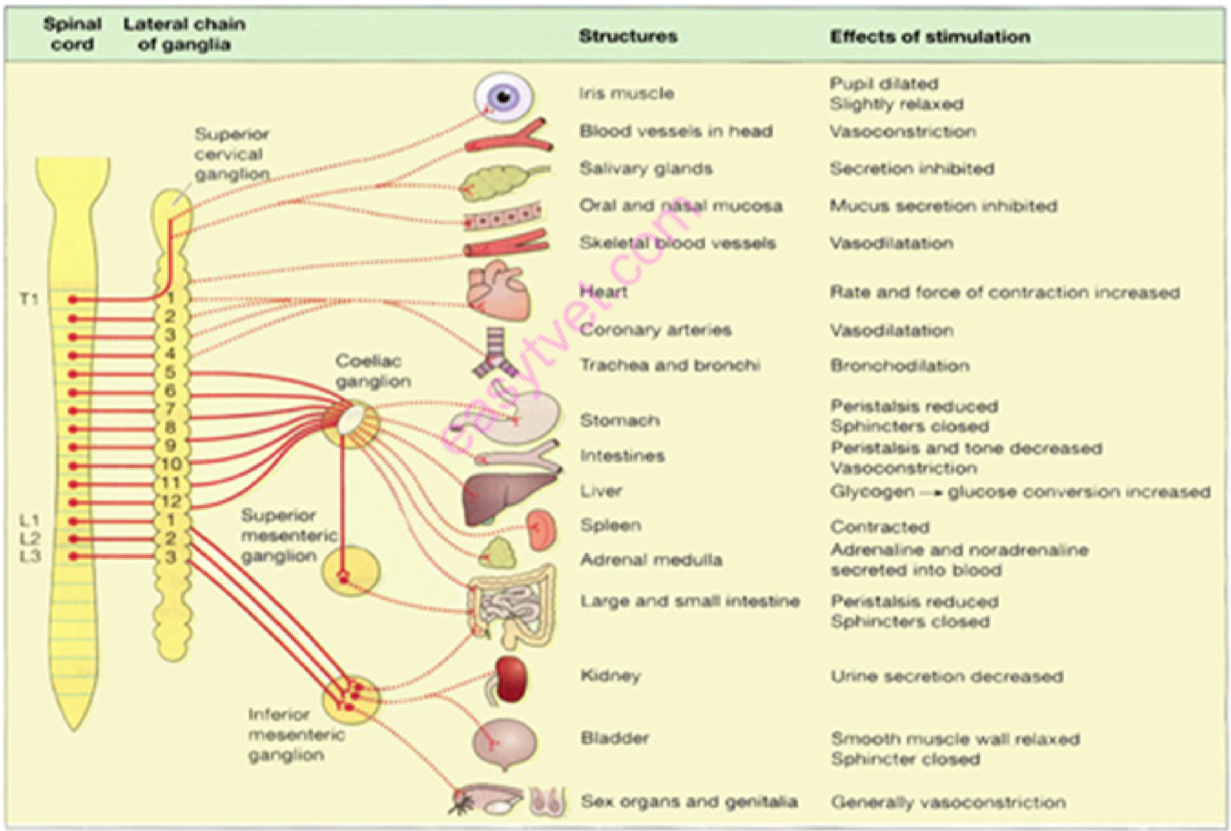
Autonomic Functioning

Sympathetic – "fight-or-flight"

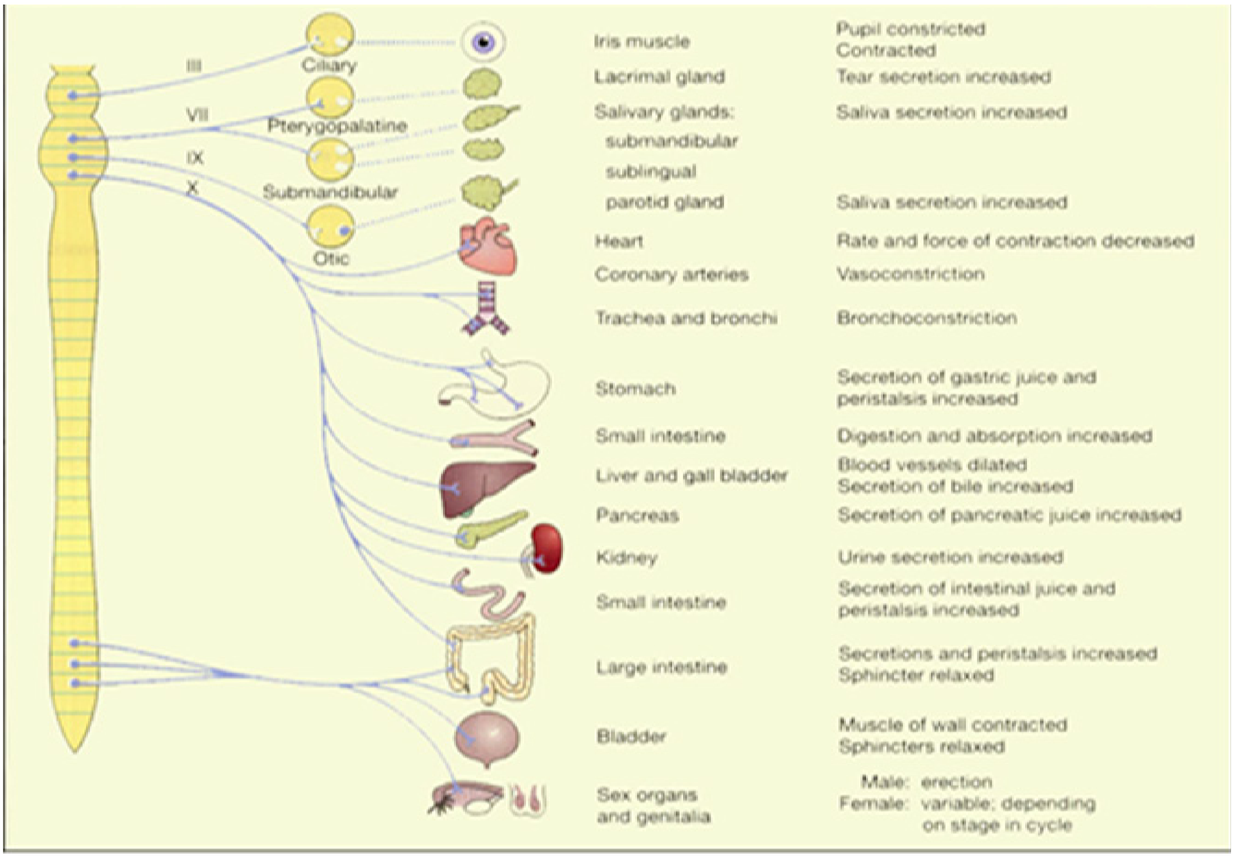
- Response to unusual stimulus
- Takes over to increase activities
- Remembered as the "E" division = exercise, excitement, emergency, and embarrassment

Parasympathetic – housekeeping activities

- Conserves energy
- Maintains daily necessary body functions
- Remembered as the "**D**" division - digestion, defecation, and diuresis



Sympathetic outflow; Solid red lines - preganglionic fibres; broken lines - postganglionic fibres.



Parasympathetic outflow; Solid blue lines-preganglionic fibres;broken lines-postganglionic fibres

THE CARDIOVASCULAR SYSTEM

Functions of the Circulatory System

- Brings blood containing oxygen, nutrients, and hormones to cells
- Transports CO2 and other wastes away from cells
- Fights infection
- Regulates body temperature
- Helps stabilize pH and ionic concentration of body fluids.

Components

- Heart
- Blood
- Vessels - Arteries | Veins | Capillaries

Paths of Circulation

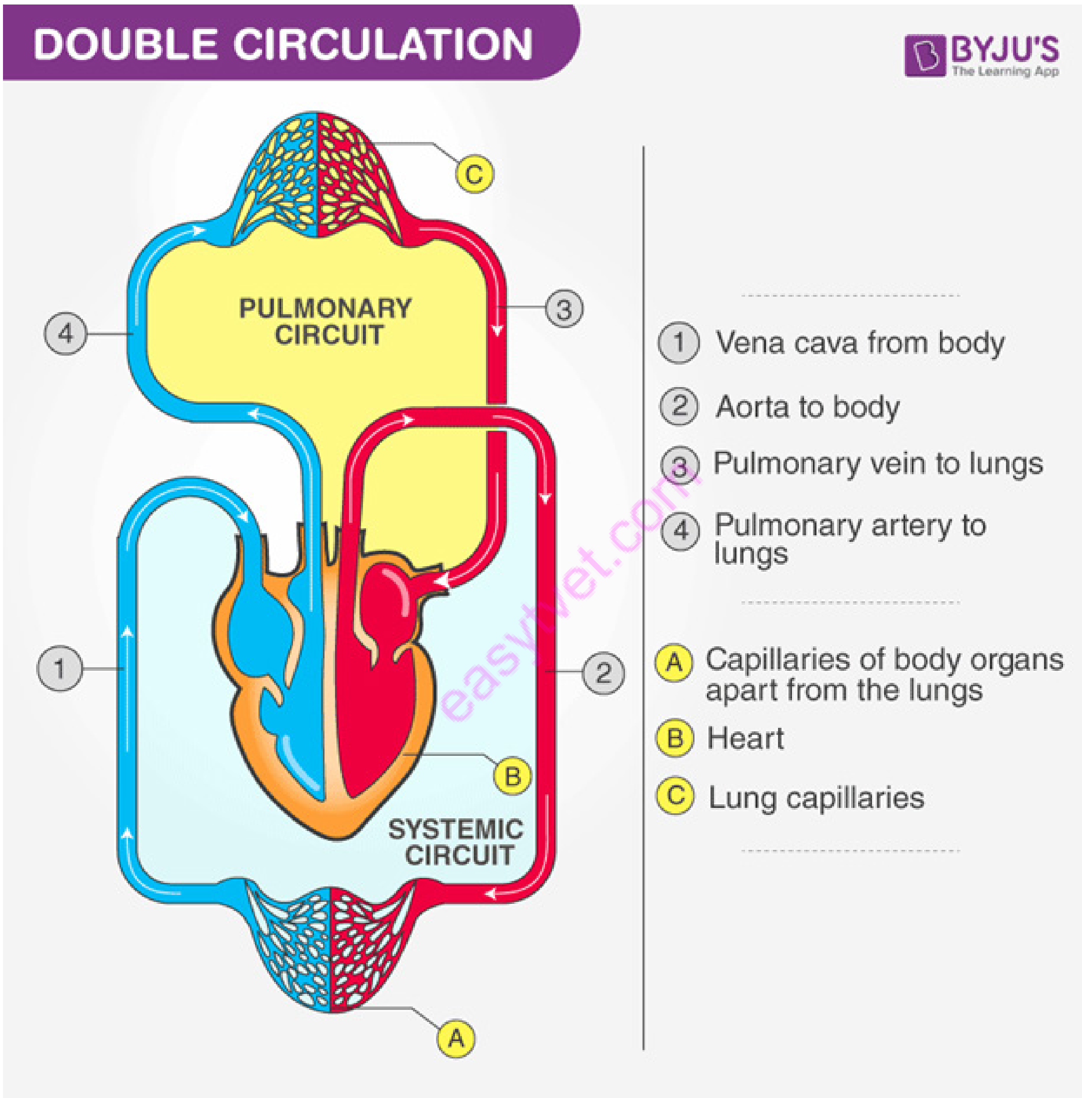
The body’s blood vessels can be divided into a pulmonary circuit, including vessels carrying blood to the lungs and back, and a systemic circuit made up of vessels carrying blood from the heart to the rest of the body and back.

1. Pulmonary Circuit

The pulmonary circuit is made up of vessels that convey blood from the right ventricle to the pulmonary arteries to the lungs, alveolar capillaries, and pulmonary veins leading from the lungs to the left atrium.

2. Systemic Circuit

The systemic circuit includes the aorta and its branches leading to all body tissues as well as the system of veins returning blood to the right atrium.



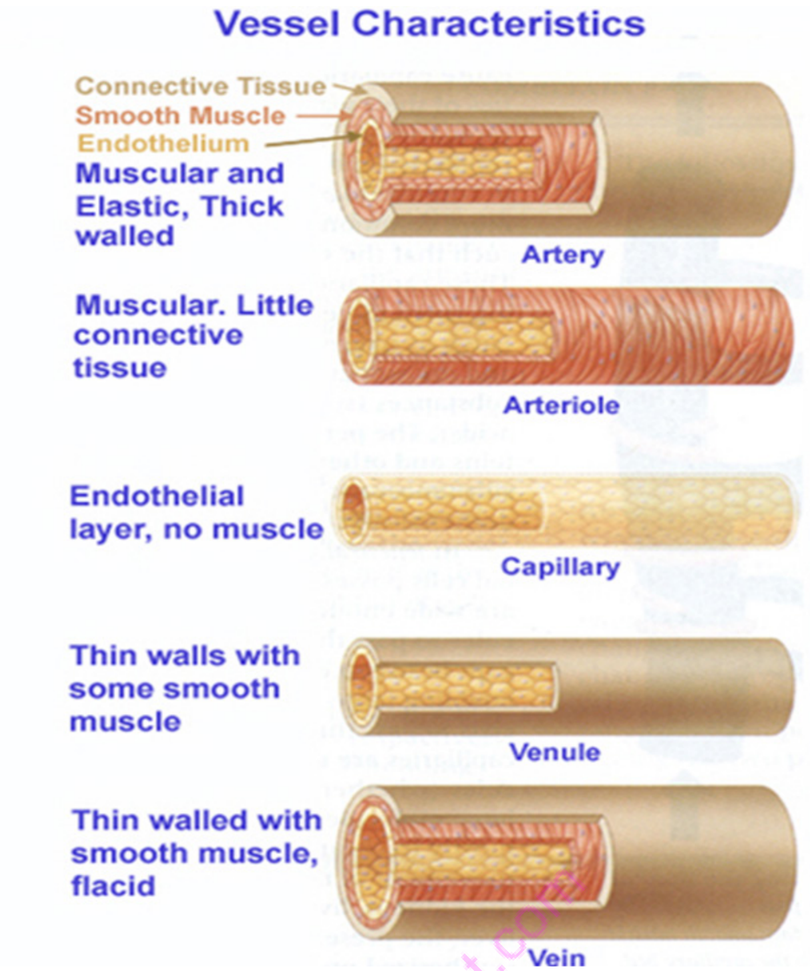
Blood Vessels

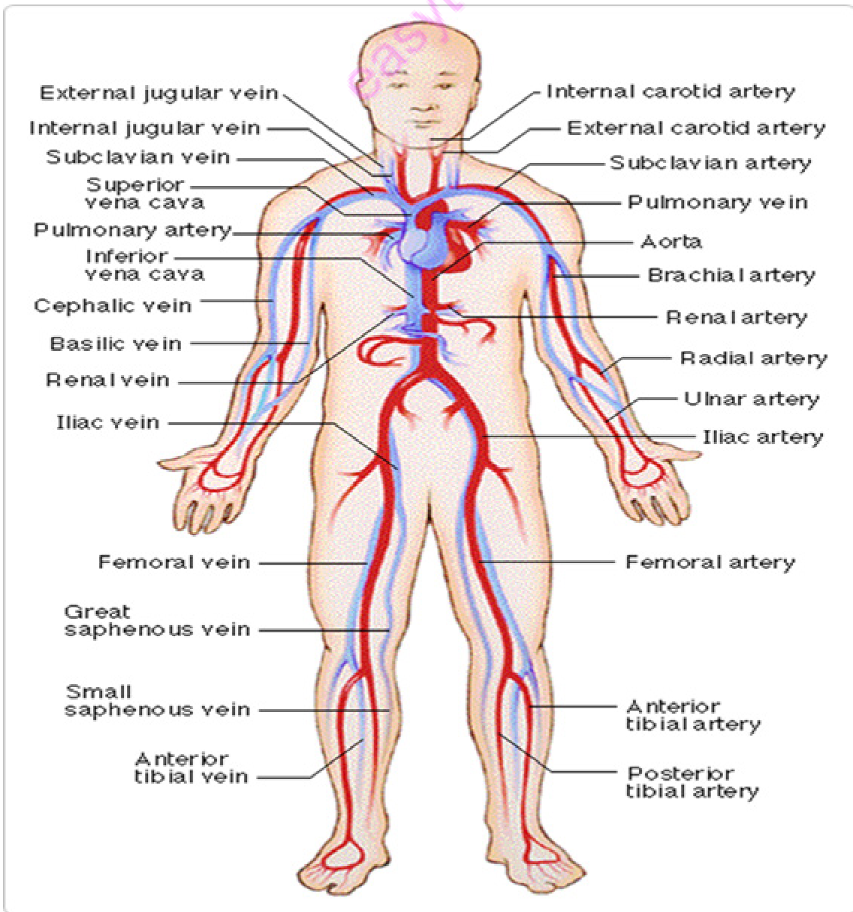
Form a closed circuit of tubes that carry blood throughout the body.

Laid end to end, the blood vessels in an average human body will stretch approximately 62,000 miles, 2.5 times around the earth

They have characteristic features:

Are distinguished by size, tissue layers and direction of blood flow.


Vessel Characteristics
Connective Tissue
Smooth Muscle
Endothelium
Muscular and Elastic, Thick walled
Artery
Muscular. Little connective tissue
Arteriole
Endothelial layer, no muscle
Capillary
Thin walls with some smooth muscle
Venule
Thin walled with smooth muscle, flacid
Vein


External jugular vein
Internal jugular vein
Subclavian vein
Superior vena cava
Pulmonary artery
Inferior vena cava
Cephalic vein
Basilic vein
Renal vein
Iliac vein
Femoral vein
Great saphenous vein
Small saphenous vein
Anterior tibial vein
Internal carotid artery
External carotid artery
Subclavian artery
Pulmonary vein
Aorta
Brachial artery
Renal artery
Radial artery
Ulnar artery
Iliac artery
Femoral artery
Anterior tibial artery
Posterior tibial artery

Arteries

- Receive blood from ventricles
- Usually carry oxygenated blood
- Withstand greater blood pressure
- Connect to capillaries
- Take blood away from the heart
- Thickest vessel walls
- Are very elastic
- Aorta is the largest artery

They have 3 basic layers or tunics.

The **tunica interna** is a.k.a. the tunica intima. It lines the lumen and consists primarily of a simple squamous epithelium underlain by loose connective tissue. This helps provide a smooth surface ideal for fluid flow.

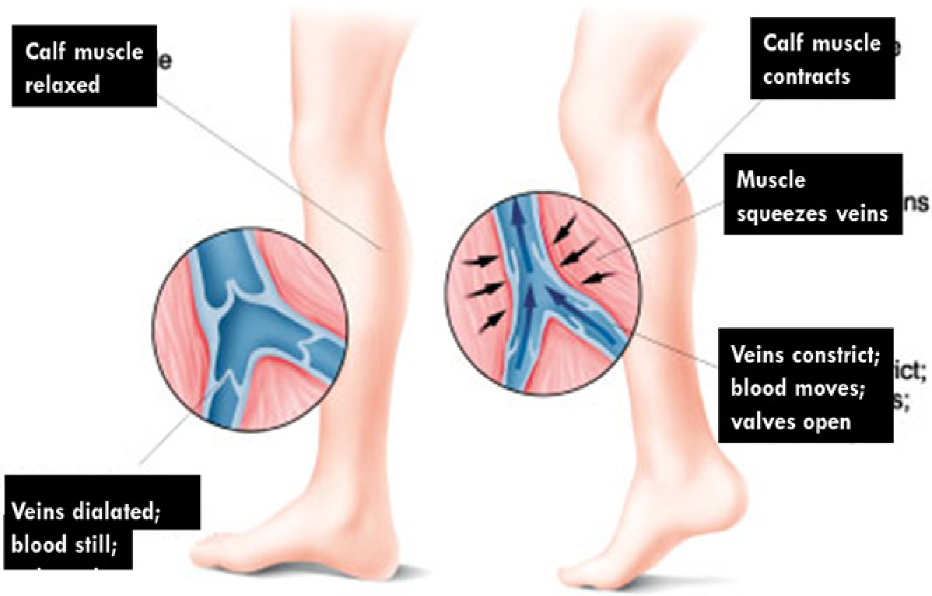
The **tunica media** consists of circularly arranged smooth muscle cells and sheets of the protein elastin.

Tunica externa is a.k.a. **tunica adventitia**. It consists of mostly collagen fibers that protect, reinforce, and support the vessel. It is the most prominent layer in veins.

Veins

- Transport blood away from capillaries
- Take blood to atria
- Thinner vessel walls with less smooth muscles than arteries
- Have larger diameters
- Vena cava is the largest vein
- Carry blood toward heart
- Have valves
- Can stretch a great deal
- Usually carry de-oxygenated blood

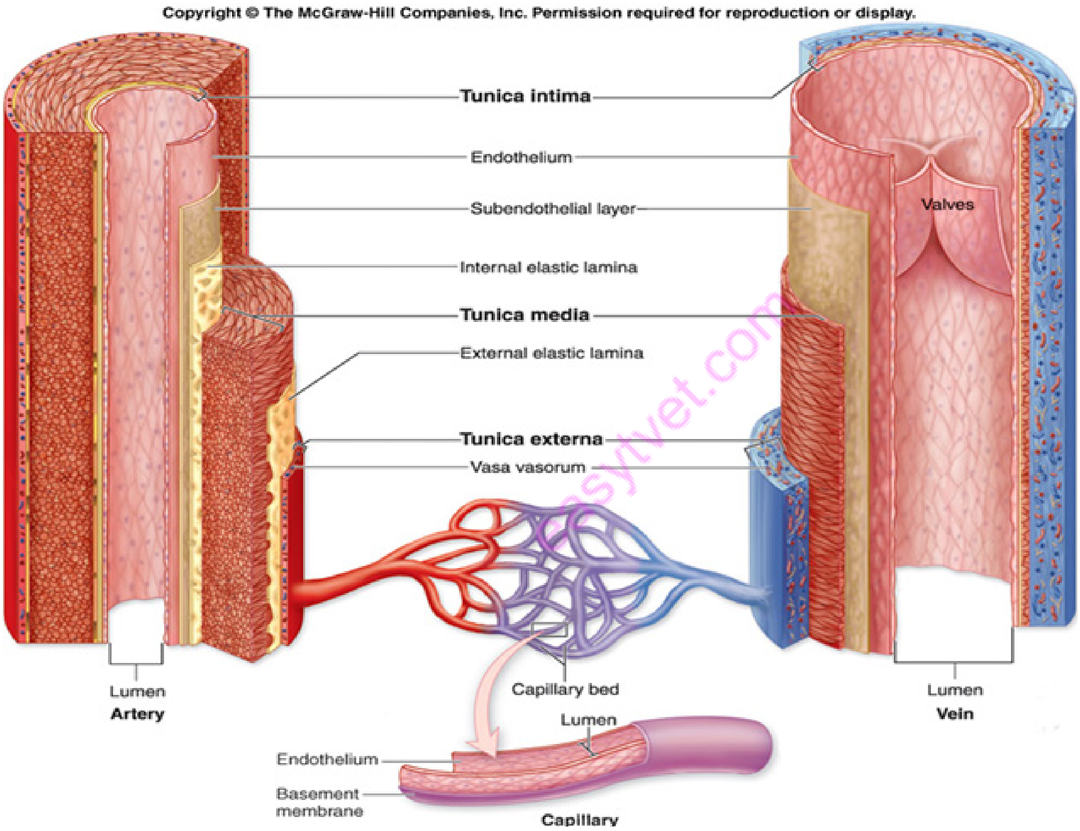
The contraction of muscles compressing veins helps push blood up through the leg veins back to the heart. The valves allow the blood to flow towards the heart only.



The walls of veins are thin and their lumens are large. They have very low resistance and are extremely compliant.

Capillaries

- Smallest of blood vessels
- Only one cell thick (epithelial cell)
- Connect arteries to veins
- Bring oxygen and nutrients to cells
- Removes CO2, urea, and other wastes from cells where blood is under low pressure and moving slowly.



Comparison of blood vessels

Control of Blood Vessel Diameter

Supplied by the ANS except the capillaries. They arise from the vasomotor centre in the medulla.

Alters the size of the lumen of the blood vessel, especially the small arteries & arterioles.

Vasodilatation and Vasoconstriction

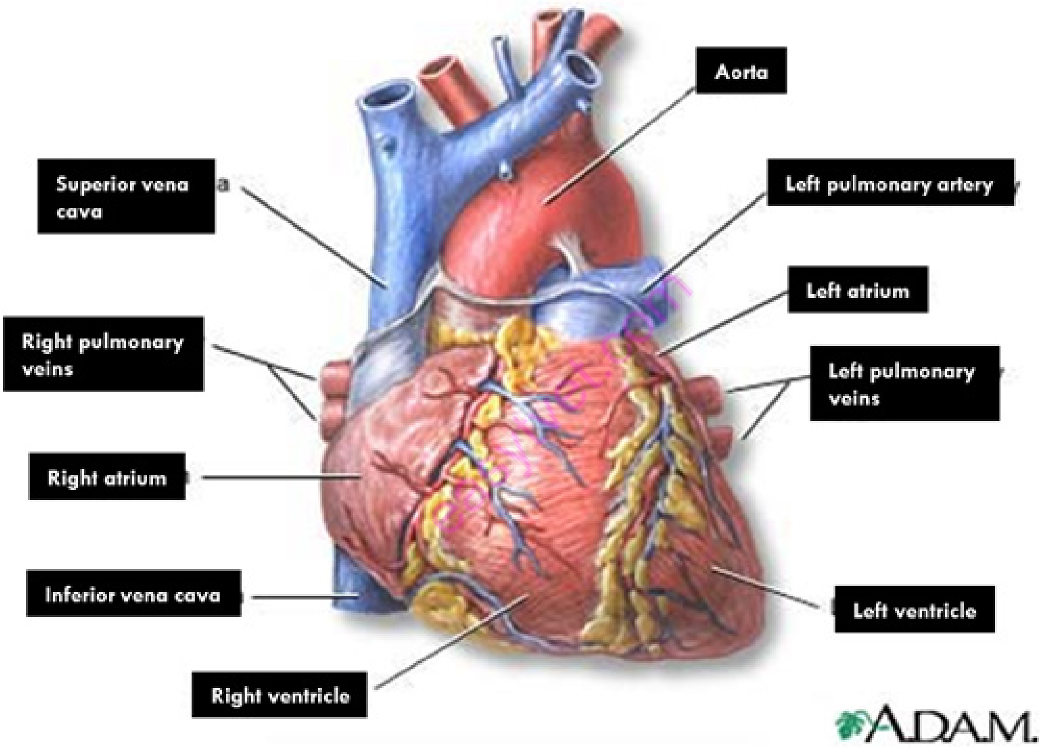
SNS supply the smooth muscles in the tunica media. ↓ in nerve stimulation relaxes the muscles enlarging the lumen i.e. vasodilatation with increased blood flow.

↑ nervous stimulation contracts the smooth muscles & decrease the lumen size thus Vasoconstriction and reduced blood flow.

These two aspects will determine peripheral resistance and systemic blood pressure.

The Heart

- A muscular pump, that moves blood through the body.
- It is suspended in the pericardial sac
- Cone shaped hollow muscular organ.
- 10cm long, the size of a fist
- About 225g in women.



The heart is located within the mediastinum, the medial cavity of the thorax.

Its apex rests on the superior surface of the diaphragm and points toward the left hip. Its base points toward the right shoulder.

The heart is medial to the lungs, anterior to the esophagus and vertebra column, and posterior to the sternum.

Relations:

Inferioly: apex rests on the central tendon of the diaphragm

Superiorly: the great blood vessels; aorta, sup.venacava, pul.artery & pul.vein.

Posterioly: esophagus, trachea, L & R bronchus, desc. Aorta, inf. venacava, thoracic vertebrae.

Laterally: the lungs; the left lung overlaps the left side of the heart

Anteriorly: sternum, ribs & intercostal muscles

Heart: Structure

1. Pericardium

A double-walled sac. The most superficial layer is the **fibrous pericardium** – a collagenous structure that protects and anchors the heart and prevents it from over distending.

Deeper is the **serous pericardium**, a 2 layered serous membrane. The **parietal pericardium** is the outer of the 2 and borders the fibrous pericardium.

The visceral pericardium is the inner of the 2 and is the external covering of the heart. It is also known as the epicardium.

The pericardial cavity is the space between the parietal and visceral layers. It contains serous fluid, which reduces friction between them when the heart beats.

2. Myocardium

It is the middle, and the muscle layer of the heart. It is strong and thick, and is composed of spontaneously contracting cardiac muscle fibers.

It can conduct electric impulses like nerves. It's blood supply comes from the coronary arteries.

The muscle fibers has cross stripes as skeletal muscles. Each fiber has a nucleus and one or more branches.

The ends of the cells or branches are in close contact with the adjacent cells with joints (intercalated discs) seen microscopically as thicker, darker lines than ordinary cross stripes thus appears as a sheet of muscle.

Because of this arrangement an impulse generated spreads from cell to cell via branches and intercalated discs over the whole muscle causing contraction.

Is thickest at the apex because of the pumping action of the ventricles.

The atrio-venticular septum separates the atria and ventricles

Electrical activity is conducted through a series of conducting system from the atria to the ventricles.

3. Endocardium

Consists of endothelium (simple squamous epithelium) resting on a layer of thin connective tissue. It lines the heart chambers and its folds create the heart valves.

Interior of the Heart

Chambers

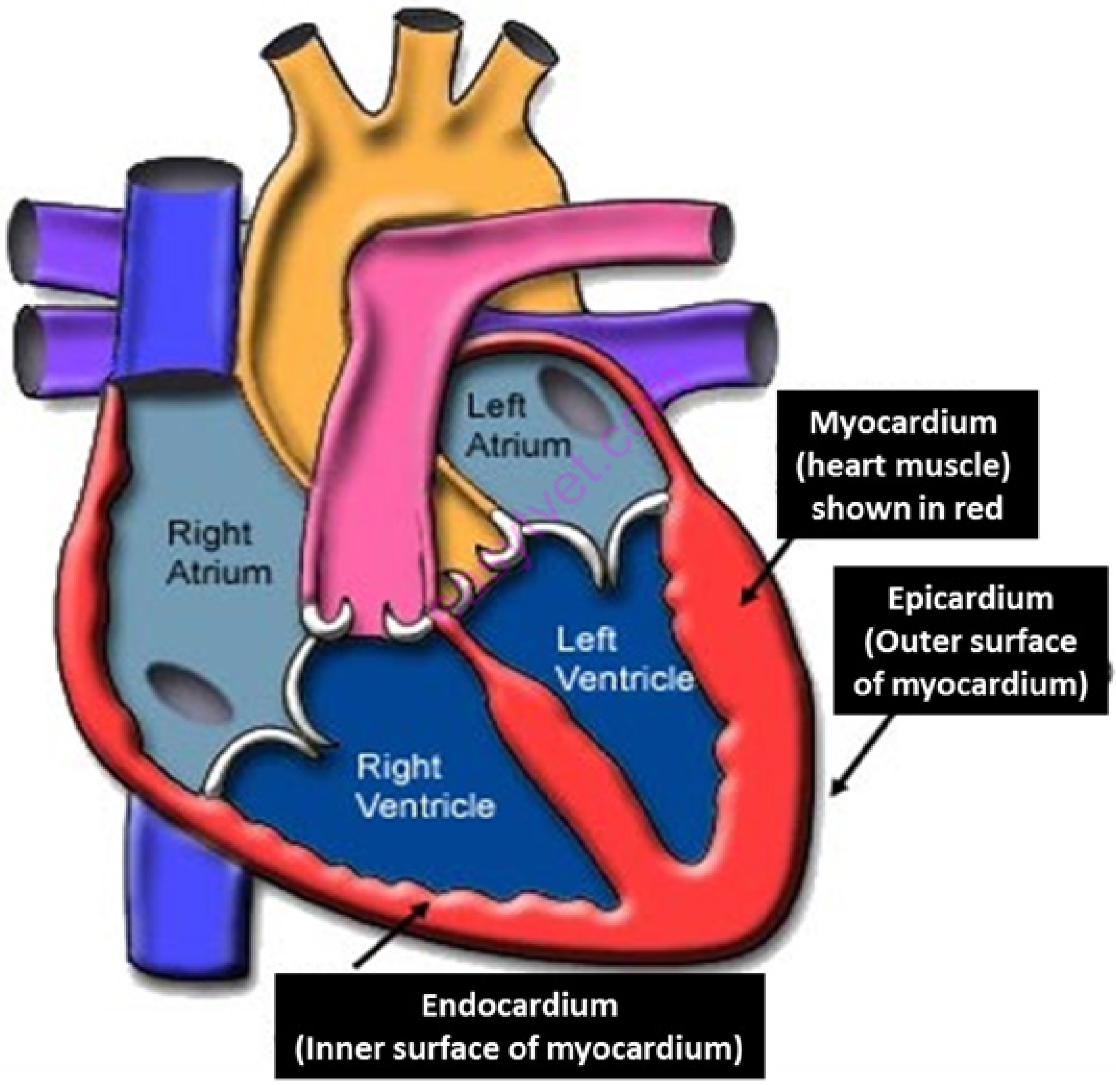
Atria- (2) upper chambers

- Thin walled
- Receive blood from veins
- Send blood to ventricles

Ventricles - (2) lower chambers

- Thick walled
- Receive blood from atria
- Pump blood out through arteries

Septum-Wall that divides heart into right and left halves.



Ventricles

These are large, muscular chambers. Thick musculature is necessary because they are the actual pumps.

They contain muscular ridges known as trabeculae carneae as well as muscular bulges known as papillary muscles.

The right ventricle discharges blood into the pulmonary trunk, the first vessel of the pulmonary circuit. The pulmonary semilunar valve separates the right ventricle and the pulmonary trunk.

The left ventricle discharges blood into the aorta, the first vessel of the systemic circuit. The aortic semilunar valve separates the LV and aortic trunk.

The left ventricle is larger (more muscular) than the right. More muscle is necessary because the left ventricle pumps blood a farther distance and against greater pressure (note – the right and left ventricle pump the same volume of blood per beat).

Atria

They are the heart's receiving chambers. They are small and thinly muscled.

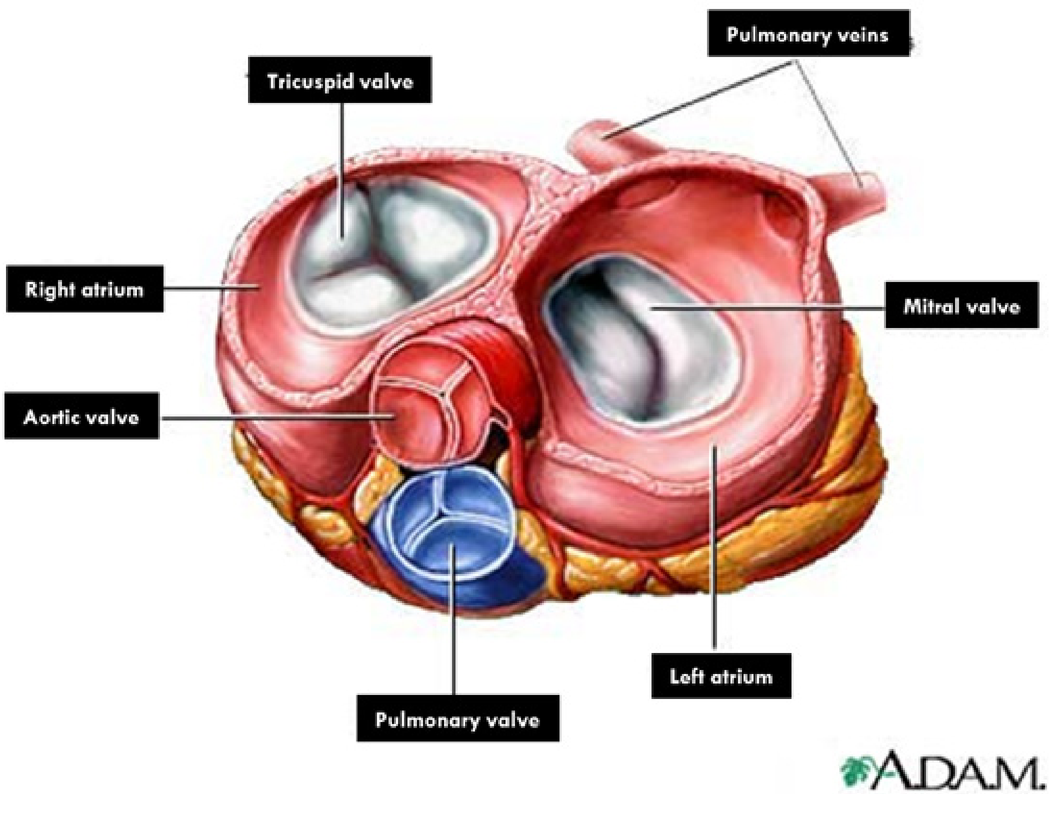
The right atrium receives blood from the systemic circuit via 3 vessels: (1) Superior vena cava carries low O_2/high CO_2 blood from arms, head, and upper torso; (2) Inferior vena cava carries low O_2/high CO_2 blood from the legs, abdomen, and pelvis; (3) Coronary sinus carries low O_2/high CO_2 blood from the coronary circulation – which nourishes the heart wall.

The right atrium passes blood to the right ventricle thru the tricuspid orifice, which is associated with the **tricuspid valve.**

Left atrium receives high O_2/low CO_2 blood from the pulmonary circuit via the 4 pulmonary veins. It passes blood to the left ventricle via the mitral (or bicuspid) orifice, which is associated with the **mitral (or bicuspid) valve.**

Valves

They prevent backflow of blood, and keep blood moving in one direction. They are situated between the chambers, at junctions of artery and chamber.



Heart Valves

Atrioventricular valves - between atria and ventricles (flaps = cusps)

Tricuspid valve: right side, 3 cusps

Bicuspid/Mitral valve: left side, 2 cusps

Cusps attached to chordae tendineae from papillary muscles on ventricle wall -contraction of papillary muscles prevent cusps opening backward during ventricle contraction.

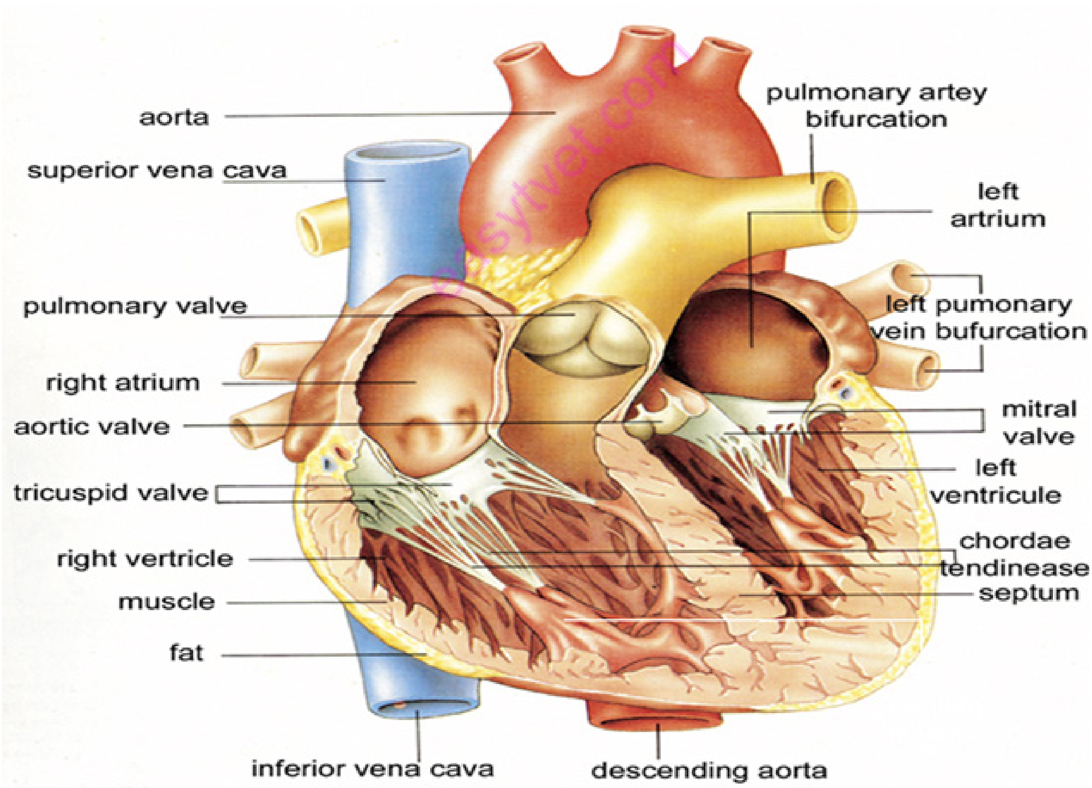
Cusps hang loose when ventricles not contracting, allow ventricles to fill with blood.

Structure of the Heart

Chordae tendineae

- Also known as "Heart strings"
- Cord-like tendons that connect papillary muscles to tricuspid and mitral valves
- Prevent inversion of valve

Papillary muscles – Small muscles that anchor the cords



Flow of blood through the heart

- Blood low in oxygen returns to the right atrium via the venae cavae and coronary sinus.
- The right atrium contracts, forcing blood through the tricuspid valve into the right ventricle.

- The right ventricle contracts, closing the tricuspid valve, and forcing blood through the pulmonary valve into the pulmonary trunk and arteries
- The pulmonary arteries carry blood to the lungs where it can rid itself of excess carbon dioxide and pick up a new supply of oxygen.
- Freshly oxygenated blood is returned to the left atrium of the heart through the pulmonary veins.
- The left atrium contracts, forcing blood through the left bicuspid valve into the left ventricle.
- The left ventricle contracts, closing the bicuspid valve and forcing open the aortic valve as blood enters the aorta for distribution to the body.

Blood Supply to the Heart

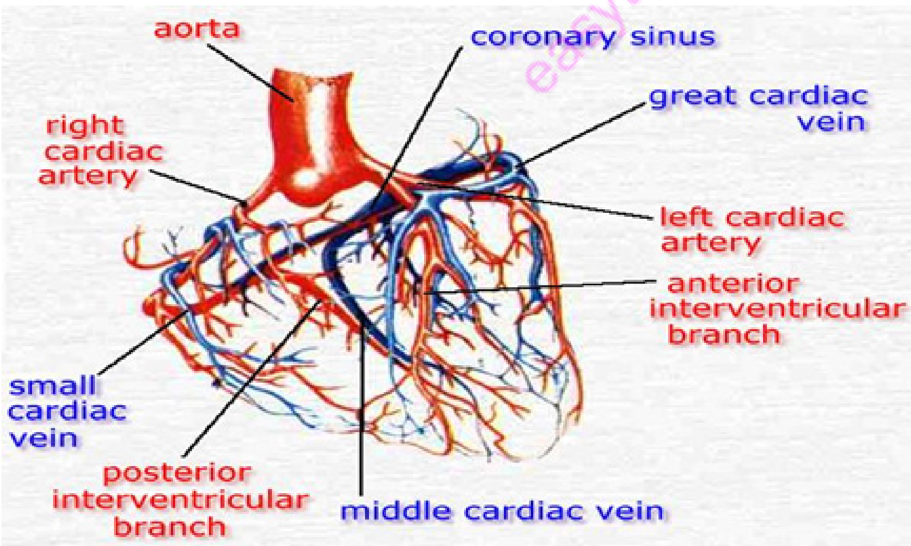
The first branches off the aorta, which carry freshly oxygenated blood, are the right and left coronary arteries that feed the heart muscle itself.

Branches of the coronary arteries feed many capillaries of the myocardium.

The heart muscle requires a continuous supply of freshly oxygenated blood, so smaller branches of arteries often have anastomoses as alternate pathways for blood, should one pathway become blocked.

Cardiac veins drain blood from the heart muscle and carry it to the coronary sinus, which empties into the right atrium.

Coronary Circulation

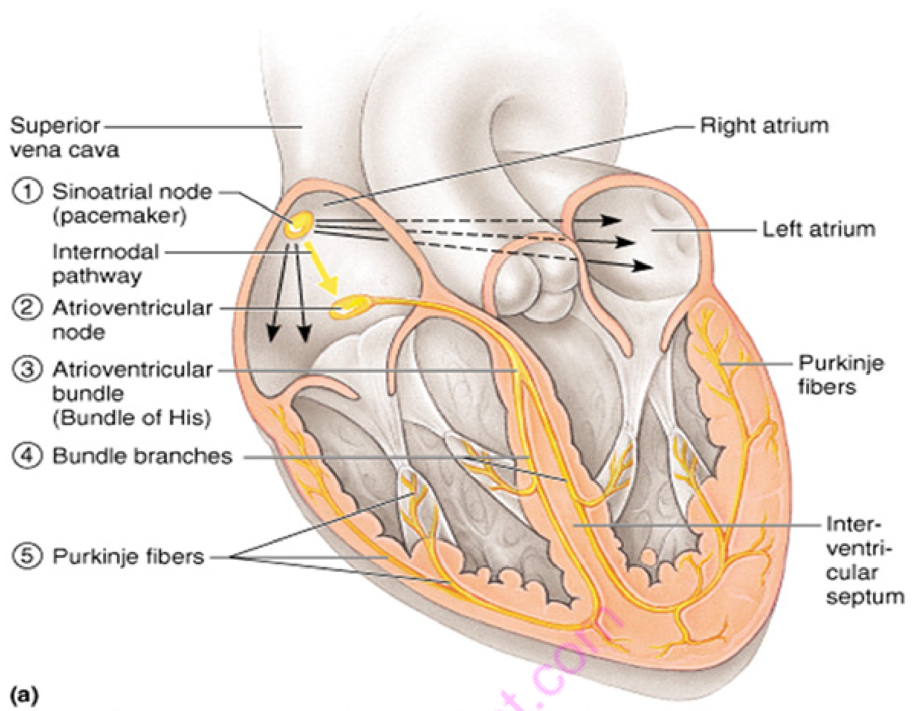


Cardiac Conduction System

Intrinsic control of the heart rate is the province of the auto-rhythmic cells (which have the ability to spontaneously and rhythmically contract without external stimulation). However this system can also be stimulated or depressed by nerve signals, hormones, and other blood-born substances).

There are 4 main groups of autorhythmic cells: Includes:

- SA node
- AV node
- Bundle of His
- Purkinje fibers



Sinoatrial Node (SA node)

It is located high on the right atrium near the opening of the sup venacava. It is the pacemaker of the heart because it initiates impulses rapidly than other neuromuscular cells.

It causes the wave of contractions in the atria, sending blood into the ventricles

1. Atrioventricular Node (AV node)

- Located in the interatrial septum close to the tricuspid valve
- Carries the electrical impulse from the SA node to fiber bundles in the ventricles.
- The electrical signal delays for 0.1s before passing through into the ventricles to allow the atria to finish contracting.
- It also acts as a secondary pacemaker as it takes over the role if there is a problem with the SA node though at a slower firing rate.

2. Atrioventricular bundle (AV bundle or Bundle of HIS)

- Originates from the AV node crosses the fibrous ring separating the atria from ventricle
- Divides at the upper end of ventricular septum into right and left bundle branches.
- The branches breaks up into fine fibres called purkinje fibres within the myocardium.

- These three fibres convey electrical impulse to the apex of the heart where ventricular contraction begins spreading upwards and outwards pumping blood to the pulmonary artery & aorta.

ECG DEFLECTION WAVES

An ECG is a recording of the deflection waves caused by depolarization of the heart.

The P wave indicates depolarization of the atria.

The QRS complex is caused by depolarization of the ventricles.

The T wave represents repolarization of the ventricles.

Nerve Supply to the Heart

ANS (SNS and PNS) originating from the cardiovascular centre in the medulla.

The vagus nerve (PNS) supply the AV and SA nodes and atrial muscles. Stimulation reduces the impulse generation rate↓ the rate & force of heart beat

The SNS supplies the SA and AV nodes and the myocardium of the ventricles. Stimulation ↑ the rate & force of the heart beat.

Cardiac cycle

Refers to all of the events from the beginning of one heart beat to the beginning of the next heart beat.

When cardiac muscle contracts it does so as a single unit, creating a heart beat.

- One heartbeat - a cardiac cycle - consists of two parts called systole and diastole
- Diastole is the period of time when the heart relaxes after contraction
- Oxygenated blood from the lungs fills the left atrium
- Deoxygenated blood from other parts of the body fills the right atrium.
- At the end of the diastole, the atria contract, starting the Systole
- Atrial systole is the contraction of the heart muscle of the left and right atria. Both atria contract at the same time, sending blood into the corresponding ventricle
- Ventricular systole is the contraction of the muscles of the left and right ventricles, which contract at the same time.
- During systole the ventricles contract, forcing the blood into the pulmonary artery to be re-oxygenated in the lungs, and into the aorta for systemic distribution of oxygenated blood.

Heart Sounds

Two normal heart sounds with each heart beat described as:

S1--"Lub"- sound- due to closure of the atrioventricular valves (mitral and tricuspid)

S2---"Dub"- sound- due to closure of the aortic valve and pulmonary valve

S3 and S4 are abnormal heart sounds.

Cardiac Output

Cardiac output is the amount of blood pumped by each ventricle in one minute. Cardiac output can be expressed mathematically as the product of heart rate and stroke volume: CO (mL/min) = HR(beats/min) x SV(mL/beat).

In an adult, SV is approx.70ml and HR 72b/m.

CO is therefore approx. 5l/min. this can be increased during exercise to about 25-30 l/min from the cardiac reserve.

Stroke volume

The amount of blood ejected when ventricles contract is known as the stroke volume.

It is determined by the volume of the blood in the ventricles before they contract. (VEDV) i.e. preload. Preload depends on the venous return.

Increased VEDV leads to stronger myocardial contraction & more blood expelled thus ↑ SV & CO

Stroke volume depends on 3 main variables: preload, contractility, and afterload.

Preload refers to the degree of ventricular stretch during filling. The more heart muscle is stretched (up to a point), the more forceful its contraction.

Contractility is the strength of the heart's contraction independent of its degree of stretch. Factors that increase contractility include: increased cardio acceleratory activity; and hormones such as epinephrine and thyroxine.

Afterload refers to the pressure that must be overcome to open the semilunar valve and eject blood. Afterload is equivalent to arterial blood pressure.

It is determined by distensibility/ elasticity of the large arteries & peripheral resistance of arterioles.

Venous Return

Blood flow through the venous system is only partially the result of heart action and instead also depends on skeletal muscle contraction, breathing movements, and vasoconstriction of veins.

Contractions of skeletal muscle squeeze blood back up veins one valve and a time especially the lower limbs (skeletal muscle pump).

Differences in thoracic and abdominal pressures draw blood back up the veins especially during inspiration.

Body position--gravity assists venous return from the head & neck and offers less resistance to venous return when lying flat.

Heart Rate (HR)

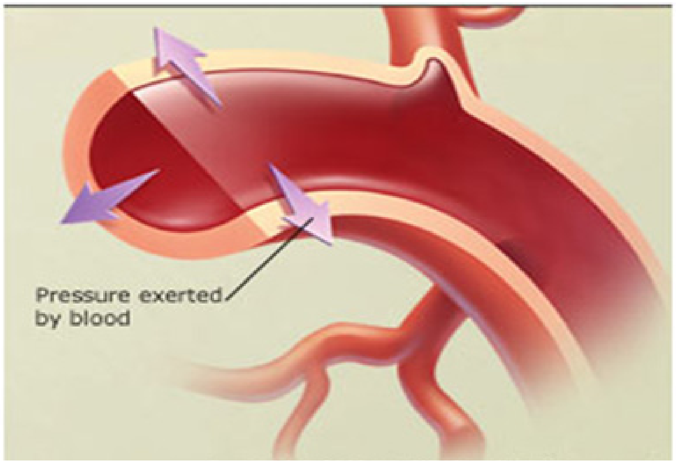
HR is affected by:

- Autonomic nervous input
    1. sympathetic = ↑ HR
    2. parasympathetic = ↓HR
- Hormones: adrenaline & noradrenaline, thyroxine
- Venous return
- More blood return = ↑ HR (stretch receptors activate sympathetic)
- Other factors (ions, drugs), hypoxia ↑, hypercalcemia
- Position: upright position, HR ↑
- Exercise: active exercise ↑ HR
- Emotional states: fear, excitement, anxiety increase HR
- Gender: faster in women
- Age; rapid in babies and small children
- Temperature: rises and falls with temp
- Baroreceptor reflex

Blood Pressure

Blood pressure refers to the force exerted by circulating blood on the walls of blood vessels

The pressure of the circulating blood decreases as blood moves through arteries, arterioles, capillaries, venules, and veins.



Blood pressure is most commonly measured via sphygmomanometer (blood pressure cuff). It uses the height of a column of mercury to reflect the circulating pressure.

Average blood pressure for an adult is 120/80 mmHg

Blood pressure readings = S/D

Pulse

Is a wave of distension and elongation felt in the artery wall due to contraction of the left ventricle. The waves travel along the walls of the arteries and can be felt on any superficial artery pressing against a bone. Is equivalent to the number of beats/min and on average about 60 to 80 at rest.

The pulse gives;

- The heart rate
- Regularity of the heartbeat
- Volume or strength of the beat
- Tension: soft and pliant
- The pulse may be different from the heartbeat because of; narrowing or blockage of an artery; a diseased or failing heart.

Common Pulse Areas

- Carotid – at the neck

- Femoral – groin
- Radial – wrist
- Brachial – arm
- Popliteal – behind the knee
- Posterior tibial artery – ankle joint
- Dorsalis pedis artery – foot

NB: During shock, the most prominent pulse is carotid followed by femoral followed by radial pulse.

Common Disorders Related to Cardiovascular System

- Hypertension
- Heart attack
- Shock
- Varicose veins
- Congenital heart diseases
- Cardiac arrhythmias
- Heart failure
- Stroke
- Coronary artery disease
- Aneurysm
- Myocarditis and pericarditis

THE BLOOD

Blood is a connective tissue. It provides means of communication between the cells of different parts of the body.

Functions of Blood:

It carries:

- Oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs for excretion
- Nutrients from the alimentary tract to the tissues and cell wastes to the excretory organs, principally the kidneys
- Hormones secreted by endocrine glands to their target glands and tissues
- Heat produced in active tissues to other less active tissues
- Protective substances, e.g. antibodies, to areas of infection
- Clotting factors that coagulate blood, minimising its loss from ruptured blood vessels.

Blood makes up about 7% of body weight (about 5.6 litres in a 70 kg man). Proportion is less in women & greater in children, gradually decreasing until the adult level is reached.

Blood in the blood vessels is in continual flow to maintain a fairly constant environment for the body cells. Blood volume and the concentration of its many constituents are kept within narrow limits by homeostatic mechanisms.

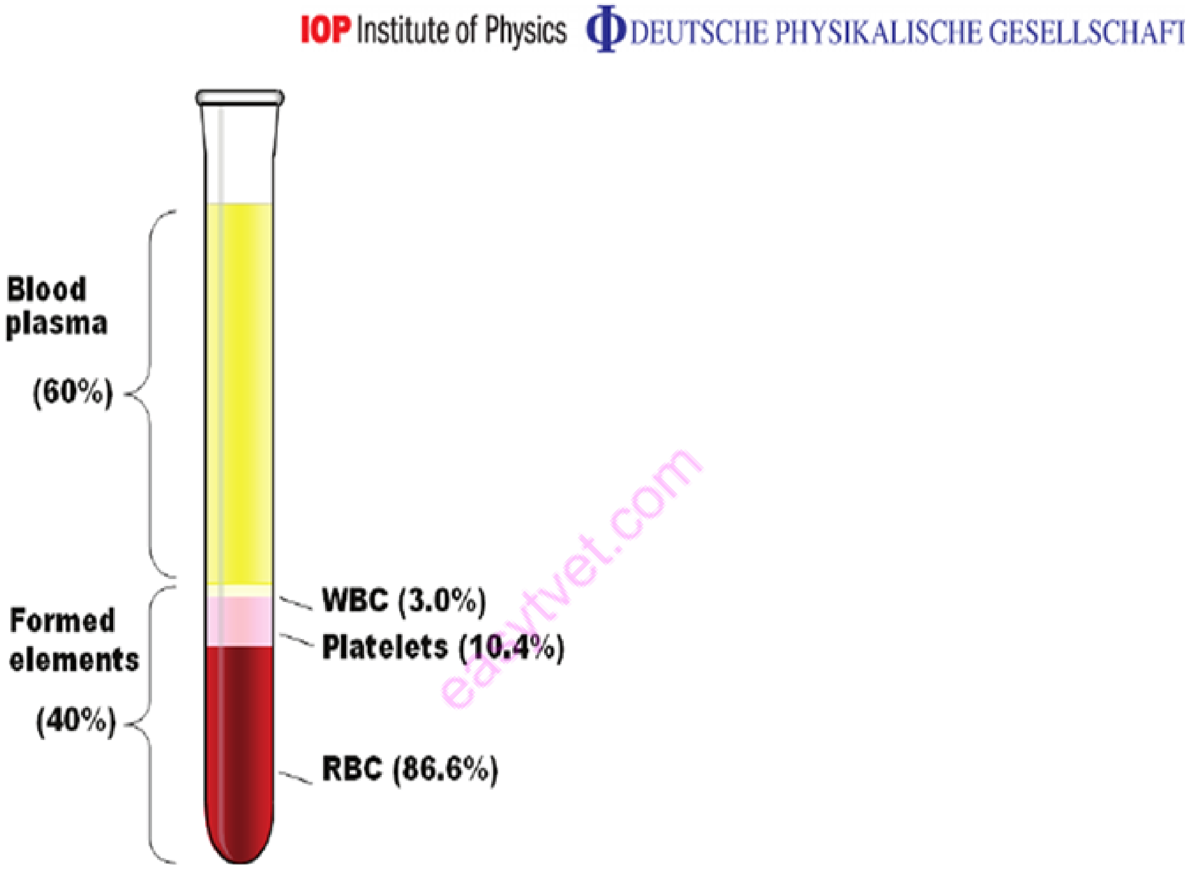
Composition of Blood

Blood makes up about 7% of body weight (about 5.6 litres in a 70 kg man).

Composed of a straw-colored (pale-yellow) transparent fluid, plasma, in which different types of cells are suspended.

Composition

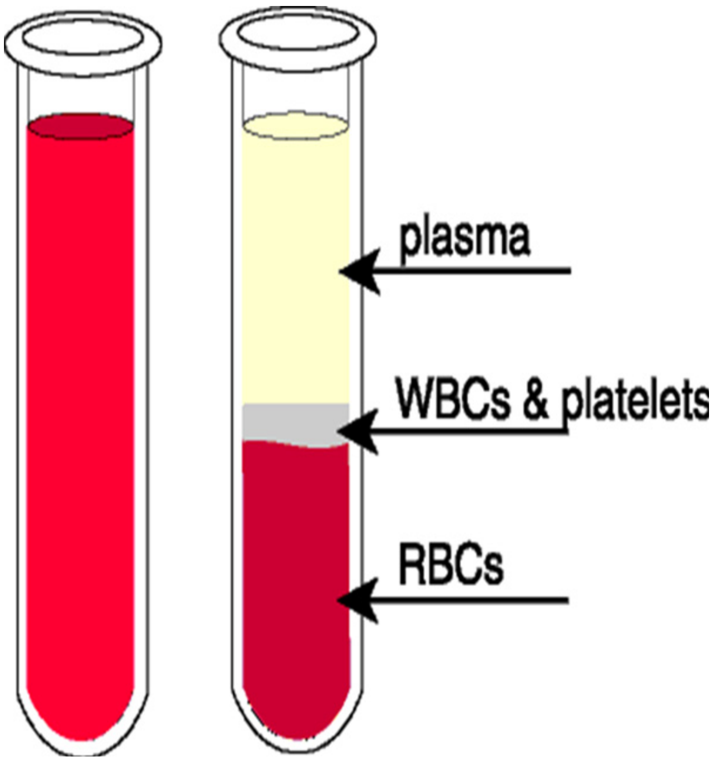
- Plasma constitutes about 55%
- Cells about 45% of blood volume



PLASMA

Constituents is water (90 to 92%) and dissolved substances, including:

- Plasma proteins: albumins, globulins (including antibodies), fibrinogen, clotting factors
- Inorganic salts (mineral salts): sodium chloride, sodium bicarbonate, potassium, magnesium, phosphate, iron, calcium, copper, iodine, cobalt
- Nutrients, principally from digested foods, e.g. Glucose, amino acids, fatty acids, glycerol and vitamins
- Waste materials, e.g. Urea, uric acid, creatinine
- Hormones
- Enzymes, e.g. Certain clotting factors
- Gases, e.g. oxygen, carbon dioxide, nitrogen.



Plasma Proteins

They make up about 7% of plasma, and are normally retained within the blood, because they are too big to escape through the capillary pores into the tissues.

Largely responsible for creating the osmotic pressure of blood which keeps plasma fluid within the circulation.

Examples:

- Albumins,
- Globulins (including antibodies),
- Fibrinogen,
- Clotting factors

Cellular Content of Blood

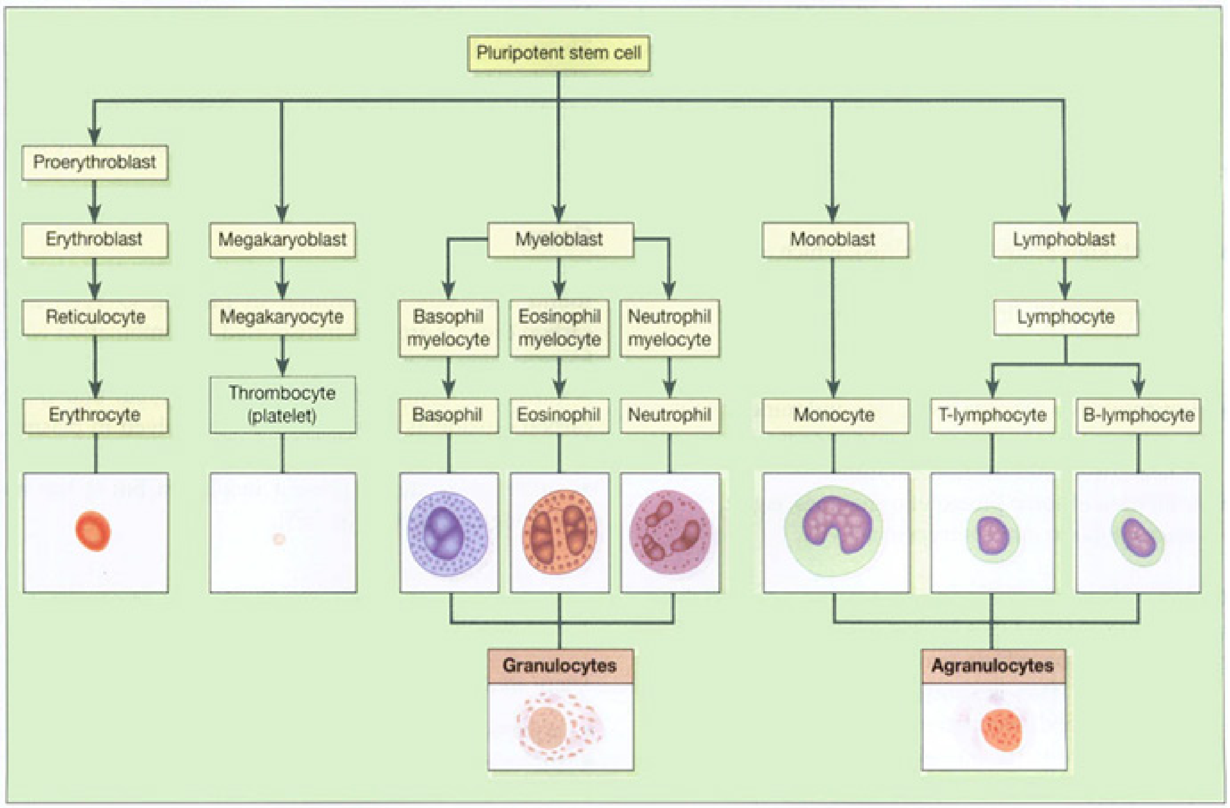
Three types of blood cells.

1. Erythrocytes or red cells
2. Thrombocytes or platelets
3. Leukocytes or white cells.

All blood cells originate from **pluripotent stem cells** and go through several developmental stages before entering the blood.

Haemopoiesis: process of blood cell formation; takes place within red bone marrow.

Haemopoiesis



ERYTHROCYTES (Red Blood Cells)

Circular biconcave non-nucleated discs with a diameter of about 7 micrometers whose main function is transport of gases.

Characteristics (Adaptations) of the R.B.C

- They are biconcave – to ↑ S.A for gaseous exchange
- They have a thin central portion – to allow fast entry and exit of gases
- They are flexible – so that they can squeeze thru narrow capillaries
- Contain no organelles – thus creating more room for heamoglobin.
- They contain hemoglobin for O2 transport

R.B.C Counts

Erythrocyte count: number of erythrocytes per litre (1) or per cubic millimetre (mm3) of blood.

Packed cell volume (PCV)or haematocrit: volume of red cells in 1 litre or 1 mm3 of whole blood.

Mean cell volume(MCV): average volume of cells, measured in femtolitres (fl = 101-15 litre).

Haemoglobin: weight of haemoglobin in whole blood, measured in grams per 100 ml.

Mean cell haemoglobin (MCH): average amount of haemoglobin in each cell, measured in picograms (pg = 101^{-12} gram).

Mean cell haemoglobin concentration (MCHC): amount of haemoglobin in 100 ml of red cells.

Development and Lifespan of the Erythrocytes

Formed in red bone marrow, which is present in the ends of long bones and in flat and irregular bones.

Life span in the circulation is about 120 days. Process of development of red blood cells from pluripotent stem cells takes about 7 days and is called **erythropoiesis.**

It is characterised by two main features:

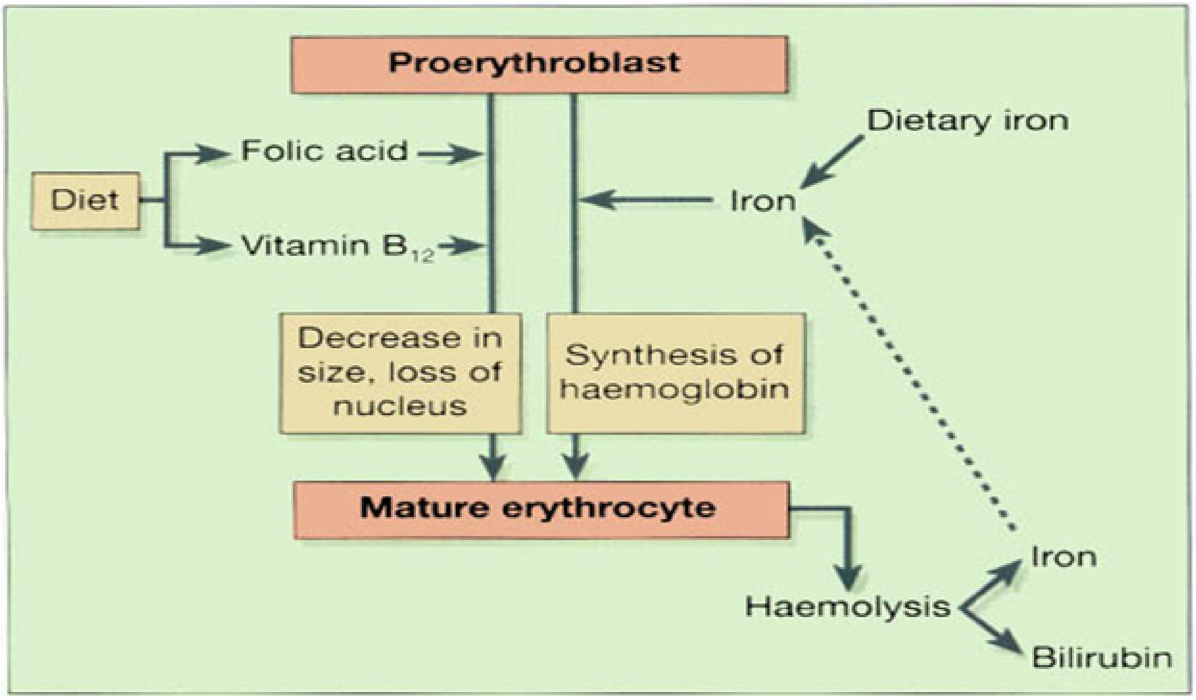
1. Maturation of the cell
2. Formation of haemoglobin inside the cell.

Maturation of the Cell

During this process the cell decreases in size and loses its nucleus.

These changes depend on the presence of vitamin B12 and folic acid. These are present in sufficient quantity in a normal diet containing dairy products, meat and green vegetables; excess is stored in the liver.

Maturation of the erythrocyte



Formation of Haemoglobin

Haemoglobin (Hb) is a complex protein, consisting of globin and an iron-containing substance called haem, and is synthesised inside developing erythrocytes in red bone marrow.

Hb in mature erythrocytes combines with oxygen to form oxyhaemoglobin, giving arterial blood its characteristic red colour.

Control of Erythropoiesis

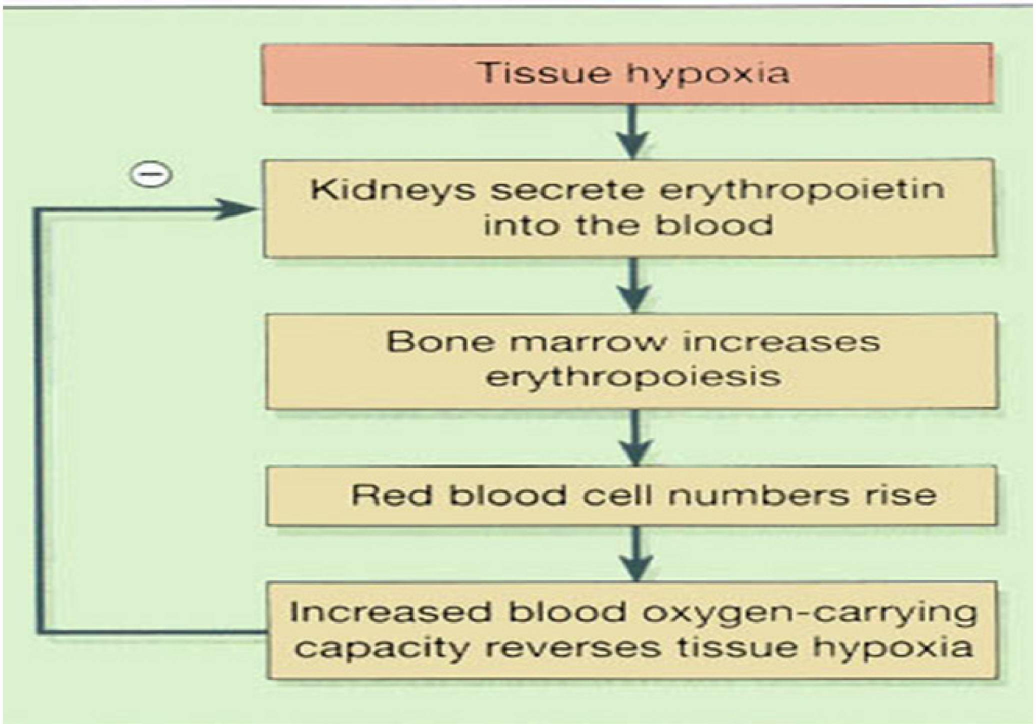
Through homeostatic negative feedback mechanism; the bone marrow produces erythrocytes at the rate at which they are destroyed.

Primary stimulus to increased erythropoiesis is hypoxia which occurs when:

- Oxygen-carrying power of blood is reduced by e.g. haemorrhage or excessive erythrocyte breakdown (haemolysis) due to disease
- Oxygen tension/concentration in the air is reduced, as at high altitudes.
- Hypoxia increases erythrocyte formation by stimulating the production of the hormone erythropoietin, mainly by the kidneys.

Effects of Erythropoietin

- Increases production of proerythrocytes
- Speeds up reticulocyte maturation
- And this ↑ oxygen carrying capacity of blood and thus hypoxia.
- When erythropoietin levels are low, red cell formation does not take place even in the presence of hypoxia, and anaemia develops.



Cotrol of Erythropoiesis

Destruction of Erythrocytes

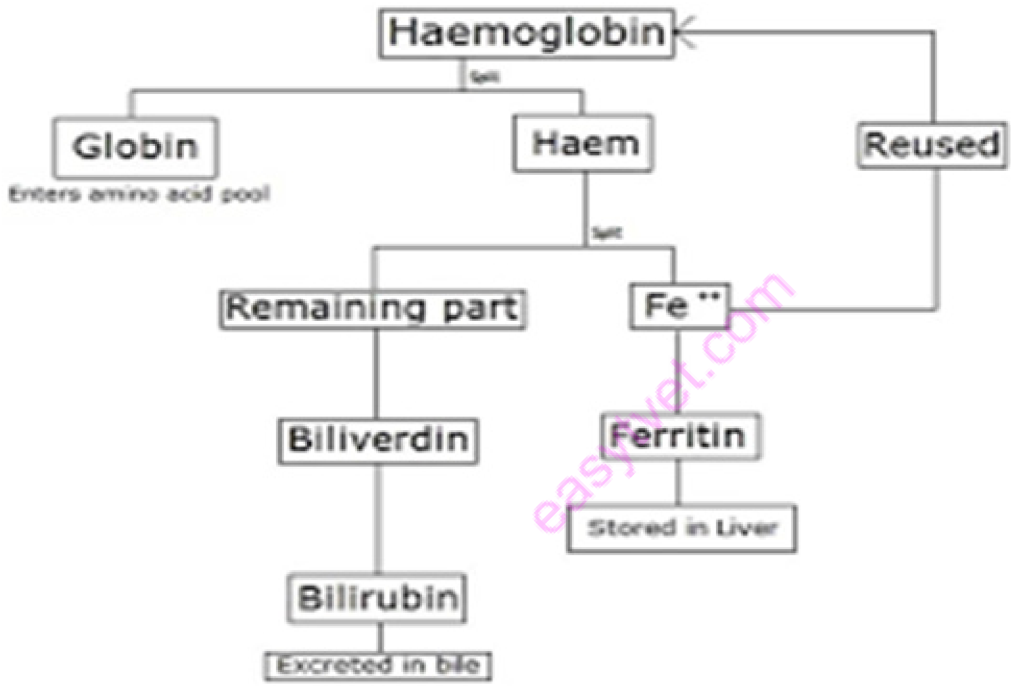
Life span of erythrocytes is about 120 days. Their breakdown/haemolysis, is by phagocytic reticuloendothelial cells found mainly in the spleen, bone marrow and liver.

As erythrocytes age, changes in their cell membranes make them more susceptible to haemolysis (membranes become fragile).

Iron released by haemolysis is retained in the body and reused in the bone marrow to form haemoglobin.

Biliverdin (green pigment) is formed from the breakdown of heme part of the hemoglobin.

It is then reduced to the yellow pigment bilirubin, before it is bound to plasma globulin and transported to the liver. In the liver it is changed from a fat-soluble to a water-soluble form before it is excreted as a constituent of bile.



Blood Groups

Antigens, found on the surfaces of individual's RBCs, which are inherited, determine the individual's blood group.

In addition, individuals make antibodies to these antigens, but not to their own type of antigen, since if they did the antigens and antibodies would react causing a transfusion reaction.

These antibodies circulate in the bloodstream and the ability to make them is genetically determined and not associated with acquired immunity.

If individuals are transfused with blood of the same group, i.e. possessing the same antigens on the surface of the cells, their immune system will not recognize them as foreign and will not reject them.

However, if they are given blood from an individual of a different blood type, i.e. with a different type of antigen on the red cells, their immune system will mount an attack upon them and destroy the transfused cells.

This is the basis of the transfusion reaction; the two blood types, the donor and the recipient, are incompatible.

There are two important systems of blood grouping:

1. ABO system
2. Rhesus system

The ABO System

About 55% of the population has either A-type antigens (blood group A), B-type antigens (blood group B) or both (blood group AB) on their red cell surface.

The remaining 45% have neither A nor B type antigens (blood group O).

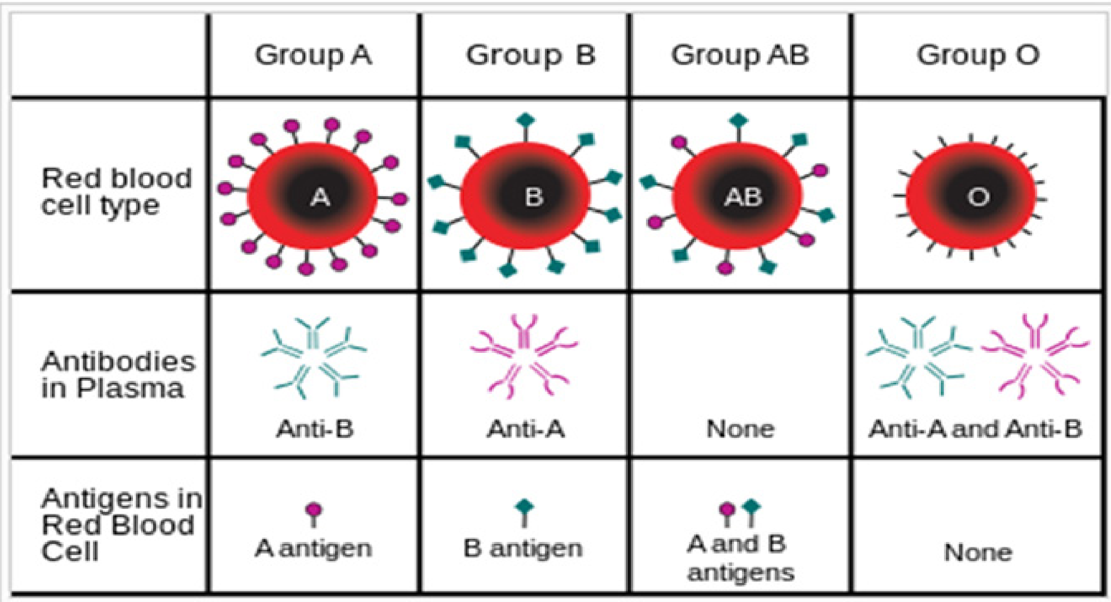
The corresponding antibodies are called anti-A and anti- B.

Blood group A individuals cannot make anti-A (and therefore do not have these antibodies in their plasma), since otherwise a reaction to their own cells would occur; they do, however, make anti-B.

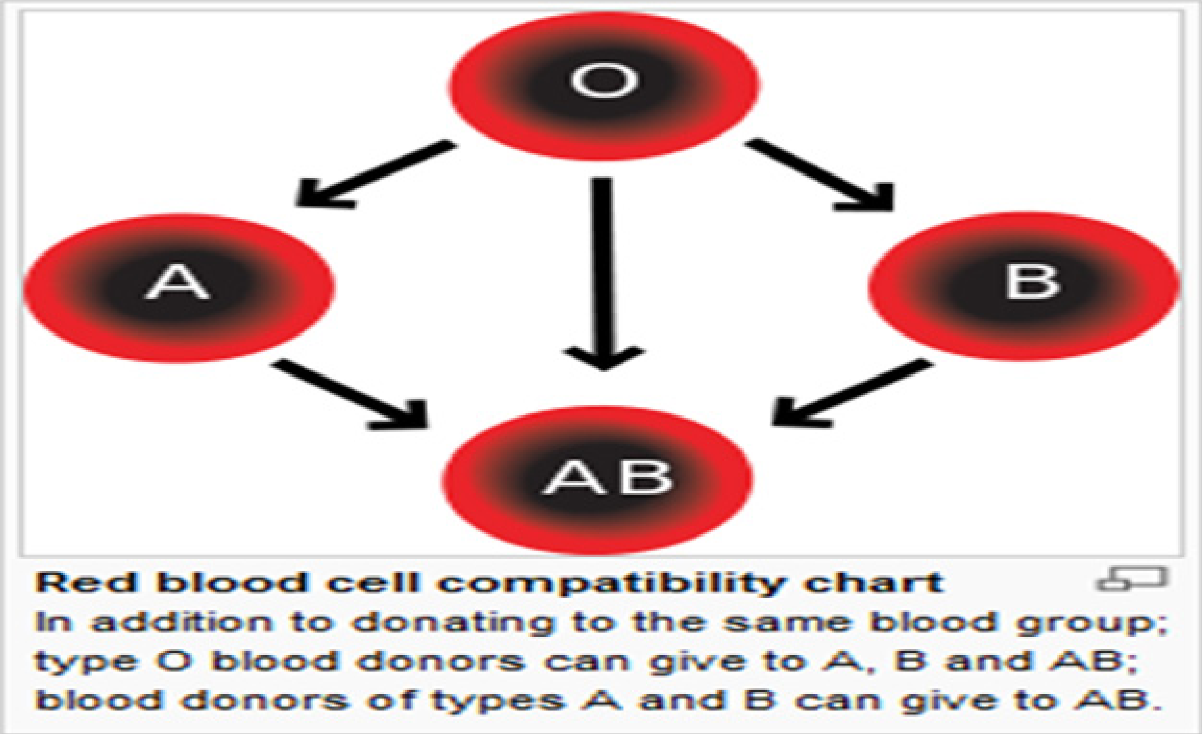
Blood group B individuals, for the same reasons, make only anti-A. Blood group AB make neither, and blood group O make both anti-A and anti-B .

Because blood group AB people make neither anti-A nor anti-B antibodies, they are known as universal recipients: transfusion of either type A or type B blood into these individuals is safe, since there are no antibodies to react with them.

Conversely, group O people have neither A nor B antigens on their red cell membranes, and their blood may be safely transfused into A, B, AB or O types; group O is known as the universal donor.



Blood type (or blood group) is determined, in part, by the ABO blood group antigens present on red blood cells.



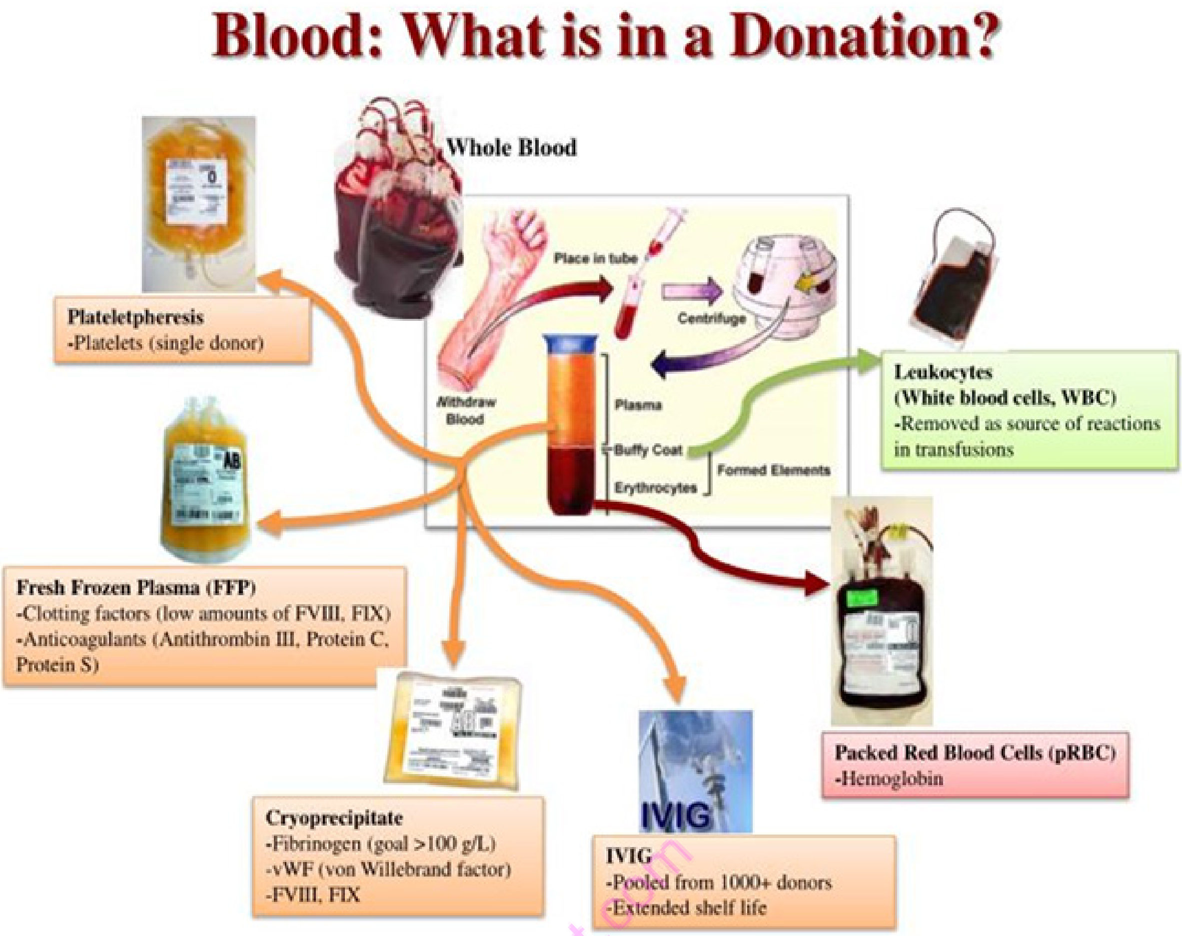
Universal Donor vs Recipient

Blood Transfusions

Blood Type of Donor	Blood Type of Recipient			
	A	B	AB	O
A	✓	X	✓	X
B	X	✓	✓	X
AB	X	X	✓	X
O	✓	✓	✓	✓

X = Unsuccessful transfusion ✓ = Successful transfusion

Red Blood Cell Compatibility Table



Explanation why Blood Group O is a Universal Donor

Why then is O still the universal donor and they have both anti-A and anti-B antibodies?

First, the blood plasma containing the antibodies is (virtually) removed after centrifugation. Hence, it can be donated to everyone, as far as that the rhesus factor matches.

Secondly, even if plasma is transfused, antibodies in the donor's plasma are a minor problem, because of the small amount of antibody present in the donated plasma, which is further diluted on transfusion into the recipient's circulation (Dean, 2005).

NB: For blood compatibility, we only check the antigen for donors and antibodies for recipients

Plasma Compatibility Table

Plasma contains anti-A and anti-B antibodies depending upon the blood group. Plasma lack antigens because they are found on the surface of red blood cell membrane. Our body also has antibodies to A and/or B antigens according to our blood group. Patients should only receive plasma that does not contain an antibody which could attack the antigens present on their own red cells.

Group A recipients have A antigen on their red cells, so they can't receive group O or group B plasma as the anti-A will attack their red cells. Group B recipients have B antigen on their red cells, so they can't receive group O or group A plasma as the anti-B will attack their red cells.

Group AB recipients can only receive group AB plasma. Group O recipients do not have either A or B antigen, so can safely receive plasma of any blood group type.

NB: Plasma compatibility table is opposite of red blood cell compatibility table. Blood group O become the universal recipient while AB become the universal donor.

Plasma compatibility table[25]

Recipient	Donor[1]			
	O	A	B	AB
O	✓	✓	✓	✓
A	✗	✓	✗	✓
B	✗	✗	✓	✓
AB	✗	✗	✗	✓

Blood group	Antigen + antibody(ies) present		As donor, is	As recipient, is
A	Antigen A	Makes anti-B	Compatible with: A and AB Incompatible with: B and O, because both make anti-A antibodies that will react with A antigens	Compatible with: A and O Incompatible with: B and AB, because type A makes anti-B antibodies that will react with B antigens
B	Antigen B	Makes anti-A	Compatible with: B and AB Incompatible with: A and O, because both make anti-B antibodies that will react with B antigens	Compatible with: B and O Incompatible with: A and AB, because type B makes anti-A antibodies that will react with A antigens
AB	Antigens A and B	Makes neither anti-A nor anti-B	Compatible with: AB only Incompatible with: A, B and O, because all three make antibodies that will react with AB antigens	Compatible with all groups **UNIVERSAL RECIPIENT** AB makes no antibodies and therefore will not react with any type of donated blood
O	Neither A nor B antigen	Makes both anti-A and anti-B	Compatible with all groups **UNIVERSAL DONOR** O red cells have no antigens, and will therefore not stimulate anti-A or anti-B antibodies	Compatible with: O only Incompatible with: A, AB and B, because type O makes anti-A and anti-B antibodies

The ABO system of blood grouping: antigens, antibodies and compatibility.

The Rhesus System

Rhesus factor; it’s a red blood cell membrane antigen.

About 85% of people have this antigen; they are said to be Rhesus positive (Rh+) and do not therefore make anti-Rhesus antibodies.

The remaining 15% have no Rhesus antigen (they are Rhesus negative, or Rh -).

Rh - individuals are capable of making anti-Rhesus antibodies, but are stimulated to do so only in certain circumstances, e.g. in pregnancy, or as the result of an incompatible blood transfusion.

Summary

Red blood cell compatibility table[24][25]

Recipient[1]	Donor[1]							
	O−	O+	A−	A+	B−	B+	AB−	AB+
O−	✓	✗	✗	✗	✗	✗	✗	✗
O+	✓	✓	✗	✗	✗	✗	✗	✗
A−	✓	✗	✓	✗	✗	✗	✗	✗
A+	✓	✓	✓	✓	✗	✗	✗	✗
B−	✓	✗	✗	✗	✓	✗	✗	✗
B+	✓	✓	✗	✗	✓	✓	✗	✗
AB−	✓	✗	✓	✗	✓	✗	✓	✗
AB+	✓	✓	✓	✓	✓	✓	✓	✓

LEUKOCYTES (White Blood Cells)

Main function: Defending the body against microbes and other foreign materials.

They are the largest blood cells, and account for about 1% of the blood volume. They contain nuclei and some have granules in their cytoplasm.

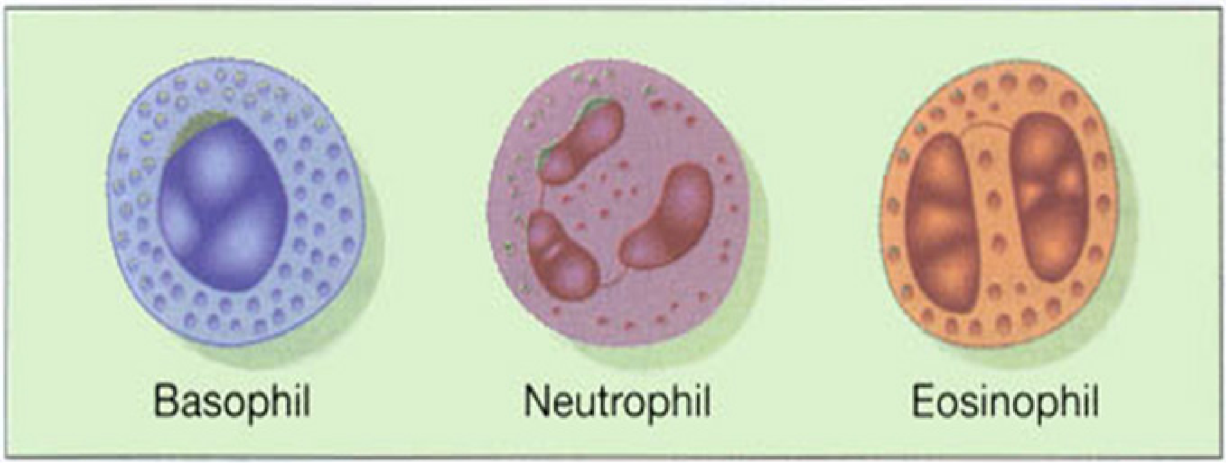
Two main types:

- Granulocytes (polymorphonuclear leukocytes) neutrophils, eosinophils and basophils
- Agranulocytes monocytes and lymphocytes.

Granulocytes (polymorphonuclear leukocytes)

They have multilobed nuclei in their cytoplasm. Their names represent the dyes they take up when stained in the laboratory.

- Eosinophils; red acid dye, eosin;
- Basophils; alkaline methylene blue;
- Neutrophils (purple); take up both dyes.



Types of Leukocytes

Granulocytes

i. Neutrophil

- Non-specific defense
- Phagocytic
- 50-70% of WBCs
- Granules contain enzymes and defensins
- Very mobile: first at injury
- Life span less than 10h.

Functions:

- Kill phagocytosed things
- Degranulation: release defensins, lyse bacteria
- Prostaglandins: induce inflammation to stop spread of injury
- Leukotrienes: attract phagocytes.

ii. Eosinophil

- Non-specific defense
- Phagocytic
- 2-4% of WBCs
- Granules contain toxins

- Life span 9 days

Functions:

- Phagocytosis of antibody covered objects
- Defense against parasites:
- Exocytose toxins on large pathogens
- Reduce inflammation: anti-inflammatory
- Chemicals/enzymes

iii. Basophil

- In tissues are called mast cell
- Non-specific defense
- Not phagocytic
- Less than 1% of WBCs
- Granules contain Histamine: dilate blood vessels
- Heparin: prevents clotting
- Life span 9 days

Functions:

- Inflammation
- Allergic response (via histamine)

iv. Agranulocytes

- Have a large nucleus
- Have no granules in their cytoplasm
- Make up 25% to 50% of all leukocytes
- Includes:
  1. Monocytes and
  2. Lymphocytes

1. Monocytes

Are large mononuclear cells that originate in red bone marrow.

Some circulate in the blood and are actively motile and phagocytic while others migrate into the tissues where they develop into macrophages.

Macrophages have important functions in inflammation and immunity, and are actively phagocytic.

The monocyte-macrophage system/ Reticuloendothelial system

Consists of the body's complement of monocytes and macrophages.

Some macrophages are mobile whereas others are fixed.

Cells of this system include:

- Histiocytes in connective tissues
- Microglia in the brain
- Kupffer cells in the liver
- Alveolar macrophages in the lungs
- Sinus-lining macrophages (reticular cells) in the spleen, lymph nodes and thymus gland
- Mesangial cells in the glomerulus of nephrons in the kidney
- Osteoclasts in bone.
- Langerhans cells in the skin
- Synovial cells in the joints.

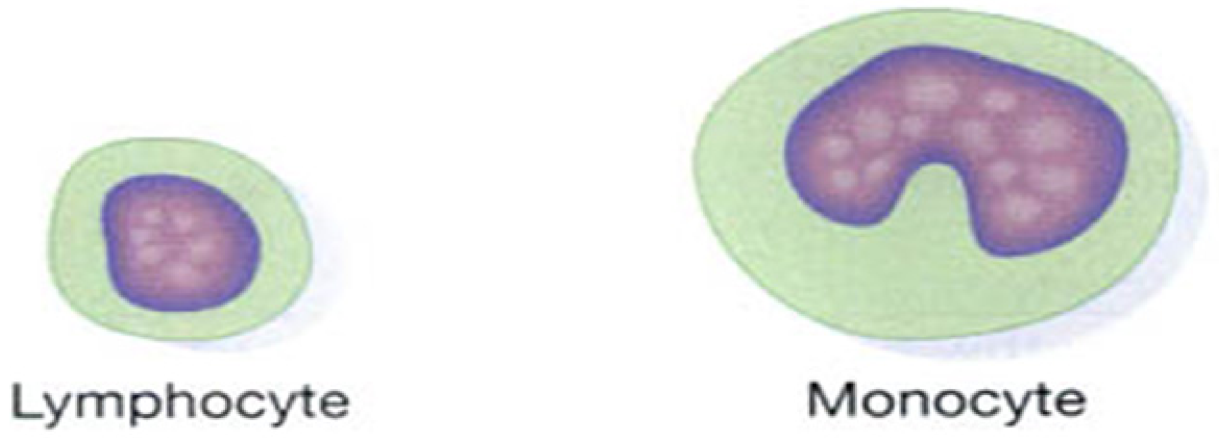
2. Lymphocytes

Smaller than monocytes and have large nuclei.

Circulate in the blood and are present in great numbers in lymphatic tissue such as lymph nodes and the spleen.

Lymphocytes are usually activated in the lymphatic tissue (especially the Thymus) to produce two distinct types: T-lymphocytes and B-lymphocytes which have different functions.

T-lymphocytes are responsible for cell mediated immunity while B-lymphocytes are responsible for antibody production against certain antigens.



THROMBOCYTES (Platelets)

Very small non-nucleated discs derived from the cytoplasm of megakaryocytes in red bone marrow.

Contain a variety of substances that promote blood clotting, which causes haemostasis (cessation of bleeding).

Control of production is a fall in platelet count (stimulus) and thrombopoietin (effector) a hormone produced by the liver and the kidney.

Life span is between 8 and 11 days.

Haemostasis

Cessation of bleeding is achieved through the following processes:

1. Vasoconstriction. When platelets come in contact with a damaged blood vessel, their surface becomes sticky and they adhere to the damaged wall.

They then release serotonin which constricts the vessel, reducing blood flow through it. Thromboxanes; released by the damaged vessel itself also cause vasoconstriction.

2. Platelet plug formation. Adherent platelets clump to each other and release adenosine diphosphate (ADP), which attract more platelets to the site.

Passing platelets stick to those already at the damaged vessel and they too release their chemicals.

Many platelets rapidly arrive at the site of vascular damage and quickly form a temporary seal — the platelet plug (within 6 minutes).

3.Coagulation (blood clotting). Results in the formation of an insoluble thread-like mesh of fibrin which traps blood cells and is much stronger than the rapidly formed platelet plug. In the final stages of this process prothrombin activator acts on the plasma protein prothrombin converting it to thrombin.

Thrombin then acts on fibrinogen converting it to fibrin.

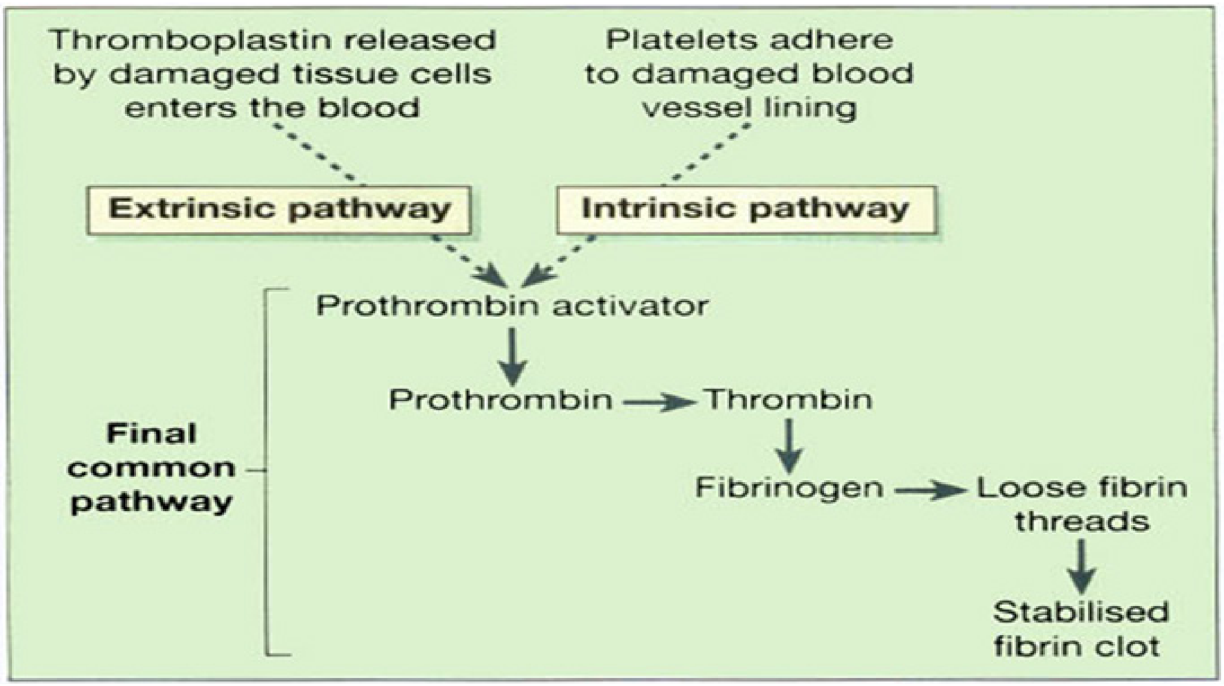
Prothrombin activator can be formed by two processes which often occur together: the extrinsic and intrinsic pathways.

Extrinsic pathway occurs rapidly (within seconds) when there is tissue damage outside the circulation. Damaged tissue releases a complex of chemicals called thromboplastin or tissue factor, which initiates coagulation.

Intrinsic pathway is slower (3-6 minutes) and is confined to the circulation. It is triggered by damage to a blood vessel lining (endothelium) and the effects of platelets adhering to it.

After a time the clot shrinks, squeezing out serum.

Stages of Blood Clotting



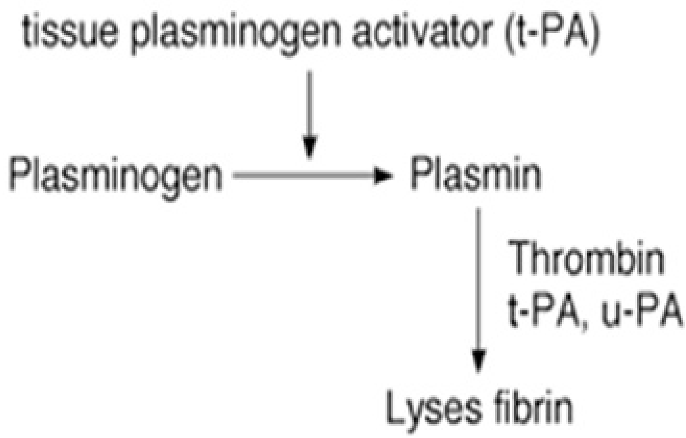
4. Fibrinolysis--after the clot has formed the process of removing it and healing the damaged blood vessel begins.

An inactive substance called plasminogen is present in the clot and is converted to the enzyme plasmin by activators released from the damaged endothelial cells.

Plasmin initiates the breakdown of fibrin to soluble products; removed by phagocytosis.

As the clot is removed, the healing process restores the integrity of the blood vessel wall.

Fibrinolysis Process



Common Blood Disorders

- Anemia
- Sickle Cell Disease
- Hemolytic Disease of the Newborn
- Rhesus disease
- Bleeding disorders like hemophilia, von Willebrand Disease
- Blood cancers such as leukemia, lymphoma, and myeloma.

THE RESPIRATORY SYSTEM

Introduction

The respiratory system consists of passages that filter incoming air and transport it into the lungs and to the many microscopic air sacs where gases are exchanged

Respiration is the process of exchanging gases between the atmosphere and body cells

It consists of the following events:

- Ventilation
- External respiration
- Transport of gases
- Internal respiration
- Cellular respiration

Respiration is associated with 4 processes:

- Pulmonary ventilation is the movement of air into/out of the lungs
- External respiration is the movement of O_2 from the lungs to the blood and CO_2 from the blood to the lungs.
- Gas transport refers to the mechanisms by which O_2 and CO_2 are moved thru the blood.
- Internal respiration is the movement of O_2 from the blood to the cell interior and CO_2 from the cell interior to the blood.

Main functions of the Respiratory System

- Exchange of O_2 and CO_2.
- Voice production.
- Regulation of plasma PH
- Olfaction (sensation of smell)
- Infection (pathogen invasion) prevention.

Organs of the Respiratory System

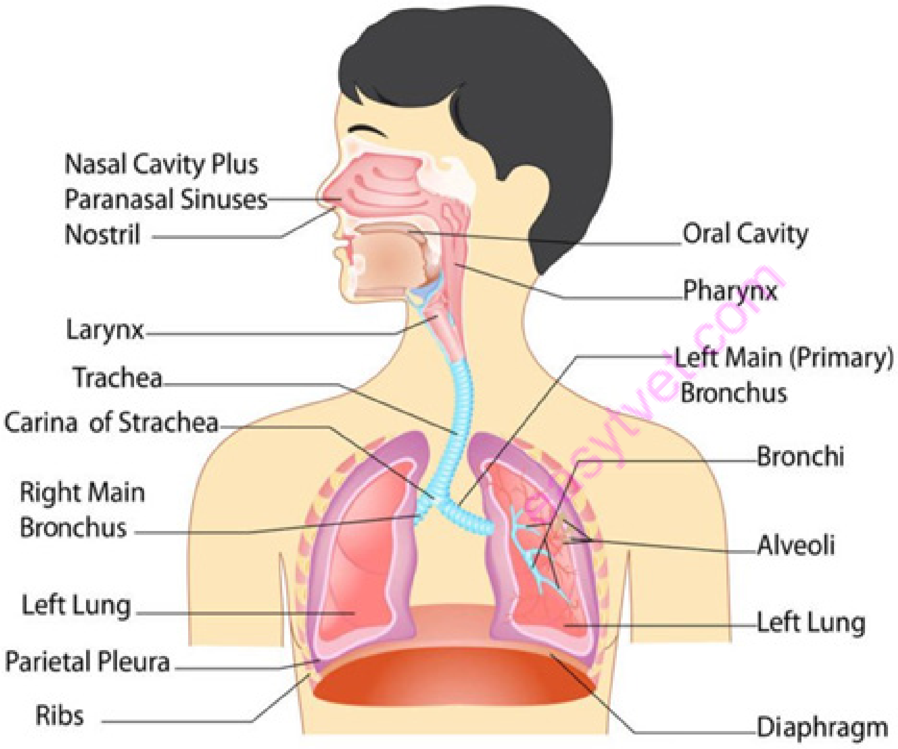
The organs of the respiratory system can be divided into two tracts:

Upper respiratory tract

- The nose
- Nasal cavity
- Sinuses
- Pharynx

Lower respiratory tract

- Larynx
- Trachea
- Bronchial tree
- Lungs
- Muscles of breathing



Zones of the Respiratory System

1. Conducting zone

Respiratory passages that carry air to the site of gas exchange. Filters, humidifies and warms air.

2. Respiratory zone

Site of gas exchange, and is composed of:

Respiratory bronchioles

- Alveolar ducts
- Alveolar sacs

The Nose

- Provides airway
- Moistens and warms air
- Filters air
- Resonating chamber for speech
- Olfactory receptors

Nasal Cavity

- Air passes through nares (nostrils)
- Nasal septum divides nasal cavity in midline (to right & left halves)
- Perpendicular plate of ethmoid bone, vomer and septal cartilage
- Connects with pharynx posteriorly through choanae (posterior nasal apertures*)
- Floor is formed by palate (roof of the mouth)
- Anterior hard palate and posterior soft palate.

Nose & Nasal Cavity

Relations

Roof: cribriform plate of the ethmoid bone and the sphenoid bone, frontal bone & nasal bones

Floor: hard and soft palate (maxilla and palatine bones & involuntary muscles)

Medial wall: nasal septum

Lateral wall: maxilla, ethmoid bone & inferior conchae

Posterior wall: post. Wall of pharynx

Lining of the Nose

The majority of the nasal cavity is lined by respiratory epithelium. Respiratory epithelium is pseudostratified columnar epithelium with goblet cells.

The mucus secreted by goblet cells, as well as by mucous glands, helps filter and trap inspired particulate matter. The moist mucus (as well as the watery solution secreted by serous glands) contributes to the humidification of inspired air.

Cilia help sweep mucus to the pharynx where it is swallowed.

Respiratory epithelium is underlain by a dense vasculature. The blood helps warm inspired air. Mucus also contains lysozyme as well as immunoglobulins, which help prevent infection.

Respiratory Mucosa

Pseudostratified ciliated columnar epithelium

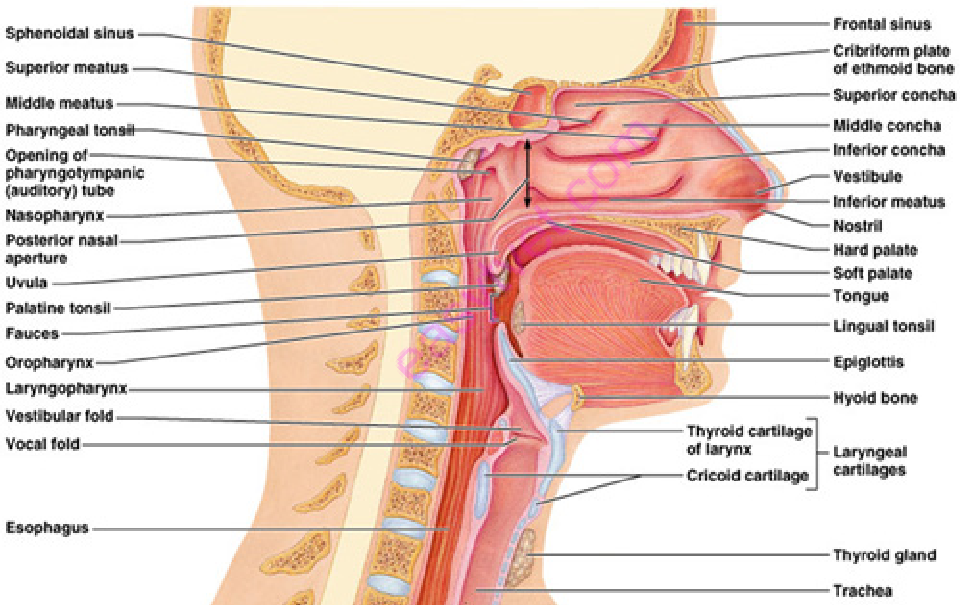
Scattered goblet cells

Underlying connective tissue lamina propria

- Mucous cells – secrete mucous
- Serous cells – secrete watery fluid with digestive enzymes, e.g. lysozyme

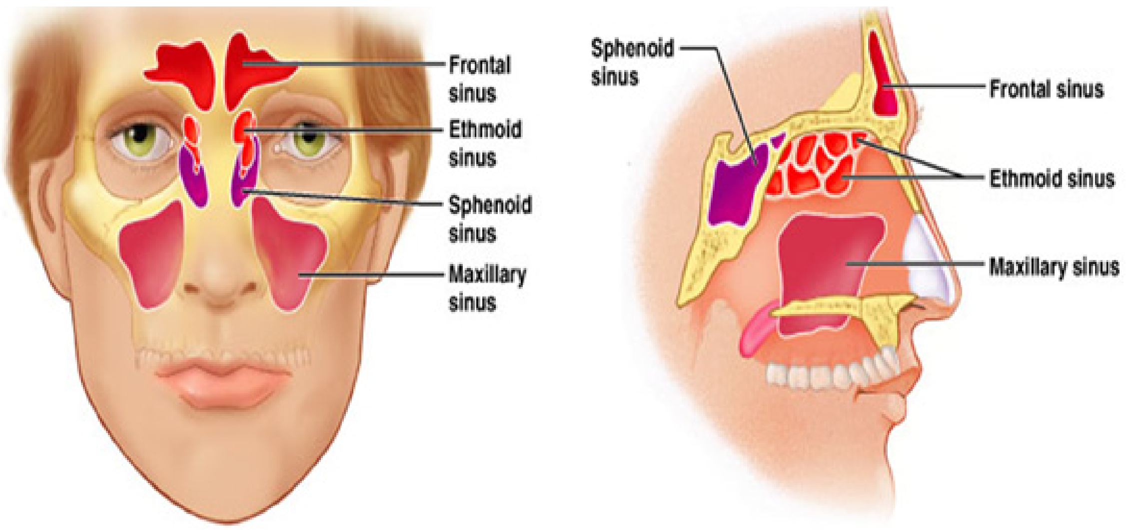
Nasal Conchae

- Inferior to each is a meatus*
- Increases turbulence of air
- 3 scroll-like structures
- Reclaims moisture on the way out



Paranasal Sinuses

- Frontal, sphenoid, ethmoid and maxillary bones
- Open into nasal cavity
- Lined by same mucosa as nasal cavity and perform same functions
- Also lighten the skull
- Can get infected: Sinusitis



Openings into the Nasal Cavity

Anterior nares: nostrils are openings from exterior to the nasal cavity. The initial space just beyond the open is the nasal vestibule and it contains vibrissae (hairs) which perform a filtration function.

Posterior nares: from the nasal cavity to the pharynx

Nasolacrimal ducts: from the lateral wall of the nose to the conjunctival sac.

Functions of the Nose

Respiratory Functions

- Warming: highly vascularised
- Filtering & cleaning: hair, mucus, cilia
- Humidification: moist mucosa

Pharynx

The pharynx is posterior to the oral cavity and between the nasal cavity and the larynx.

It conducts air to larynx and food to esophagus, and is divided into 3 sections: nasopharynx, oropharynx, & laryngopharynx.

1. Nasopharynx

Is lined by respiratory epithelium. The posterior-most portion that hangs down is the uvula. The soft palate and uvula flip up during swallowing and help prevent food/drink from entering the nasopharynx.

On the lateral walls of the nasopharynx are the openings to the auditory tubes (Eustachian tubes). Each auditory tube connects the pharynx to a middle ear cavity. They ensure that air pressure within the middle ear cavities is equal to atmospheric pressure.

The nasopharynx also contains the pharyngeal tonsil. (lymphoid tissue) prominent up to to 7yrs of age then atrophy.

2. Oropharynx

Is inferior to the uvula and superior to the epiglottis .

It's posterior to the oral cavity.

Two sets of tonsils (palatine and lingual) are located right nearby.

It's lined by nonkeratinized stratified squamous epithelium.

This provides the necessary protection since this region is a common pathway for food and air.

3. Laryngopharynx

The is inferior to the epiglottis and superior to the split between the larynx and the esophagus

It's lined by nonkeratinized stratified squamous epithelium because it is also a common pathway for food and air.

It's continuous with the larynx inferiorly.

Pharynx: Structure

Mucus membrane: at the nasopharynx is ciliated columnar epithelium, oropharynx & laryngopharynx, stratified squamous epithelium like esophagus & mouth to protect it from abrasive action of foodstuffs passing.

Smooth muscle; involuntary constrictor muscles for swallowing

Pharynx: Functions

- Passage for airway and food
- Taste
- Protection from infections
- Warming and humidifying air
- Hearing
- Speech (voice resonator)

The Larynx (Voice box)

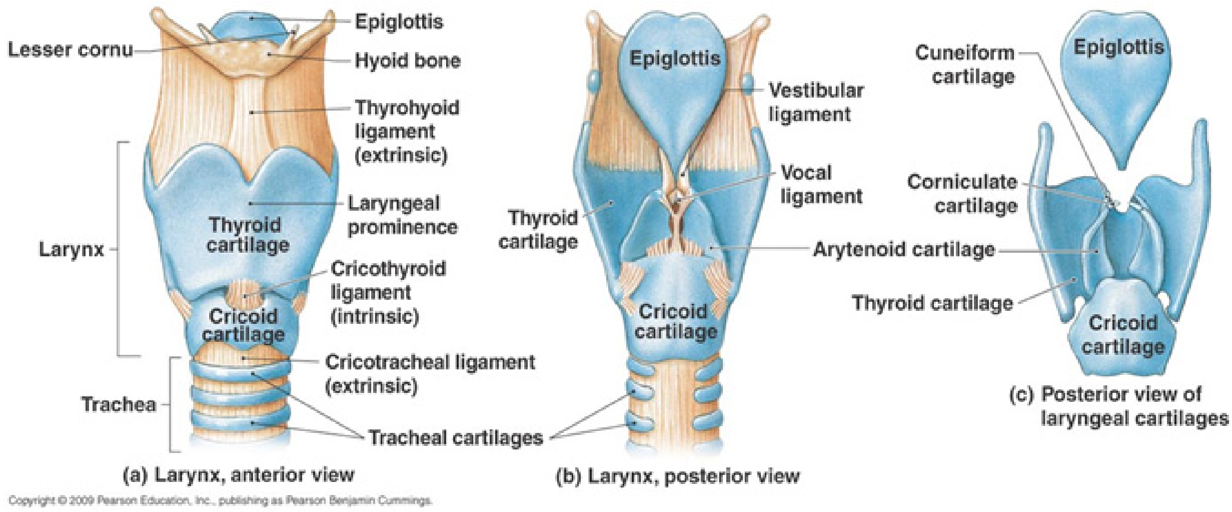
Rigid structure between laryngopharynx and trachea, that contain vocal cords, which produce voice on vibration

Rigidity is maintained by muscles, ligaments and 9 cartilages.

Three functions:

- Produces vocalizations (speech)
- Provides an open airway (breathing)
- Switching mechanism to route air and food into proper channels.

Closed during swallowing, Open during breathing



Epiglottis* (the 9th Cartilage)

Elastic cartilage covered by mucosa (stratified sq.epi)

Epiglottis tips inferiorly to cover and seal laryngeal inlet

Keeps food out of lower respiratory tract

Larynx: Functions

- Sound production-
  - o Pitch; depends on the length & tightness of the cord
  - o Volume; depends on the force of cord vibration during exhalation
  - o Resonance; depends on the shape of the mouth, tongue position, lips position, facial muscles & air and paranasal sinuses
- Speech: occurs during expiration when sounds produced by vocal cords are manipulated by the tongue, cheeks & lips.
- Protection of lower respiratory tract during swallowing
- Passage for air
- Humidifying, filtering & warming air.

Trachea

The trachea (windpipe) is a flexible cylindrical tube about 2.5 centimeters in diameter and 12.5 centimeters in length.

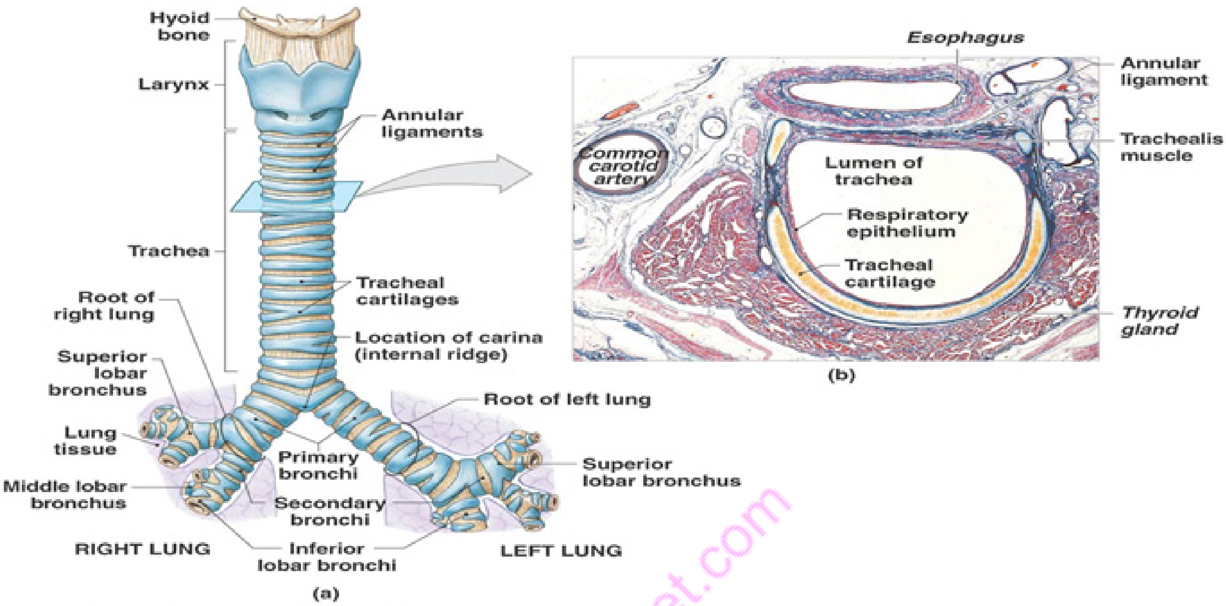
As it extends downward anterior to the esophagus and into the thoracic cavity, it splits into the right and left primary bronchi.

Trachea: Structure

16-20 C-shaped rings of hyaline cartilage joined by fibro-elastic connective tissue posteriorly intact with esophagus.

The trachea is associated with copious mucus secretion – due to its abundant seromucous glands

The lack of posterior cartilage is important because it provides the esophagus with room to expand when a large bolus of food is swallowed.



Trachea: Functions

Support and patency: cartilage arrangement and presence of supporting connective tissue posteriorly.

Mucocilliary escalator: beating of the cilia wafts adherent particles upwards and are either coughed or swallowed.

Cough reflex: irritation in the airway stimulates nerve endings which generates impulses through the vagus nerve to the respiration center which cause coughing.

Warming, humidifying and filtering the air

Lungs

The right and left lungs are soft, spongy, cone-shaped organs in the thoracic cavity. The right lung has three lobes and the left lung has two lobes

Relations

Apex: rounded, rises into the root of the neck, lies close to 1st rib, blood vessels & nerves in the root of the neck.

Base: concave & semilunar in shape, lies in the thoracic surface of the diaphragm

Costal surface: convex and lies against the costal cartilages, ribs & intercostal muscles

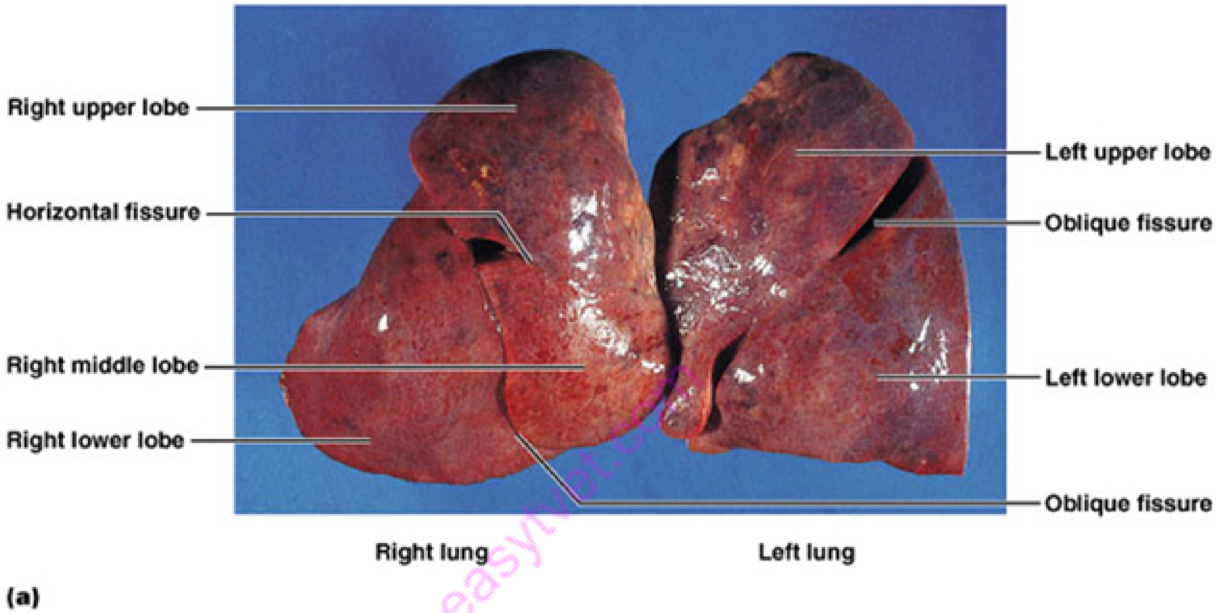
Medial surface: concave, has a roughly triangular shaped area; hilum.

Structures forming the root of the lungs enter and leave the lung through the hilum i.e. primary bronchus, pulmonary aa, pulmonary v., bronchial aa & v, lymphatic & nerve supply.

Lungs

Each is cone-shaped with anterior, lateral and posterior surfaces contacting ribs, Superior tip is apex, just deep to clavicle

Concave inferior surface resting on diaphragm is the base.



Hilus or (hilum)

- Indentation on mediastinal (medial) surface.
- Place where blood vessels, bronchi, lymph vessel, and nerves enter and exit the lung.
- Each lobe is made up of bronchopulmonary segments separated by dense connective tissue
- Each segment receives air from an individual segmental (tertiary) bronchus
- Approximately 10 bronchopulmonary segments in each lung
- Limit spread of infection
- Can be removed more easily because only small vessels span segments
- Smallest subdivision seen with the naked eye is the lobule
- Hexagonal on surface, size of pencil eraser
- Served by large bronchiole and its branches
- Black carbon is visible on connective tissue separating individual lobules in smokers and city dwellers.

Difference between the lungs

	Right lung	Left lung
length	Shorter.	Longer.
width	Wider.	Narrower.
lobes	3 (upper, middle and lower).	2 (upper and lower).
fissures	oblique,horizontal.	Oblique.
cardiac notch	absent.	present.
Lingula	absent.	present.

Lungs and Pleura

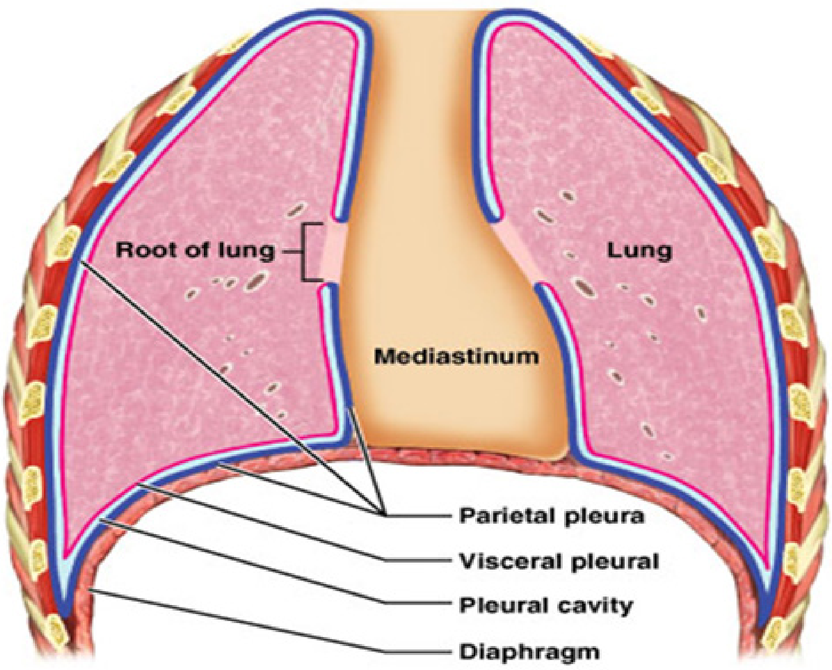
Around each lung is a flattened sac of serous membrane called pleura.

Parietal pleura – outer layer, adheres inside the chest wall, continuous with visceral pleura

Visceral pleura – directly on lung, passes all round the lungs

Pleural cavity – slit-like potential space filled with pleural fluid separating the 2 pleura layers.

Pleural fluid *reduces friction* during expansion and contraction of the lungs.



Interior of the lungs

Consists of bronchi, bronchioles, alveoli, CT, blood vessels, lymph vessels, nerves and embedded elastic connective tissue matrix .

Pulmonary blood supply: pulmonary trunk divides to R & L pulmonary artery which eventually divides to dense capillary network at the walls of the alveoli. (one cell thick) where exchange of gases takes place through this fine membrane (respiratory membrane)

Pulmonary capillaries join to form 2 pulmonary veins which leaves the lungs at the hilum with oxygenated blood to the left atrium.

Bronchial tree bifurcation

- Right main bronchus (more susceptible to aspiration)
- Left main bronchus

Each main or primary bronchus runs into hilus of lung posterior to pulmonary vessels

Branches of the Bronchial Tree

The successive divisions of the branches from the trachea to the alveoli are:

- Right and left primary bronchi
- Secondary or lobar bronchi
- Tertiary or segmental bronchi

- Intralobular bronchioles
- Terminal bronchioles
- Respiratory bronchioles
- Alveolar ducts
- Alveolar sacs
- Alveoli

Bronchial Tree

The bronchial tree consists of branched airways leading from the trachea to the microscopic air sacs in the lungs.

Bronchi

As the bronchial tree branches, its histology changes markedly:

Cartilage rings are replaced by cartilage plates, and within the bronchioles, cartilage is absent entirely.

Epithelium changes from pseudostratified columnar to simple columnar to simple cuboidal.

The number of cilia declines.

The number of goblet cells declines.

The relative amount of smooth muscle increases.

Bronchi: Functions

- Control of air entry: through contraction and relaxation of the muscles of the respiratory passage under ANS control.
- Warming and humidifying air
- Support and patency
- Removal of foreign body
- Cough reflex

Respiratory Zone

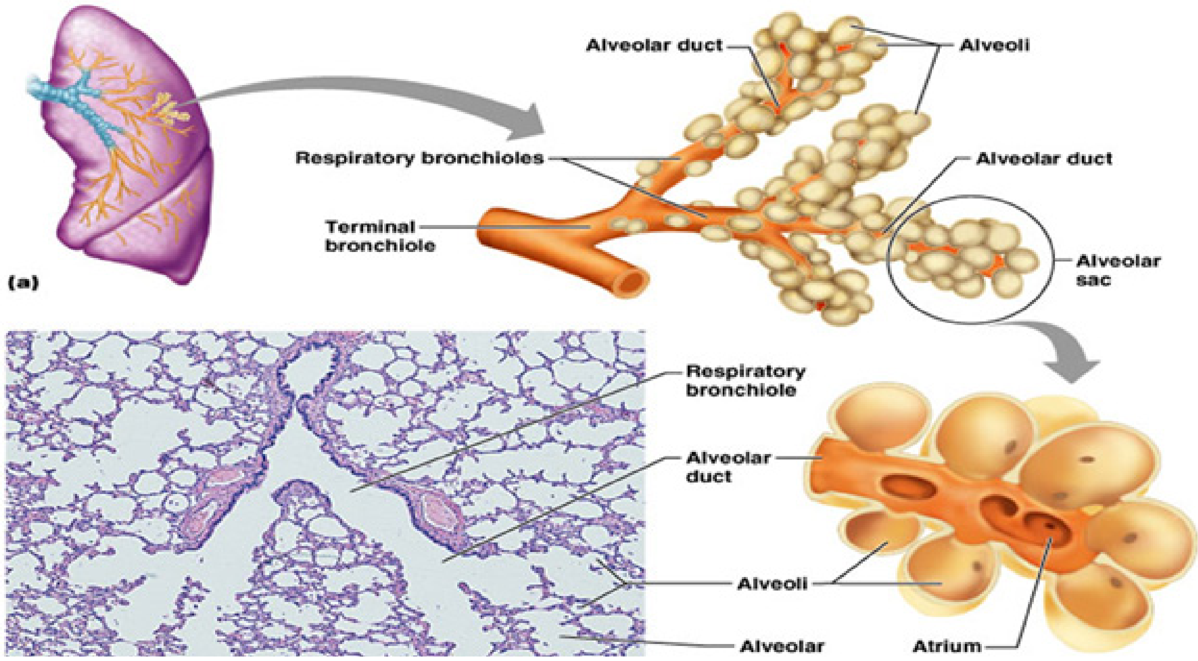
End-point of respiratory tree

Structures that contain air-exchange chambers are called alveoli

Respiratory bronchioles lead into alveolar ducts: walls consist of alveoli

Ducts lead into terminal clusters called alveolar sacs – are microscopic chambers

There are 3 million alveoli!



Respiratory Bronchioles and Alveoli lungs-lobules, supplied by terminal bronchioles which divides to respiratory bronchioles, alveolar ducts and finally alveoli.

About 150m alveoli in an adult.

The wall a single layer of simple squamous epithelial cell is found at the alveoli level supported by loose network of CT in which nerves, lymph vessel, blood vessels, and macrophages are found.

Alveoli is surrounded by dense capillary network where external respiration takes place through the respiration membrane. (fusion of alveolar wall and capillary wall)

Type II cuboidal epithelial cells lies between squamous cells and secrete surfactant.

Surfactant prevents the alveoli from drying out, reduces surface tension and prevents alveolar walls from collapsing.

Begins at 35th week fetal life, in newborn babies it facilitates lung expansion of the lungs and establishment of respiration.

Gas Exchange

- Air filled alveoli account for most of the lung volume
- Very great area for gas exchange (1500 sq ft)
- *Alveolar wall:* Single layer of squamous epithelial cells (type 1 cells) surrounded by basal lamina
- 0.5um (15 X thinner than tissue paper)
- External wall covered by cobweb of capillaries

- Respiratory membrane: fusion of the basal laminas of
  - Alveolar wall
  - Capillary wall

Respiratory Bronchioles

Functions

1. Defense against microbes: defense cells are present in the lungs; includes, macrophages, lymphocytes and plasma cells.
2. Warming and humidifying air.
3. Provides airway
4. Ventilation

   Breathing = "pulmonary ventilation"

Pulmonary means related to the lungs

Two phases

- Inspiration (inhalation) – air in | • Expiration (exhalation) – air out

Muscle of breathing

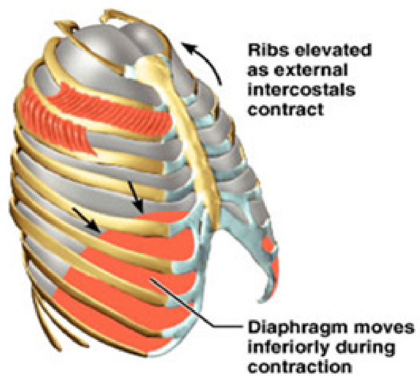
- Intercostal muscles
- Diaphragm

Diaphragm: Dome shaped, separates thoracic and abdominal cavities,

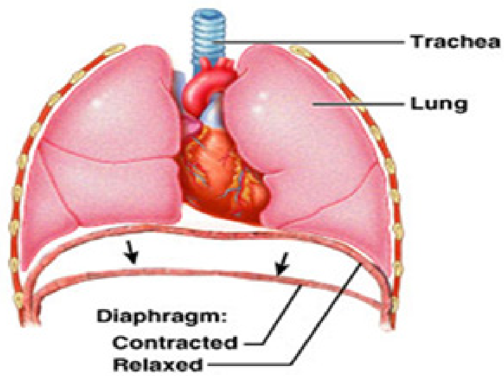
Contraction shortens the muscles enlarging the thoracic cavity while relaxation decreases the thoracic cavity pressure. Supplied by Phrenic n.

The Intercostal muscles: 11 pairs, occupy the space between the 12 ribs.

Internal intercostal muscles: extends downwards & backwards from the lower border off the ribs above to the upper border of the ribs.



(d) Inspiration



(a) Superoinferior expansion

During deep or forced inspiration, additional muscles are recruited:

Accessory Muscles of Respiration

Scalene muscles- a group of three pairs of muscles in the lateral neck

Sternocleidomastoid (some of these "accessory muscles" of ventilation are visible to an observer; it usually tells you that there is respiratory distress – working hard to breathe)

Atmospheric pressure due to the weight of the air is the force that moves air into the lungs

At sea level, atmospheric pressure is 760 millimeters of mercury (mm Hg)

Moving the plunger of a syringe causes air to move in or out

Air movements in and out of the lungs occur in much the same way

Intra-alveolar pressure decreases to about 758 mmHg as the thoracic cavity enlarges due to diaphragm downward movement caused by impulses carried by the phrenic nerves.

Atmospheric pressure then forces air into the airways

Major Events in Inspiration

1. Nerve impulses travel on phrenic nerves to muscle fibers in the diaphragm, contracting them
2. As the dome shaped diaphragm moves downward, the thoracic cavity expands
3. At the same time, the external intercostal muscles may contract, raising the ribs and expanding the thoracic cavity further
4. The intra-alveolar pressure decreases
5. Atmospheric pressure, greater on the outside, forces air into the respiratory tract through the air passages
6. The lungs fill with air.

Expiration

Quiet expiration in healthy people is chiefly passive.

Inspiratory muscles relax

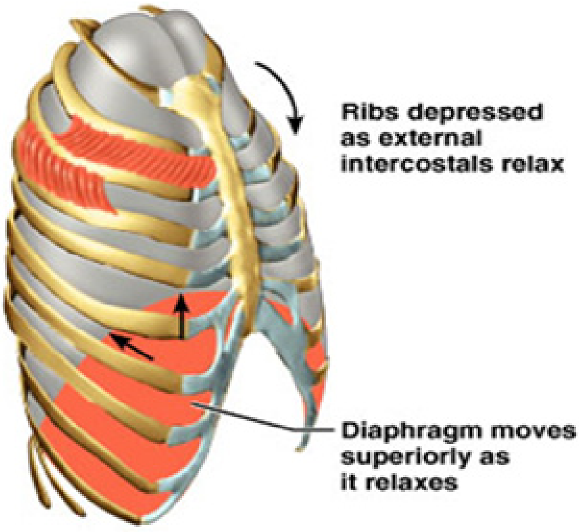
Rib cage drops under force of gravity

Relaxing diaphragm moves superiorly (up)

Elastic fibers in lung recoil

Volumes of thorax and lungs decrease simultaneously, increasing the intra thoracic pressure.

Air is forced out



Expiration

The forces responsible for normal resting expiration come from elastic recoil of lung tissues and from surface tension.

These factors increase the intra-alveolar pressure about 1 mm Hg above atmospheric pressure forcing air out of the lungs

Major Events in Expiration

1. The diaphragm and external respiratory muscles relax
2. Elastic tissues of the lungs and the thoracic cage, stretched during inspirations, suddenly recoil, and the surface tension collapses the alveolar walls
3. Tissues recoiling around the lungs increases the inta-alveolar pressure
4. Air is squeezed out of the lungs

Physiological Variables Affecting Breathing

1. Airway resistance can sometimes affect airflow. It's normally insignificant due to the relatively large diameters of the air passages, low viscosity of air, and incredible amount of branching. However, during severe allergic reactions histamine causes contraction of bronchiolar smooth muscle. This decreases airway volume and increase airway resistance.
2. Compliance refers to the ability of the lungs to expand. The ease with which the lungs can expand facilitates efficient ventilation. Replacement of the elastic lung tissue with inelastic scar tissue as well as reduced surfactant production will decrease lung compliance.
3. Elasticity: refers to the ability of the lung to return to its normal shape after each breath. Loss of elasticity necessitates forced expiration & increased effort on inspiration.

Lung Capacities

Not all inspired air is exchanged b/c not all of it reach the alveoli. An example is the air that occupies the conducting zone. B/c that air cannot be exchanged, structures in the conducting zone are collectively referred to as the anatomical dead space.

Any alveoli not involved in exchange (due to collapse or obstruction) comprise the alveolar dead space. The combination of anatomical and alveolar dead spaces is known as the total dead space.

Alveolar Ventilation

The volume of new atmospheric air moved into alveoli per minute is Alveolar ventilation= (TV-anatomical dead space) X Respiratory rate

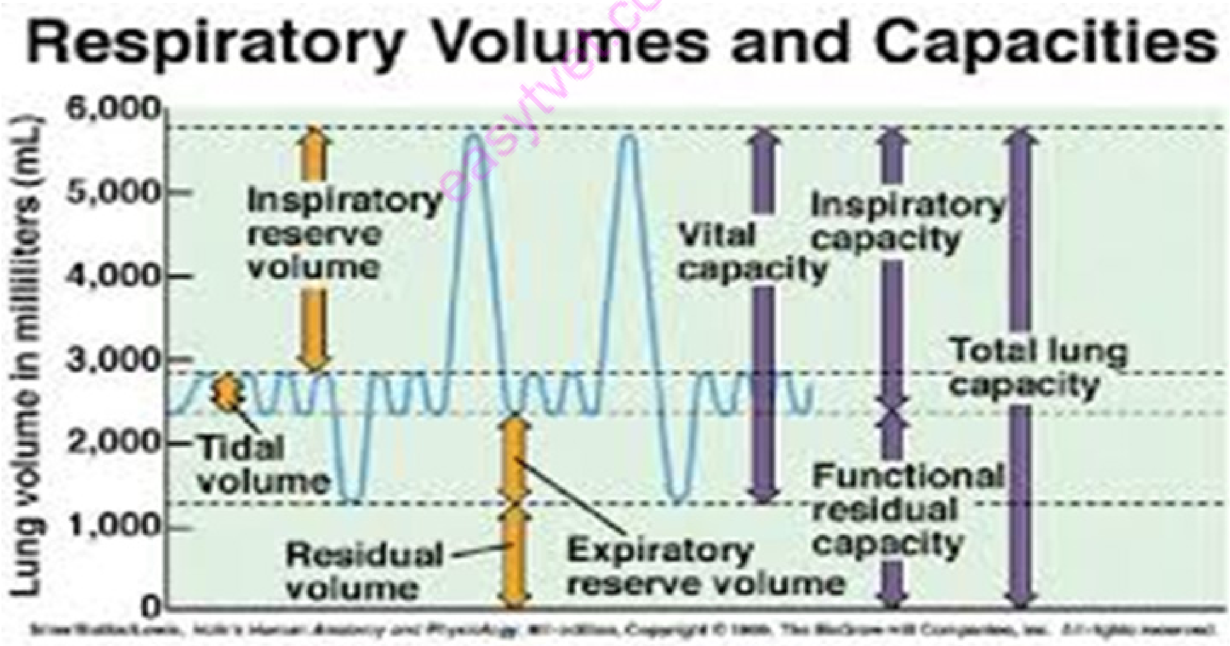
= (500 - 150) ml x 15 per minute

= 5.25 litres per minute

Respiratory Air Volumes and Capacities

Different degrees of effort in breathing move different volumes of air in and out of the lungs. A normal respiratory cycle is about 15 cycle per minute.

This measurement of volumes is called spirometry.



Lung Volumes and Capacities

The tidal volume (TV), about 500 mL, is the amount of air inspired during normal, relaxed breathing.

The inspiratory reserve volume (IRV), about 3,100 mL, is the additional air that can be forcibly inhaled after the inspiration of a normal tidal volume.

The expiratory reserve volume (ERV), about 1,200 mL, is the additional air that can be forcibly exhaled after the expiration of a normal tidal volume.

Residual volume (RV), about 1,200 mL, is the volume of air still remaining in the lungs after the expiratory reserve volume is exhaled.

Summing specific lung volumes produces the following lung capacities:

The total lung capacity (TLC), about 6,000 mL, is the maximum amount of air that can fill the lungs (TLC = TV + IRV + ERV + RV)..

The vital capacity (VC), about 4,800 mL, is the total amount of air that can be expired after fully inhaling (VC = TV + IRV + ERV = approximately 80 percent TLC). The value varies according to age and body size.

The inspiratory capacity (IC), about 3,600 mL, is the maximum amount of air that can be inspired (IC = TV + IRV).

The functional residual capacity (FRC), about 2,400 mL, is the amount of air remaining in the lungs after a normal expiration (FRC = RV + ERV).

Composition of air

Air is a mixture of gases: nitrogen, oxygen, CO_2, water vapour and some inert gases.

Each gas in a mixture of gases exerts a certain amount of pressure, which is known as the partial pressure for that gas. PO_2, PCO_2.

Composition of inspired and expired air

	Inspired air &	Expired air &
Oxygen	21	16
Carbon dioxide	0.04	4
Nitrogen	78	78
Water vapor	variable	variable

Gas Transport

Blood transports O2 and CO2 between the lungs and the body cells.

As the gases enter the blood, they dissolve in the plasma or chemically combine with other atoms or molecules.

Oxygen Transport

Oxygen is carried by blood in 2 ways.

1.5% of the O_2 is simply dissolved in plasma.

The other 98.5% is bound to hemoglobin within red blood cells in the form of oxyhemoglobin.

Chemical bonds between O_2 and hemoglobin are relatively unstable.

Oxyhemoglobin releases O_2 into the body cells.

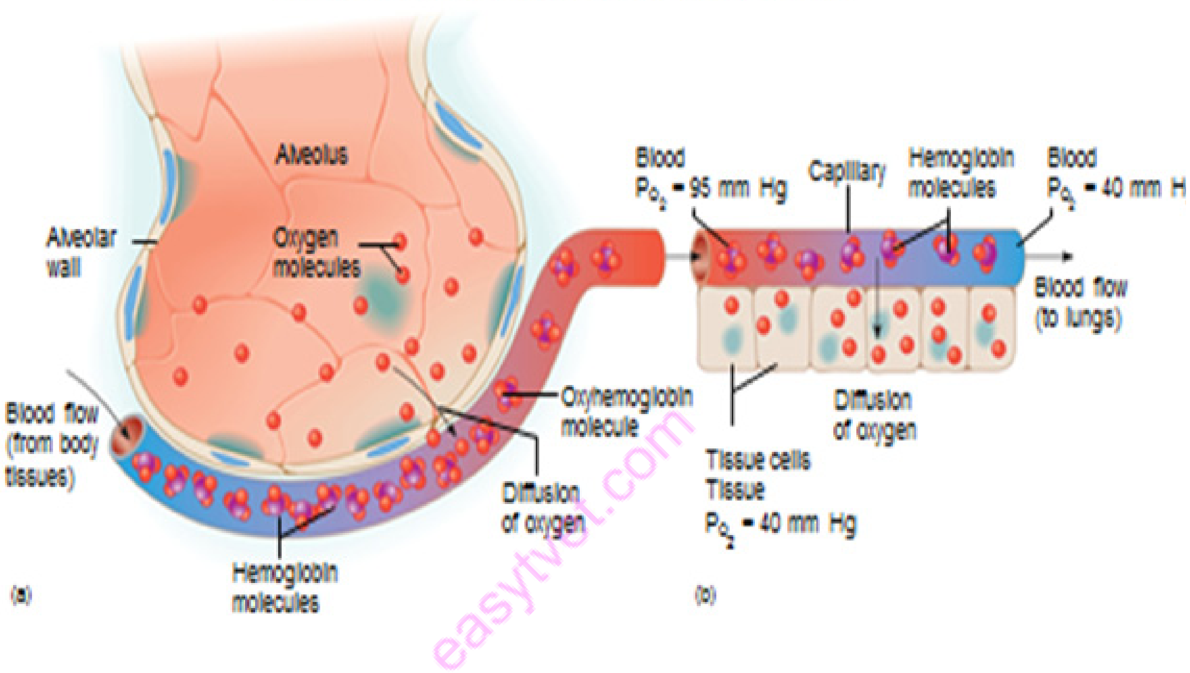
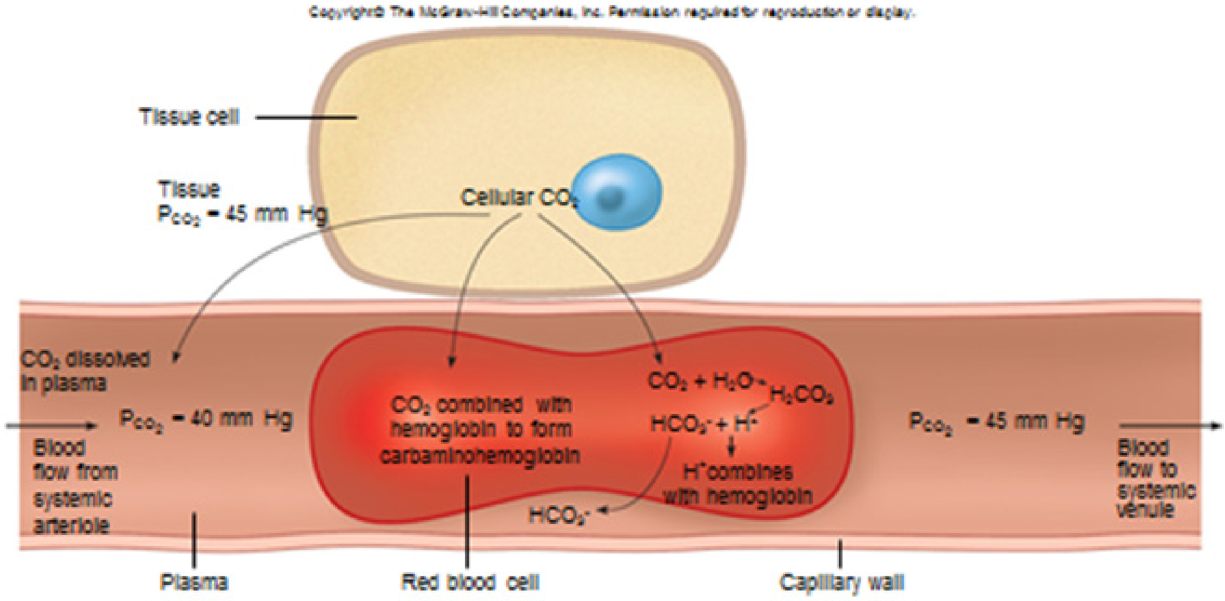


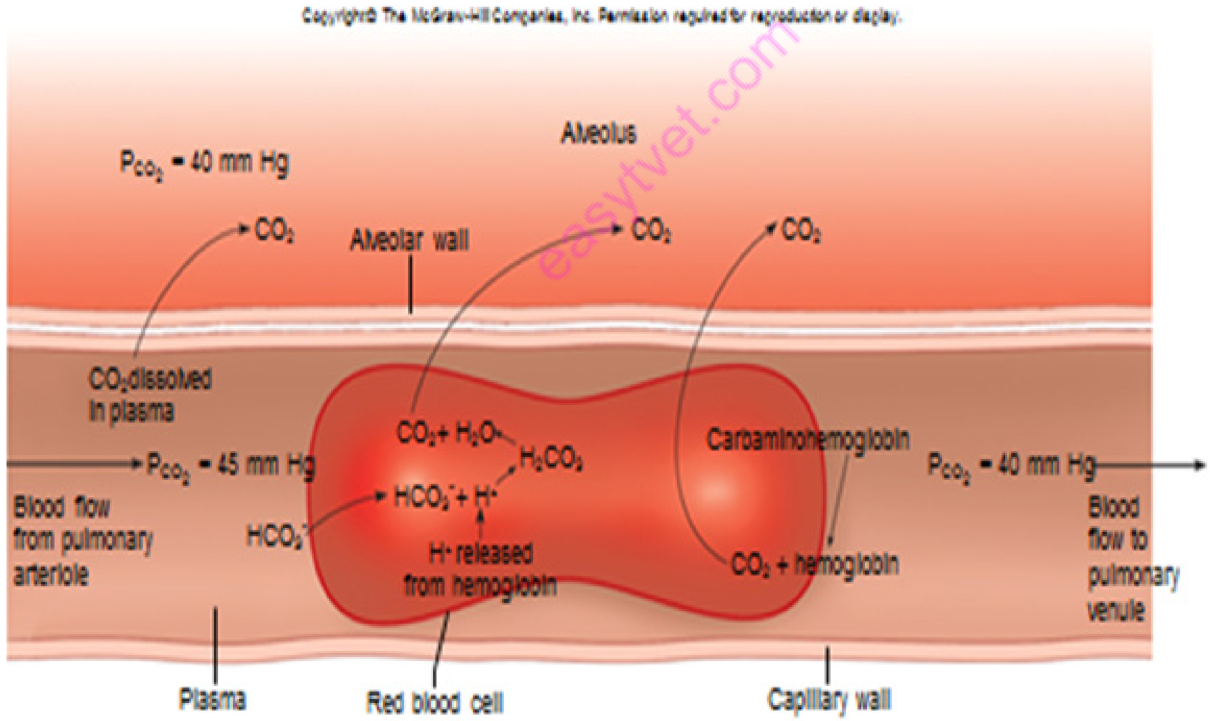
Figure shows the diffusion of oxygen gas at the alveoli and at the tissues

Carbon Dioxide Transport

- Blood flowing through capillaries gains CO_2 because the tissues have a high Pco_2.
- The CO_2 is transported to the lungs in one of three forms:
  - o As CO_2 dissolved in plasma
  - o As part of a compound with hemoglobin--carbaminohemoglobin
  - o As part of a bicarbonate ion



The figure above shows the diffusion of carbon dioxide gas in the tissues



The figure above shows the diffusion of carbon dioxide gas at the alveoli.

Control of Breathing

Normal breathing is a rhythmic, involuntary act that continues when a person is unconscious

Respiratory muscles can be controlled as well voluntarily

Respiratory Areas

Groups of neurons in the brainstem comprise the respiratory areas that control breathing

Respiratory areas also adjust the rate and depth of breathing

The respiratory areas include:

- Respiratory center of the medulla
- Respiratory group of the pons.

Neural Control of Ventilation

Chemo-Receptors

Central in the medulla---When PCO_2 rises (Hypercapnia), they stimulate the respiratory centre, to increase lung respiration and lower arterial PCO_2.

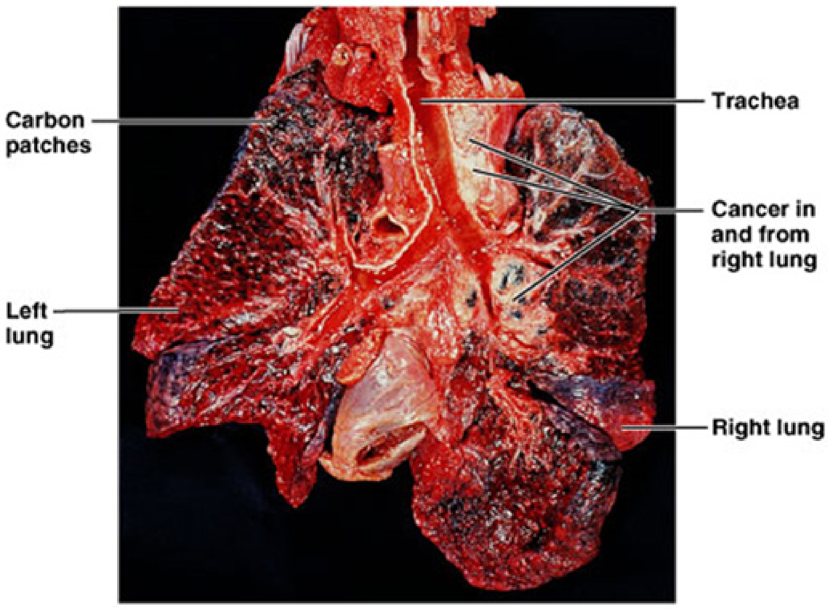
This sensitivity is important in controlling blood gas levels.

Factors Affecting Breathing

A number of factors affect breathing rate and depth including:

- Partial pressure of oxygen (Po_2)
- Emotional state
- Level of physical activity
- Partial pressure of carbon dioxide (Pco_2)
- Drugs e.g. sedatives
- Chemoreceptors

You might want to think twice about smoking….



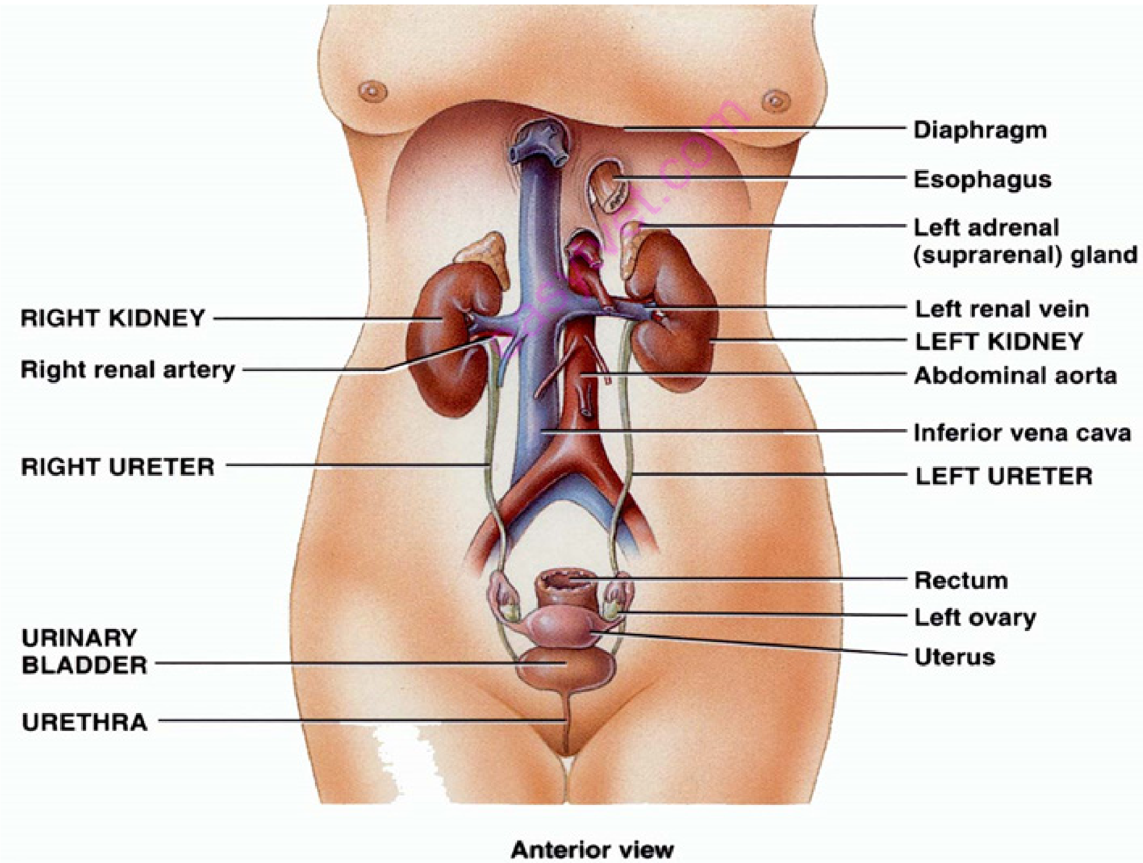
THE RENAL SYSTEM

GUT

- Genital urinary system/tract (GUT) is the main excretory organ.
- Excretion is process of eliminating wastes from the body.
- Kidney is primary excretory organ

Major Components

1. 2 kidneys – secretes urine
2. 2 ureters – conveys urine from the kidneys to the urinary bladder
3. 1 urinary bladder – collects and stores urine temporarily
4. 1 urethra – urine passes from the bladder to the exterior.



Functions of Kidneys

1. Excrete wastes in urine.
2. Regulate blood volume.
3. Regulate blood composition.
4. Regulate blood pressure.
5. Release erythropoietin.
6. Participate in vitamin D synthesis.
7. Secretion of Renin

Development of the GUT

Through by 2nd month of development

Defects includes

1. Displaced kidneys
2. Undersized
3. Cystic kidney-numerous sac-like structures containing water, pus or gas
4. One kidney
5. Horse shoe kidney- kidneys fuse together to form a horse shoe shape.

Kidneys

The paired kidneys are reddish, kidney-bean-shaped organs.

They are located above the waist between the peritoneum and the posterior wall of the abdomen.

The kidneys lie behind peritoneum on the posterior abdominal wall on either side of vertebral column. Extends from T12 to L3

They are retroperitoneal.

The right kidney is slightly lower than the left due to the presence of the liver.

External Anatomy Of The Kidneys

A typical kidney is 10-12 cm long, 5-7 cm wide and 3 cm thick. Weighs 150g

The concave medial border of the kidneys faces the vertebral column.

Embedded and held in position by a mass of fat.

Enclosed by a connective tissue-renal fascia.

Relations

Right Kidney

Superiorly-rt adrenal gland

Anteriorly- rt lobe of the liver, duodenum, hepatic flexure of the colon

Posteriorly- diaphragm, muscles of the posterior abdominal wall

Left Kidney

Superiorly- left adrenal gland

Spleen, stomach, pancreas, jejunum and splenic flexure of the colon

Posteriorly- diaphragm, muscles of the posterior abdominal wall

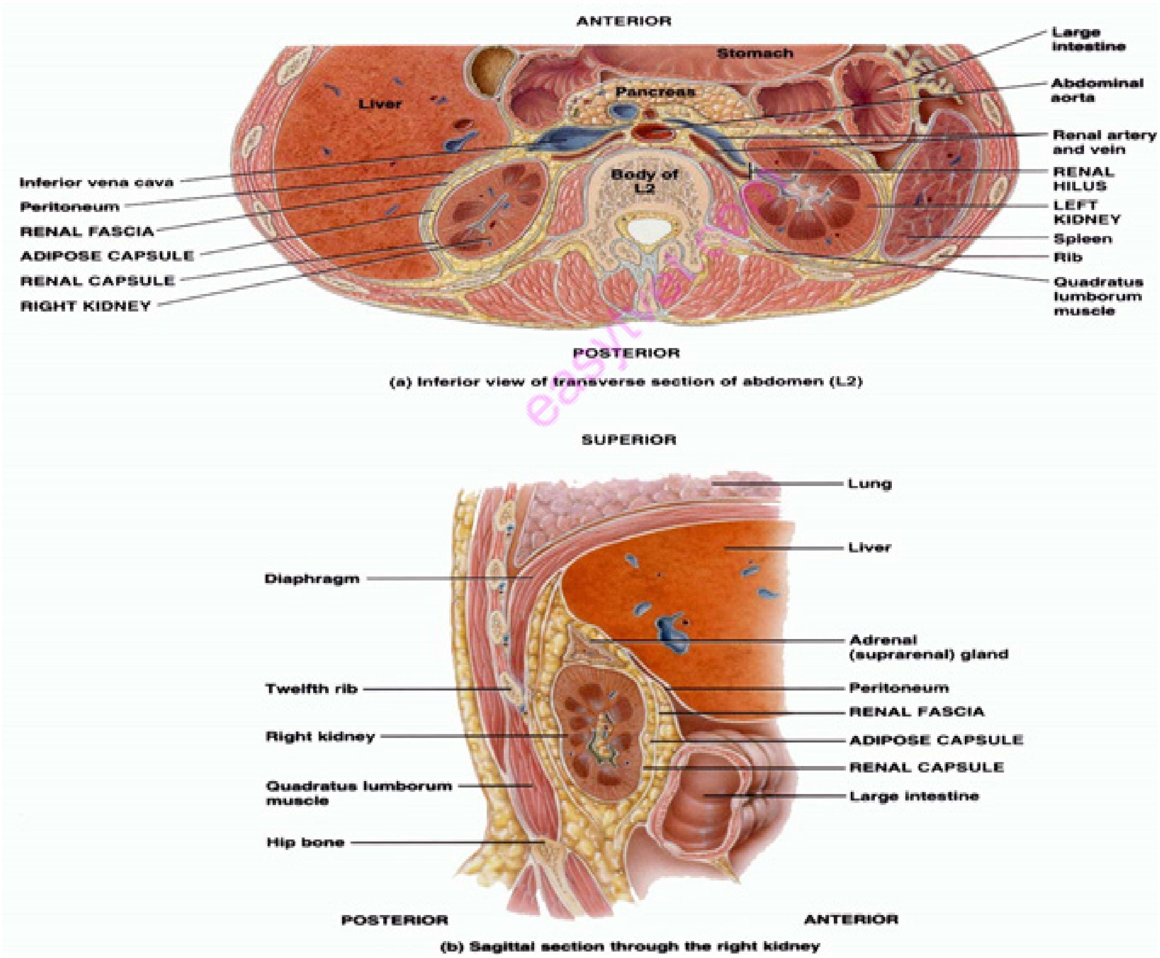
External Anatomy Of The Kidneys

Layers of tissue around the kidneys

Renal capsule – deep layer. Smooth transparent sheet of dense irregular connective tissue. Maintains the shape of the kidney.

Adipose capsule – mass of fatty tissue. Protects the kidney from trauma and holds it in place.

Renal fascia – superficial layer. Anchors the kidney to the surrounding structures and to the abdominal wall.



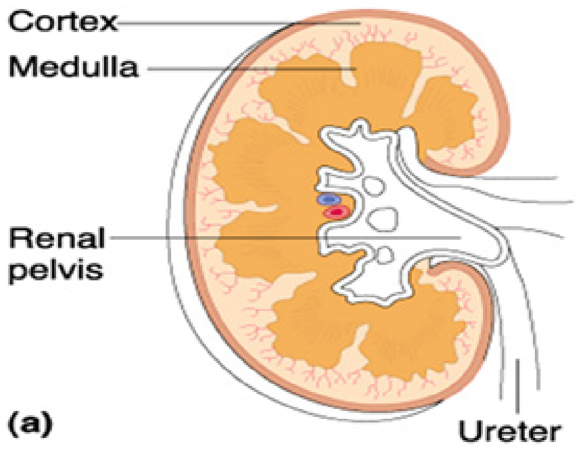
Internal Anatomy of the Kidney

A frontal section of a kidney reveals 3 regions:

Namely: 1. Renal Cortex

2. Renal Medulla

3. Renal Pelvis



Cortex has parts of nephron

Medulla most part of nephron found hear

Nephrons drain into collecting duct which form pyramids.

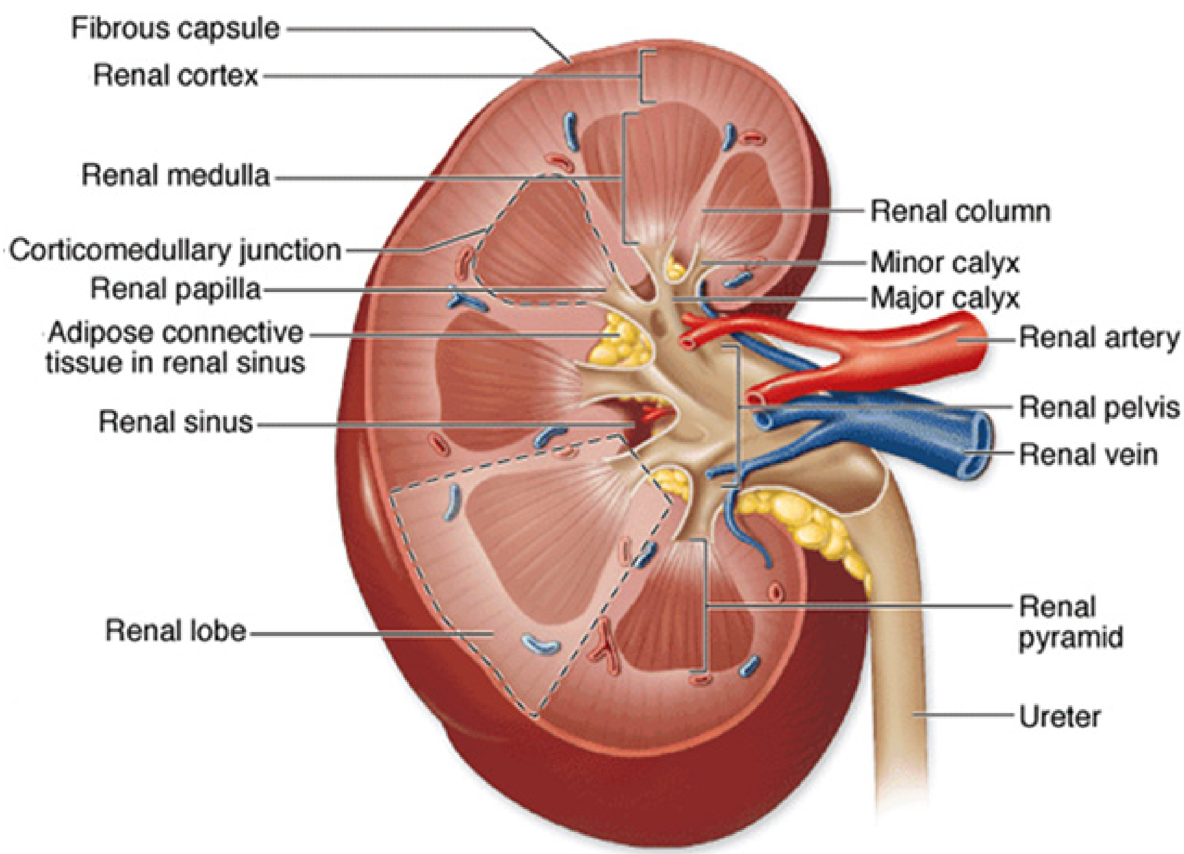
Pyramid end into papilla that drain into renal pelvis that drains into ureters.

Hilum: concave medial border of the kidneys where renal blood and lymph vessels, ureters and nerves enter.

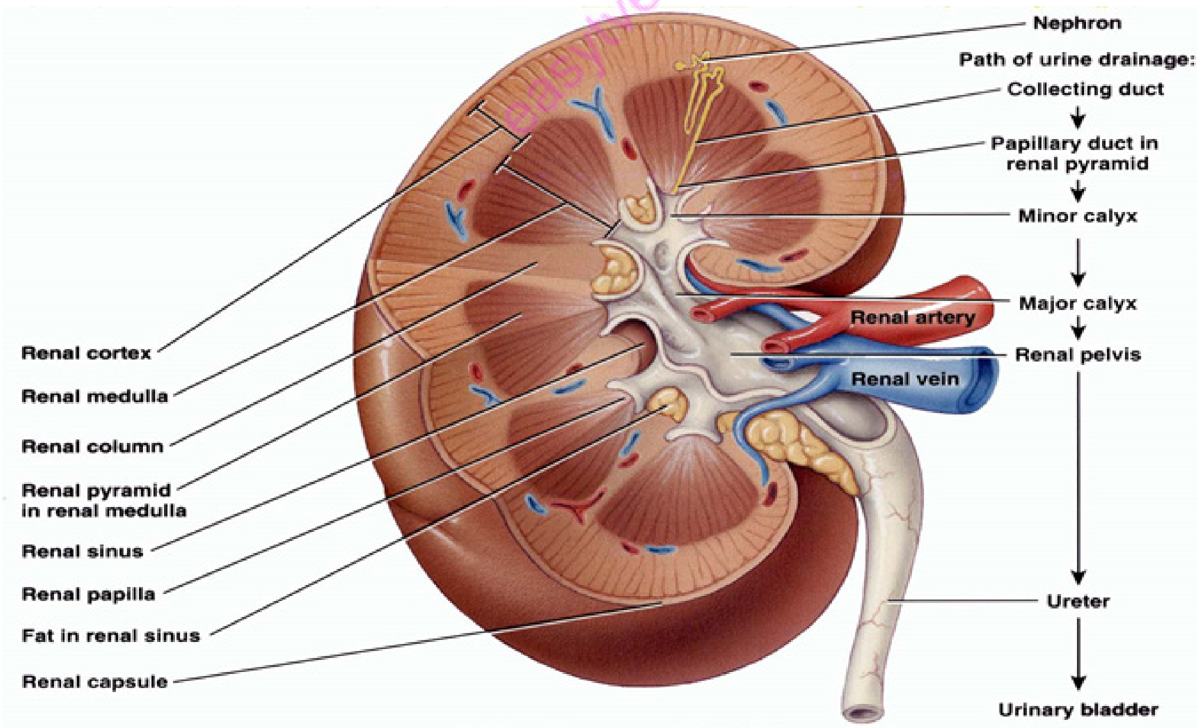
Renal pelvis: funnel shaped; it collects urine formed by the kidneys

The nephrons of the kidneys produces urine.

It flows from the renal papilla, to the minor calyx, to the major calyx, to the renal pelvis, and finally exits the kidney within the ureter.



Right kidney, coronal section



(a) Frontal section of right kidney

Blood Supply Of The Kidneys

The kidneys have abundant blood vessels.

The kidneys remove wastes from the blood and regulate its volume and ionic composition.

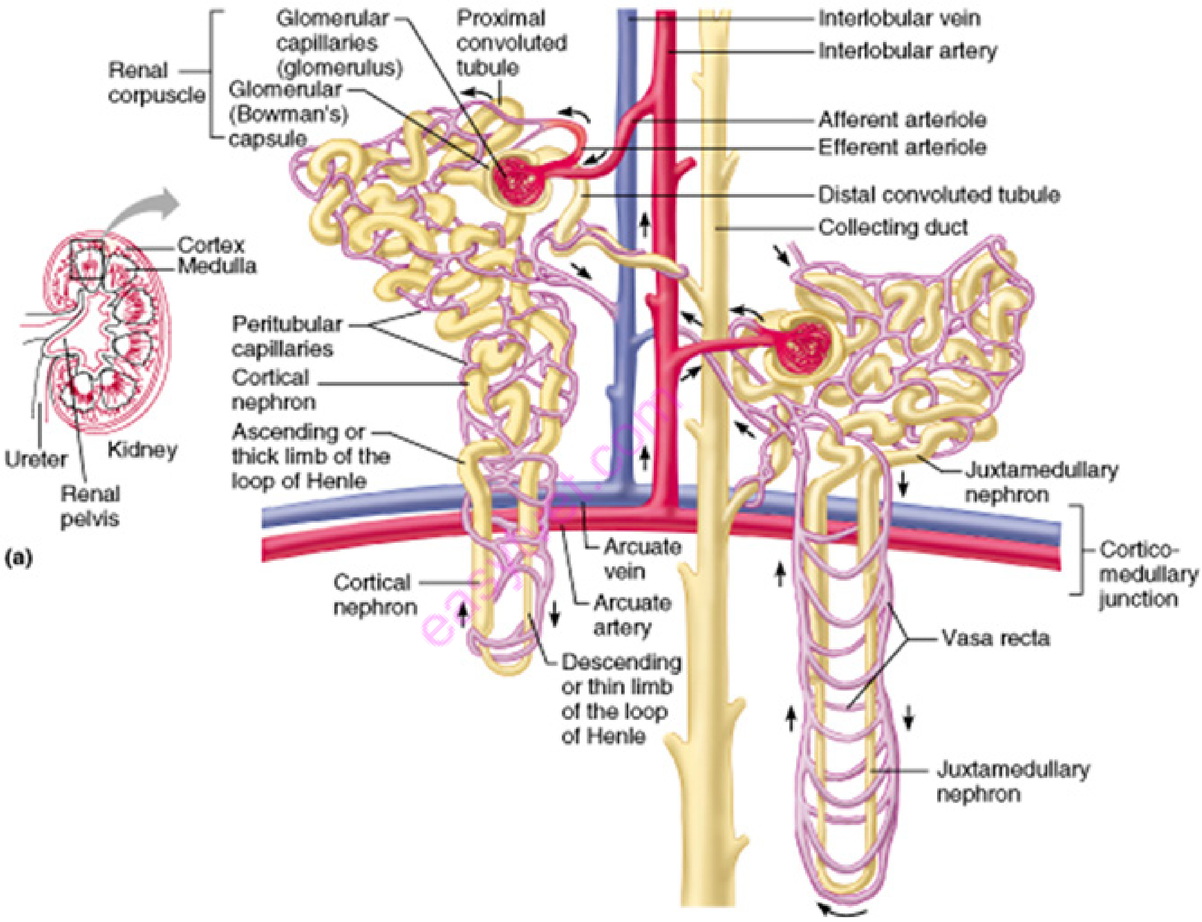
Right and left renal arteries supply the kidneys which divides to form the Afferent arterioles.

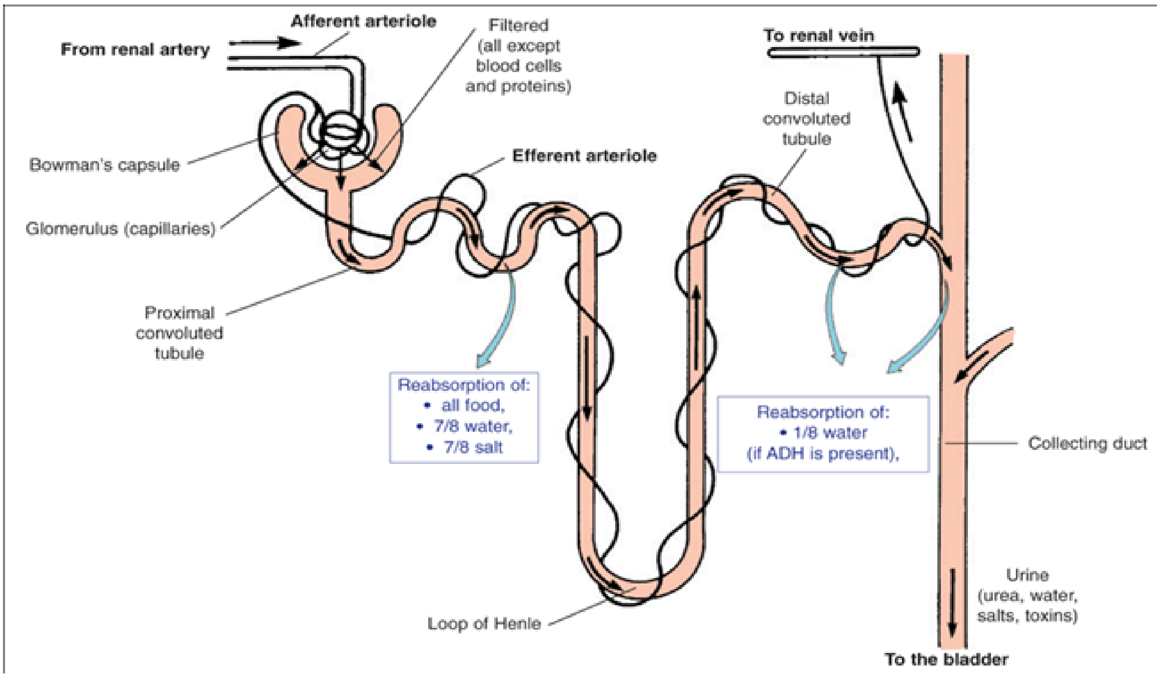
The afferent arteriole divides into a ball of capillaries called a glomerulus.

The glomerular capillaries reunite to form the efferent arteriole.

The efferent arteriole divides to form the peritubular capillaries.

These reunite to eventually form the renal vein.



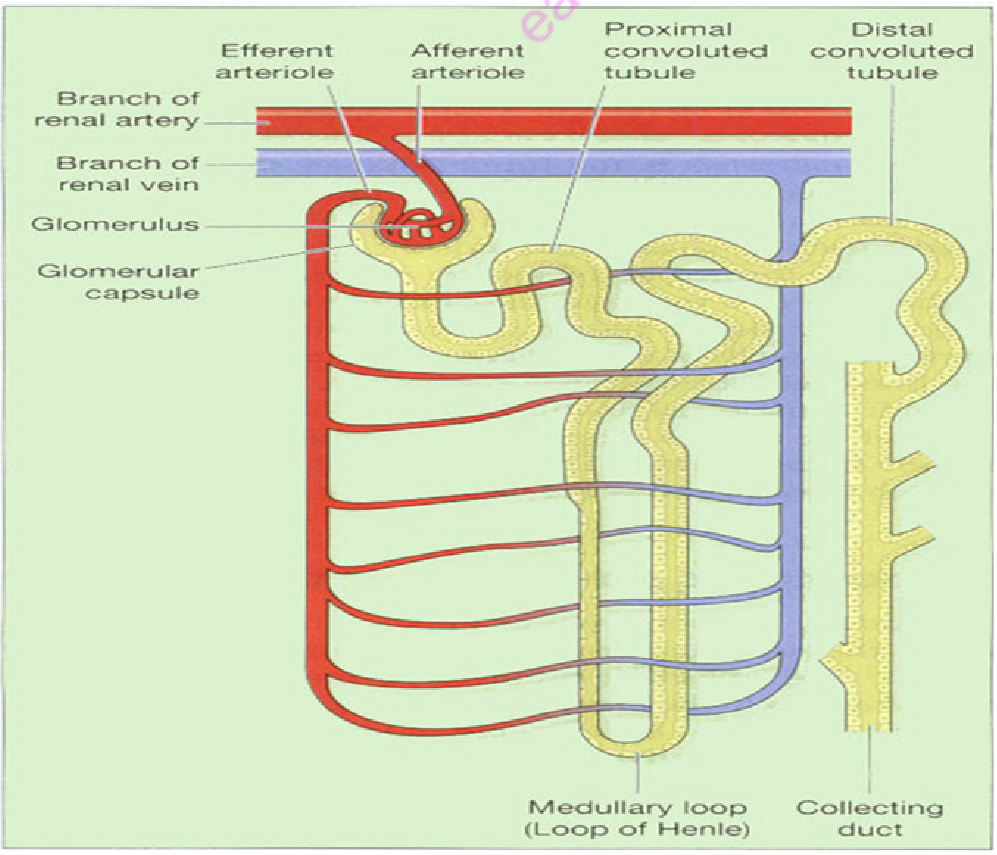


Nephron

Nephrons are the functional units of the kidneys.

Two main parts:

- **Renal corpuscle** – where blood plasma is filtered.
- **Renal tubule** – into which the filtered fluid passes.

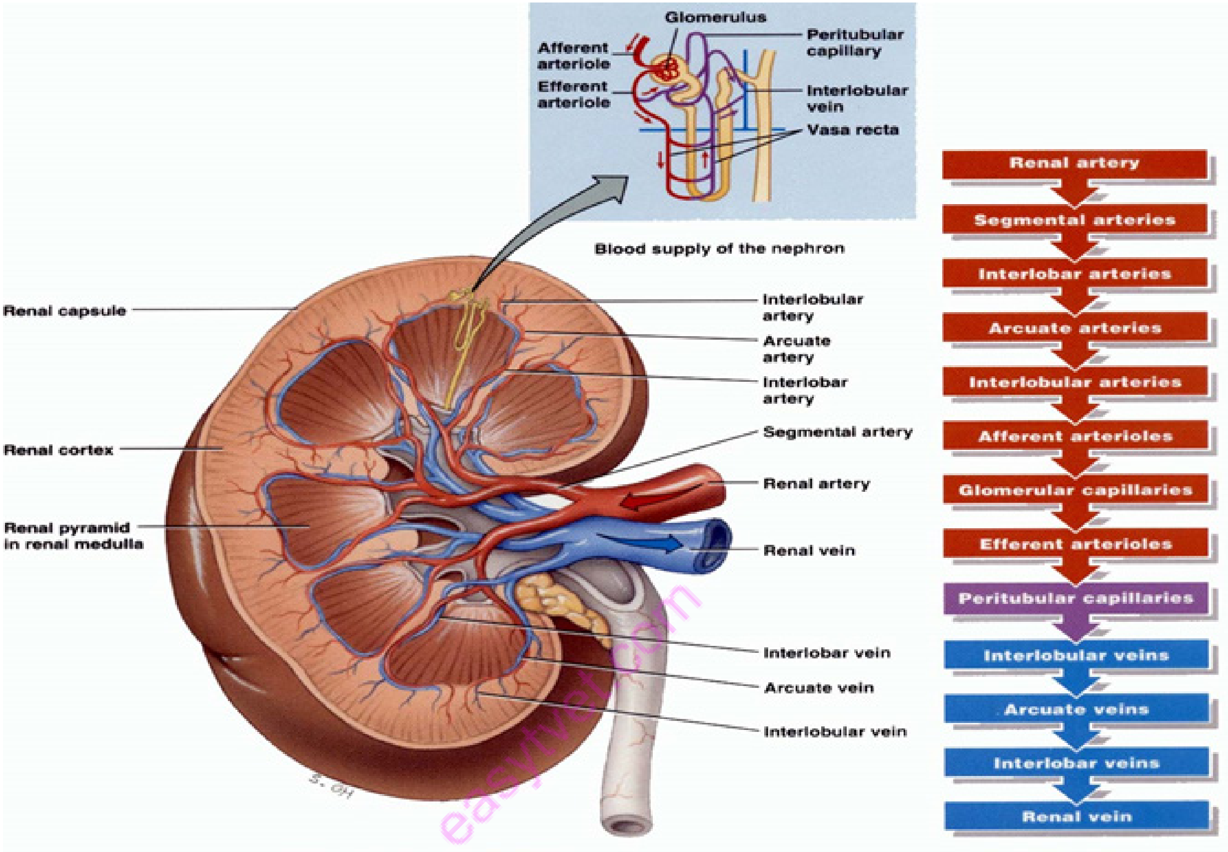


1. Renal Corpuscle

Two components:

Glomerulus – a capillary network.

Glomerular (bowman's) capsule – a double walled epithelial cup that surrounds the glomerular capillaries.



(a) Frontal section of right kidney (b) Path of blood flow

2. Renal Tubule

Three main sections:

- Proximal convoluted tubule.
- Loop of Henle (nephron loop).
- Distal convoluted tubule.

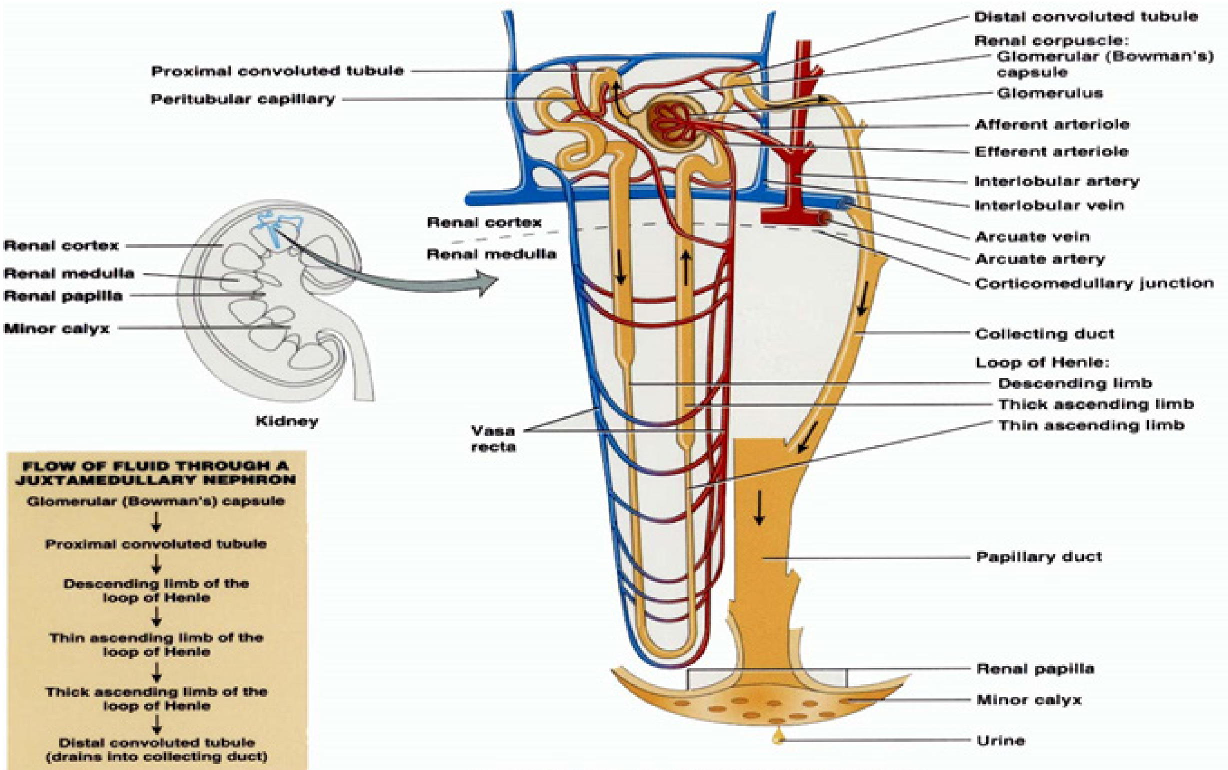
The distal convoluted tubules of several nephrons empty into a single collecting duct.

Collecting ducts then unite and converge into papillary ducts, which drain into minor calyces.

1 kidney has approximately 1 million nephrons.

Loop of Henle

The loop of Henle connects the proximal and distal convoluted tubules. It consists of a descending limb and an ascending limb.



(b) Juxtamedullary nephron and vascular supply

Glomerular Capsule

The glomerular (bowman's) capsule consists of visceral and parietal layers with a capsular (bowman's) space in between.

Visceral layer – modified simple squamous epithelial cells called podocytes.

Parietal layer – simple squamous epithelium.

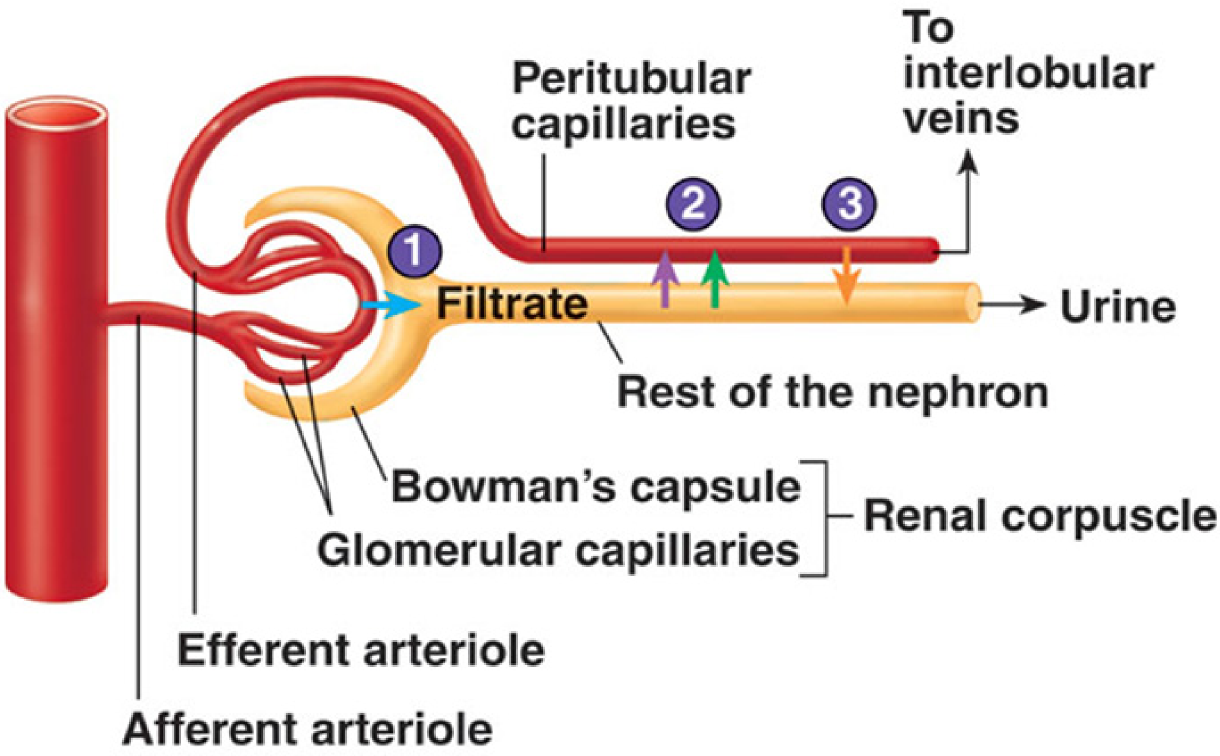
Fluid filtered from the glomerular capillaries enters the capsular space.

Kidney Physiology

- Urine formation and the simultaneous adjustment of blood composition involves

Three major processes:

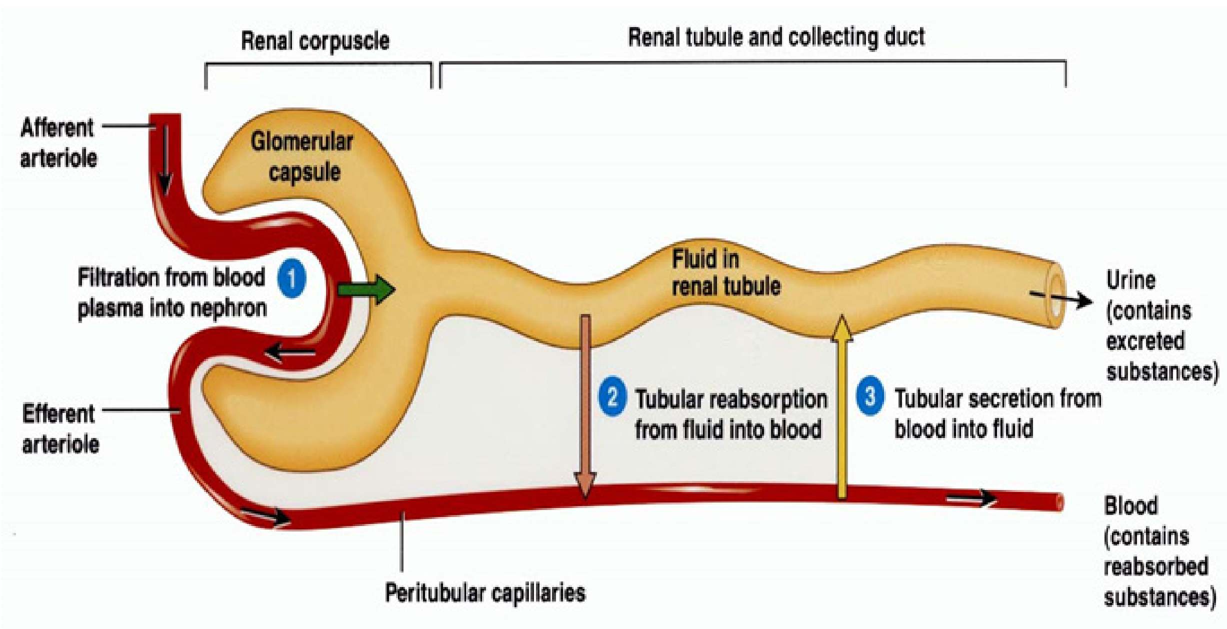
1. Glomerular filtration
2. Tubular reabsorption
3. Secretion



Filtration is the movement of substances from the glomerulus into the lumen of bowman's capsule. This forms filtrate.

Reabsorption is the movement of substances, solutes and water, across the walls of nephron tubule into the capillaries associated with the nephron.

Secretion is the transfer of materials from peritubular capillaries to the renal tubular lumen; it is the opposite process of reabsorption.



Glomerular Filtration

Glomerular filtrate – the fluid that enters the capsular space.

Filtration fraction – the fraction of blood plasma in the afferent arterioles of the kidneys that becomes filtrate (typically 16-20%).

Filtration Membrane

The endothelial cells of the glomerular capillaries and the podocytes, which encircle the capillaries, form a leaky barrier known as the filtration membrane.

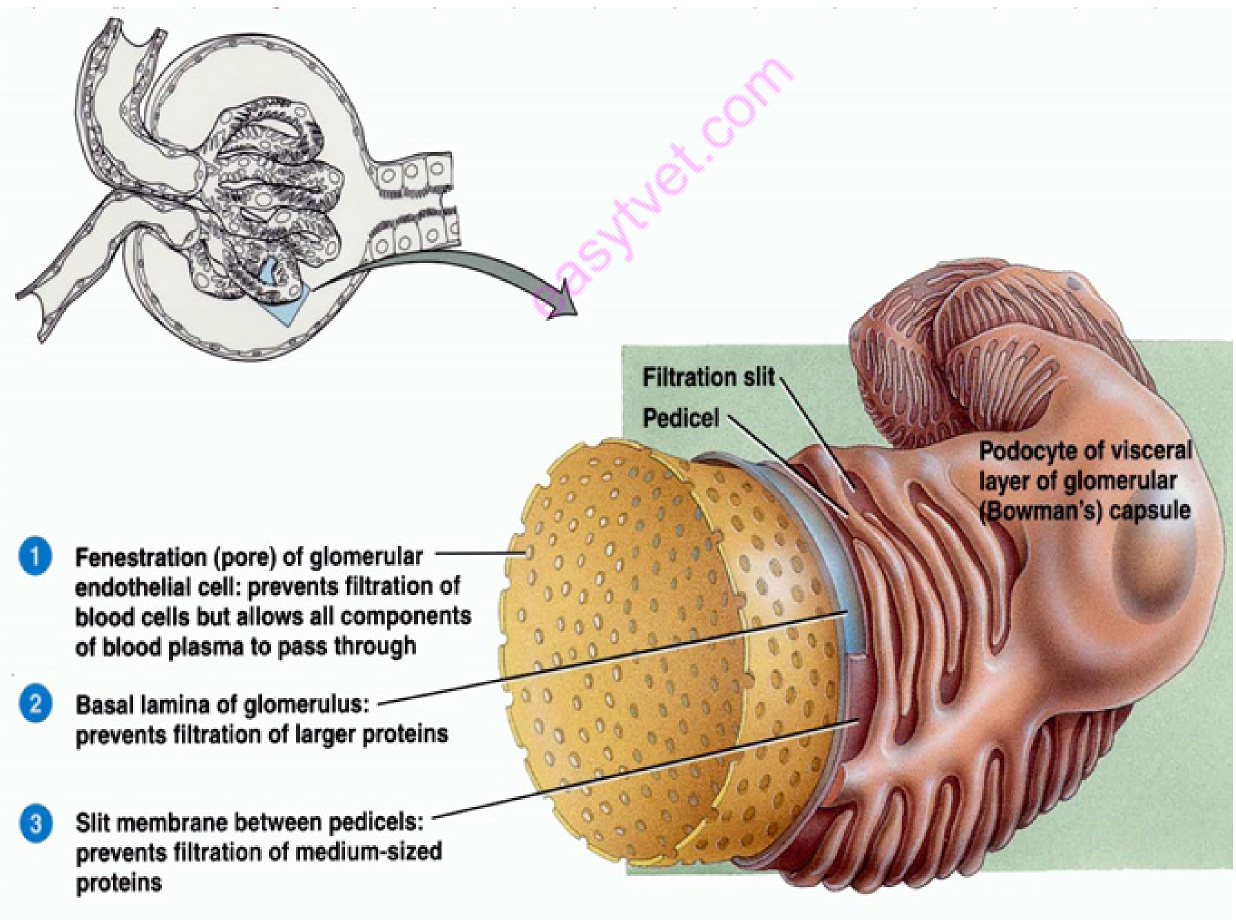
Fenestrations (pores) in the glomerular epithelial cells cause them to be quite leaky.

Filtration slits are spaces between the pedicels (footlike processes from the podocytes), which allow passage of molecules smaller than 6-7 nm.

Water, glucose, vitamins, amino acids, very small plasma proteins, ammonia, urea, and ions can pass through.

Albumin is too large to easily pass through the slits.

Filtration utilizes pressure to drive fluids and solutes through a membrane.



(a) Details of filtration membrane

Factors That Affect Filtration

Glomerular capillaries present a large surface area for filtration because they are long and extensive.

The filtration membrane is thin and porous. Glomerular capillaries has fenestrations.

Glomerular capillary blood pressure is high due to a small diameter of the efferent arteriole resulting in backflow of blood.

Net Filtration Pressure

Three main pressures determine the level of glomerular filtration.

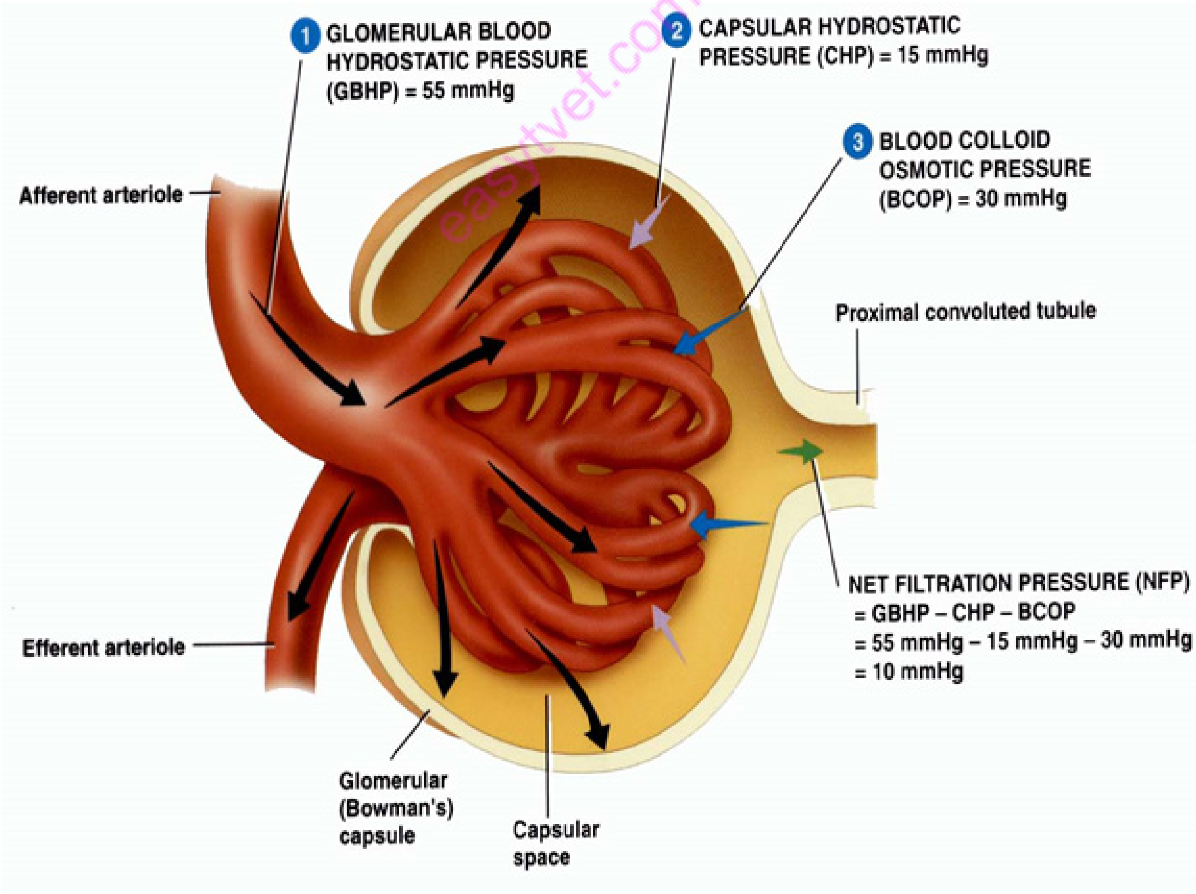
Capillary hydrostatic pressure (CHP) – promotes filtration. 55 mmHg.

Filtrate hydrostatic pressure (FHP) – opposes filtration. Hydrostatic pressure exerted by fluid already in the capsular space (back pressure). 15 mmHg.

Blood osmotic pressure (BOP) – opposes filtration. Plasma proteins (albumin, fibrinogen, globulins) draw fluid into capillaries. 30 mmHg.

Net filtration pressure (NFP) = CHP – FHP – BOP.

NFP = 55mmhg – 15mmhg – 30mmhg = 10mmhg.



Glomerular Filtration Rate

The amount of filtrate formed in all the renal corpuscles of both kidneys each minute is the glomerular filtration rate (GFR)---125ml/min

If the GFR is too high, substances may pass too quickly through the tubules that they are not reabsorbed.

If the GFR is too low, nearly all the filtrate may be reabsorbed resulting in inadequate excretion.

Renal autoregulation of gfr

To maintain a stable GFR, the kidney regulates the diameter of the afferent arteriole.

Therefore, when B.P. decreases the vessel dilates, and when B.P. increases the vessel constricts.

This results in a stable G.F.R.

Tubular reabsorption

The proximal convoluted tubules are the most active in tubular reabsorption.

All glucose, lactate, and amino acids are reabsorbed in this area.

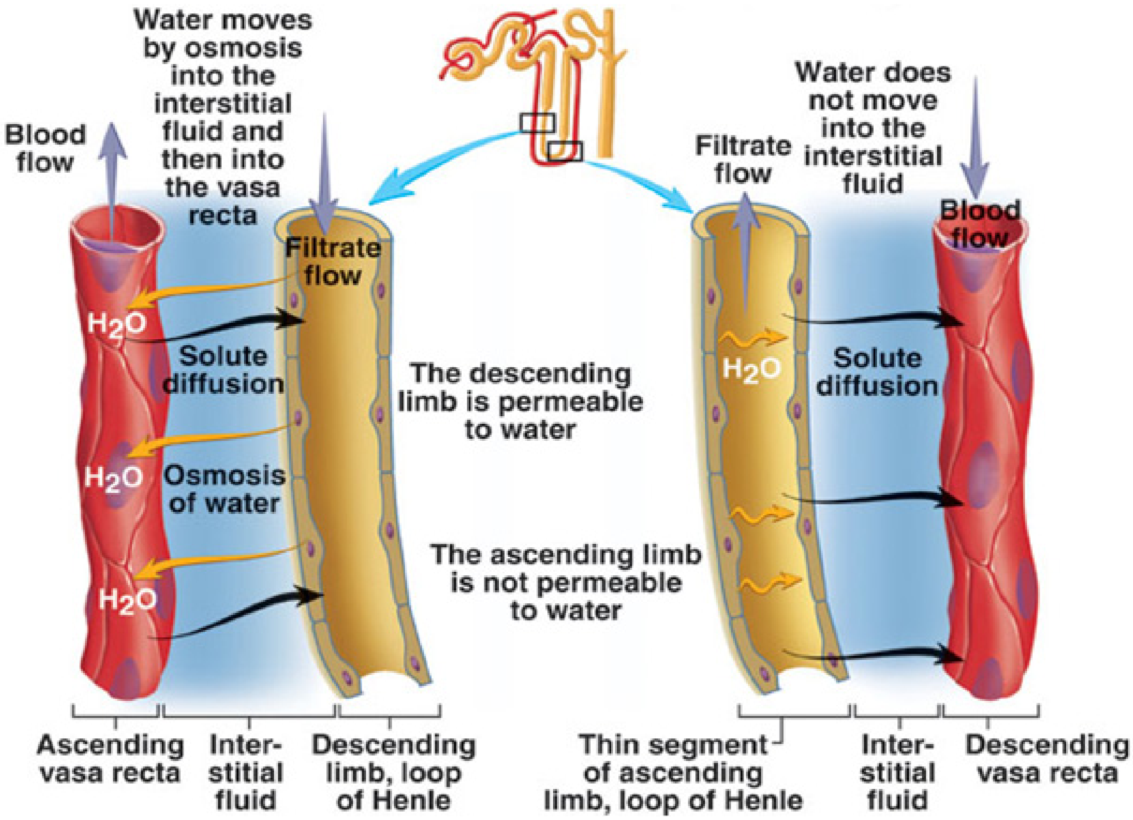
About 65% of sodium, 70% of water, are also reabsorbed.

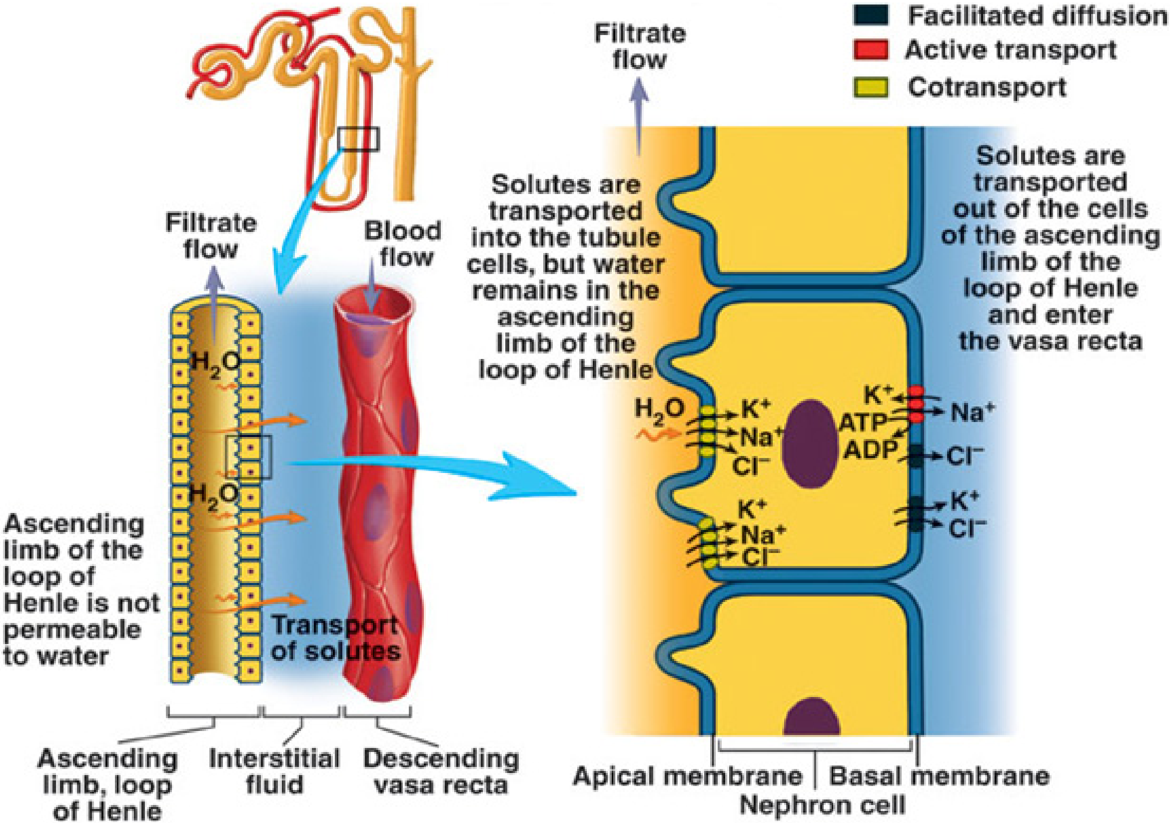
90% of bicarbonate ions, 50% of chloride ions, and 55% of potassium are reabsorbed in the proximal convoluted tubules.

This large amount of tubular reabsorption associated with the PCT, results in the GFR being reduced from 120 ml/min to about 40 ml/min.

Tubular reabsorption from the loop of Henle results in 10% of water being reabsorbed from the descending limb, 30% of potassium ions, 20% of sodium, and 35% of chloride from the ascending limb.

Reabsorption in loop of henle





Fluids enter the distal convoluted tubules at a rate of about 25 ml/min because about 80% of the water in the filtrate has been reabsorbed.

As fluid flows through the DCT, sodium and chloride are reabsorbed.

By the time fluids reaches the end of the DCT, about 90% of the filtered solutes and water has been returned to the blood.

Hormonal Regulation of Tubular Reabsorption & Secretion

1. Parathyroid hormone:

Parathyroid hormone is produced by the parathyroid gland in response to low levels of Ca2+ ions in the blood. EFFECTS OF PTH: Causes the break down of the inorganic matrix of bone, releasing Ca2+ ions, Increase absorption of Ca2+ ions from the intestines and Reabsorption of Ca2+ ions from the DCT thus increasing calcium concentration in the blood.

2. Calcitonin Hormone

Calcitonin is a hormone produced by the thyroid gland in response to high levels of Ca2+ ions in the blood. ITS EFFECTS: It increases Ca2+ ion deposition into bone and Inhibit osteoclasts that breaks down bone to produce Ca2+ thus lowering Calcium concentration in the blood.

3. Aldosterone

Produced from the adrenal cortex. Increases secretion of K+ and reabsorption of Na+, Cl-. This increases reabsorption of water and increases blood volume.

4.**Antidiuretic hormone (ADH) or vasopressin**

Increases facultative/situational reabsorption of water at the distal convoluted tubule and collecting ducts.

5.**Atrial natriuretic peptide (ANP)** – secreted by the atria of the heart in response to stretch of the arterial wall. Increases excretion of Na^+ in urine (natriureses), increases urine output (diuresis) and decreases blood volume.

TUBULAR SECRETION

Tubular secretion is the movement of chemicals from the blood into the nephron.

This process can occur in the proximal or distal convoluted tubules.

This process is important for:

- Disposing of substances which were not filtered
- Removal of excess K^+
- Controlling blood PH
- Eliminating substances which have been reabsorbed.
- Most secretion occurs within the PCT.
- Substances such as neurotransmitters, bile pigment, uric acid, penicillin, atropine, morphine, H^+, and ammonia are secreted.

The DCT receives mainly K^+ and H^+ ions from the blood.

Evaluation of Kidney Function

The kidneys are evaluated by assessing the quantity of urine, the quality of urine, and the level of wastes in blood.

Urinalysis, blood urea nitrogen (BUN) test, plasma creatinine, and renal plasma clearance tests are utilized to assess kidney functioning.

Characteristics of Normal Urine

- *Volume* – 1 to 2 liters / 24 hours (varies).
- *Color* – yellow or amber, but varies with concentration and diet. Concentrated urine is darker. Diet (reddish color from beets), medications, and diseases may affect color. Kidney stones can produce blood in urine.
- *Turbidity* – transparent when freshly voided, but becomes turbid (cloudy) upon standing.
- *Odor* – mildly aromatic but becomes ammonia-like upon standing. Urine of diabetics has a fruity odor due to ketone bodies.
- *pH* – ranges between 4.6 and 8.0 (average 6.0). High protein diets increases acidity, vegetarian diets increase alkalinity.

- *Specific gravity (density)* – ranges from 1.020 to 1.030. Greater concentration of solutes yields greater specific gravity.

Water Balance and Urine Output

- Sources of body water: dietary food, & fluids; metabolic water
- Excreted through: urine, expired air, faeces and sweat
- Fluid intake and output is controlled by the kidneys
- The minimum volume of water required to excrete body waste is about 500ml per day.
- This is controlled by ADH though negative feedback mechanism.

Antiduretic Hormone (ADH)

Solute concentrations in the blood are monitored by osmoreceptors in the hypothalamus.

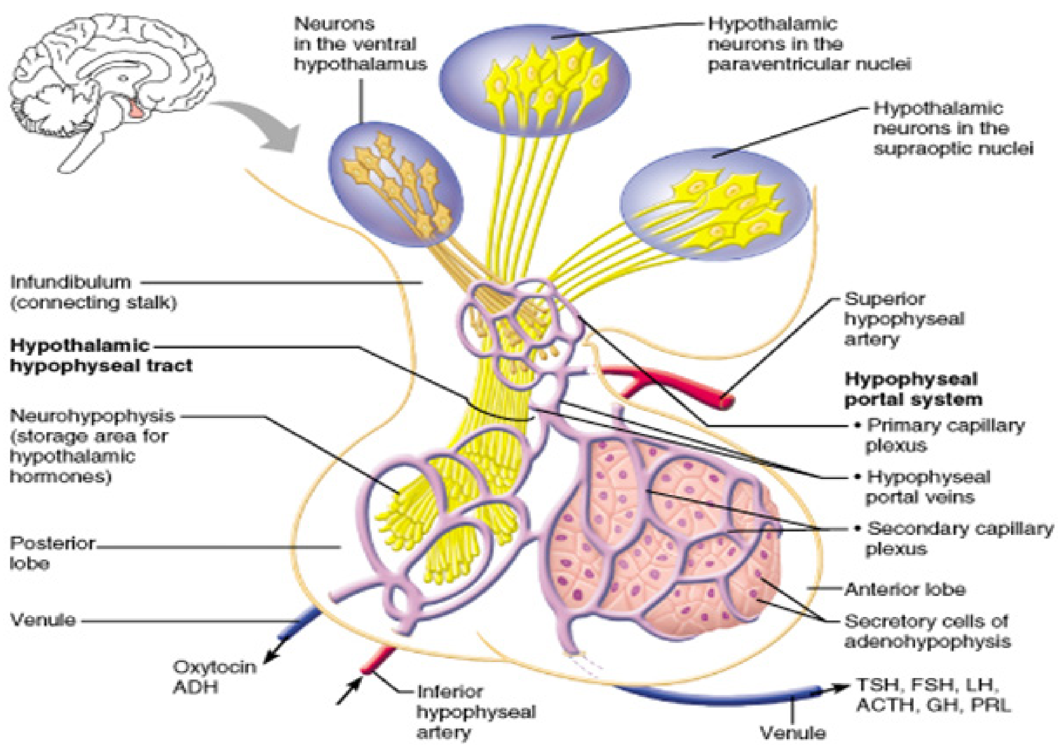
This is an example of humerol control. A humoral stimulus refers to the control of hormone release in response to changes in extracellular fluids, such as the ion concentration in the blood. For example, a rise in blood glucose levels triggers the pancreatic release of insulin.

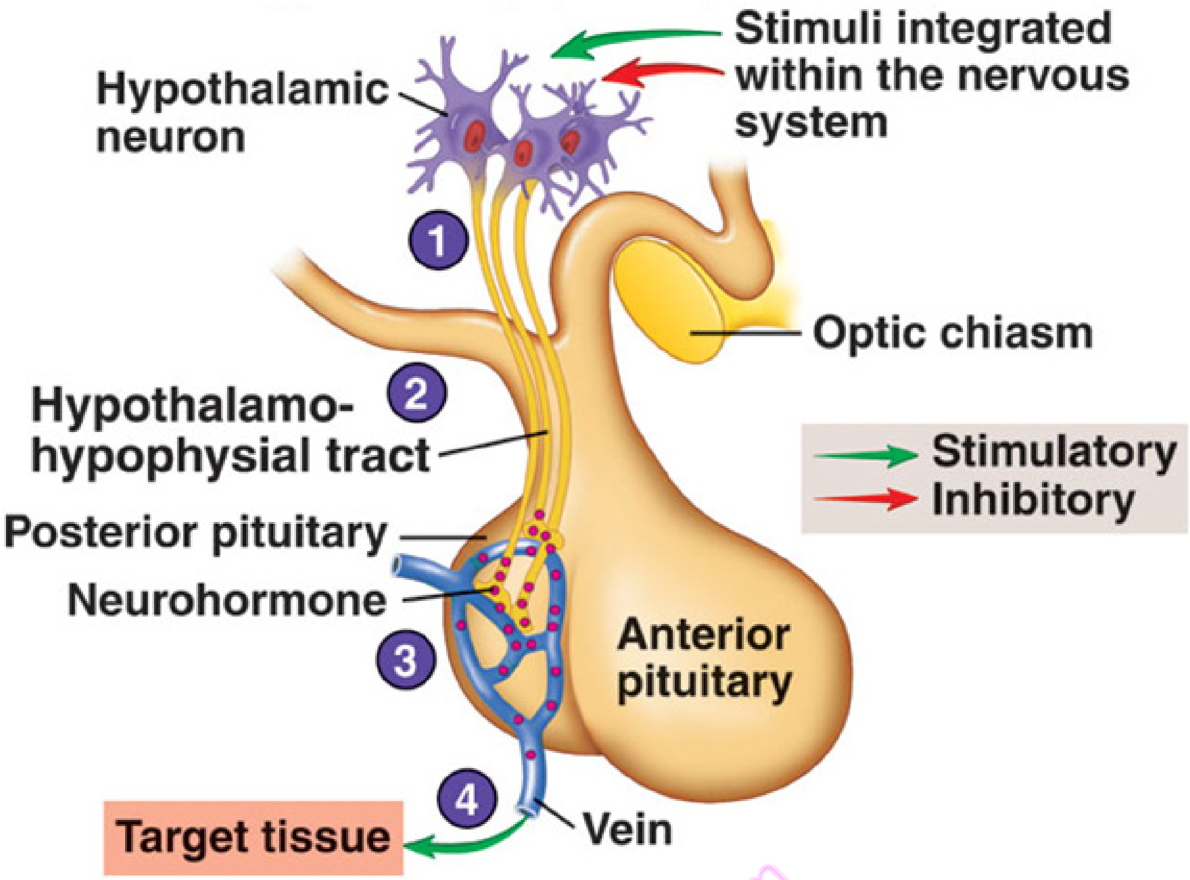
When solute concentrations increase, thereby, increasing osmotic pressure, the receptors are stimulated.

The osmoreceptors, in turn, stimulate hypothalamic neurons in the supraoptic nucleus, which synthesize ADH.

Nerve action potentials trigger the release of ADH from the axonal terminals in the posterior lobe of the pituitary.

ENDOCRINE SYSTEM



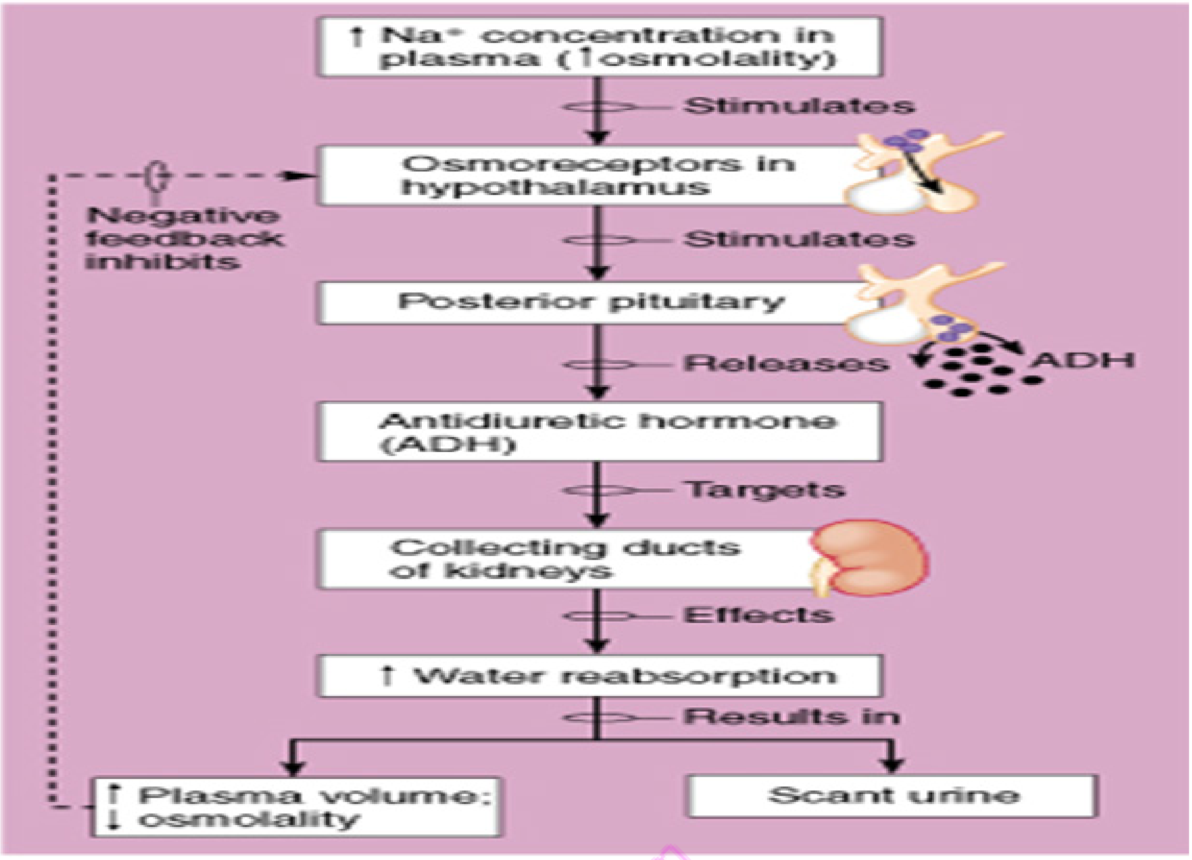


ADH travels through the systemic circulation to the distal convoluted tubules of the nephronand the collecting ducts.

ADH causes water to be reabsorbed from the D.C.T. and the collecting ducts into the capillaries which surround the nephron.

THE RESULTS OF ADH:

- A decrease in osmolality
- An increase in blood volume
- A decrease in urine output
- An increase in the concentration of the urine.



ADH is regulated by negative feedback; when solute concentrations are reduced to normal levels the amount of ADH is reduced.

The feedback mechanism is suppressed with excessive solute dissolved in blood.

In DM-diabetes mellitus when the blood glucose levels is beyond transport maximum, excess water is excreted with glucose (polyuria) which may lead to dehydration with acute thirst and water intake.

Atrial Natriuretic Peptide

Secreted by the atria of the heart in response to increased blood volume in the atria.

Reduces reabsorption of water in the PCT and CT.

This lowers blood volume and reduces atrial stretching

It also inhibits ADH and Aldosterone.

It's controlled via negative feedback.

Electrolyte Balance

Imbalance may occur due to changes in body water content or electrolyte level.

Sodium and Potassium Balance

Sodium-extracellular

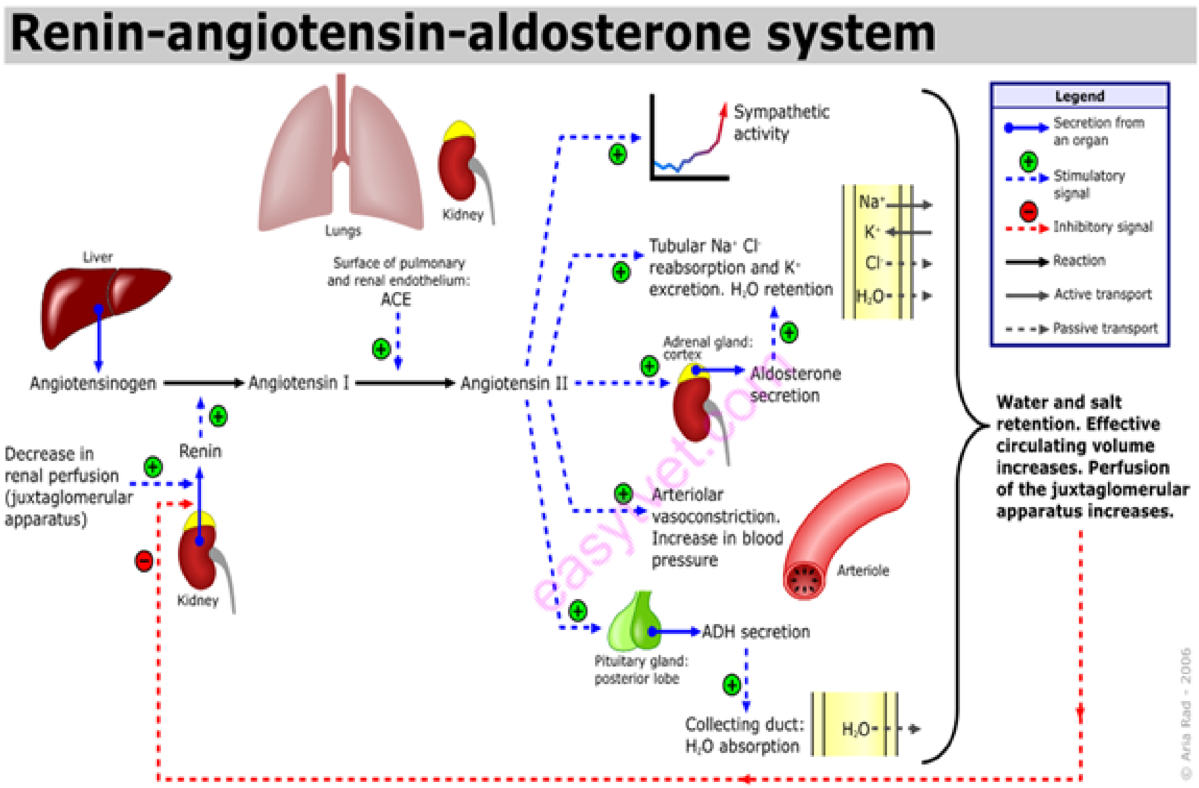
Potassium- intracellular

Intake of sodium is through food and is excreted through urine and sweat.

Excessive sodium losses may occur during high temp, fevers and sustained physical exercise.

In hot climate, acclimatisation (adjustment of an organism to the external envmt changes like temperature or altitude) occurs in 7 to 10 days and the amount of electrolytes lost in sweat is reduced.

Sodium is more in gastric juice while potassium in pancreatic and intestinal juice.

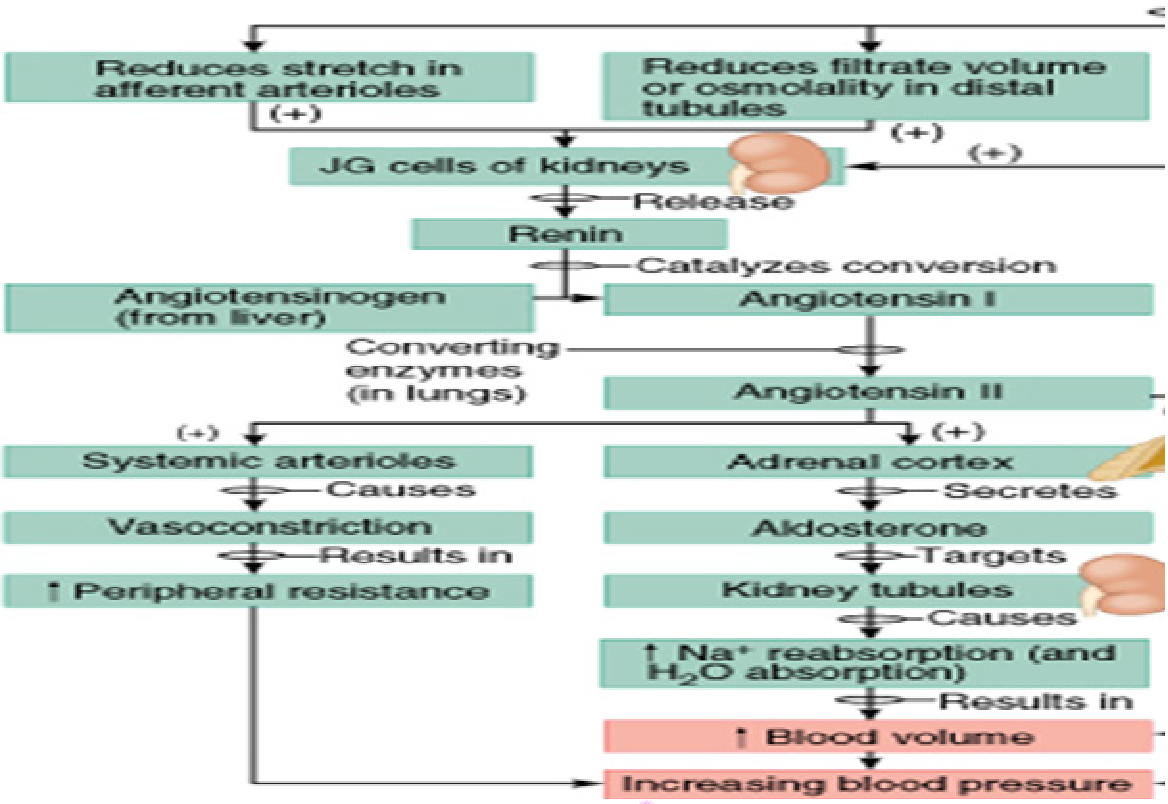


ALDOSTERONE

Aldosterone's function is to help maintain Na+ ion balance, and indirectly water balance and K+, within the fluid compartments of the body.

The chemical class of aldosterone is steroid

A decrease in blood pressure



Aldosterone targets the D.C.T. of the nephron.

EFFECTS OF ALDOSTERONE:

Reabsorption of Na+ ions.

Water is reabsorbed using the same transport mechanism.

K+ ions are secreted into the DCT from the capillaries.

Aldosterone secretion is controlled by negative Feedback.

PH Balance

H+ determines pH of urine.

The cells of the PCT secretes H+

Buffering system is present:

$H^+ + HCO_3^- \rightarrow H_2CO_3$

$H^+ + NH_3 \rightarrow NH_4^+$

$H^+ + HPO_3^{2-} \rightarrow H_2PO_3^-$

CARBON DIOXIDE & pH

$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$

H+ is excreted in urine as ammonium salts and hydrogen phosphate.

Normal urine pH- 4.5 to 8 depending on diet and time of the day.

Ureters

These originate from the renal pelvis which in turn is formed by the union of the major calyces

They terminate in the wall of the urinary bladder

They pursue a retroperitoneal course over the posterior abdominal wall from the hilum of the kidneys at the level of L2 to the inferior portion of the urinary bladder (trigone)

The ureters enter the bladder wall obliquely and this arrangement prevent reflux of urine from a distended bladder except in congenital anomalies or in chronic obstruction

Microscopic Anatomy

The ureter is composed of three layers:

The inner mucosa is composed of transitional epithelium and these cells are specialised to withstand the toxic effects of urine

The middle muscularis consists of two layers; an inner longitudinal and outer circular layer

The adventitia is composed of dense connective tissue and serves to anchor the ureter on the posterior abdominal wall

The ureter is constricted in three portions; the pelviureteric junction, the pelvic brim and the ureterovesical junction

Ureters: Function

Propels urine from the kidneys into the urinary bladder by peristaltic contractions of the smooth muscle layer.

Peristalsis originates in a pacemaker in the minor calyces

Peristalsis sends little spurts of urine in the bladder

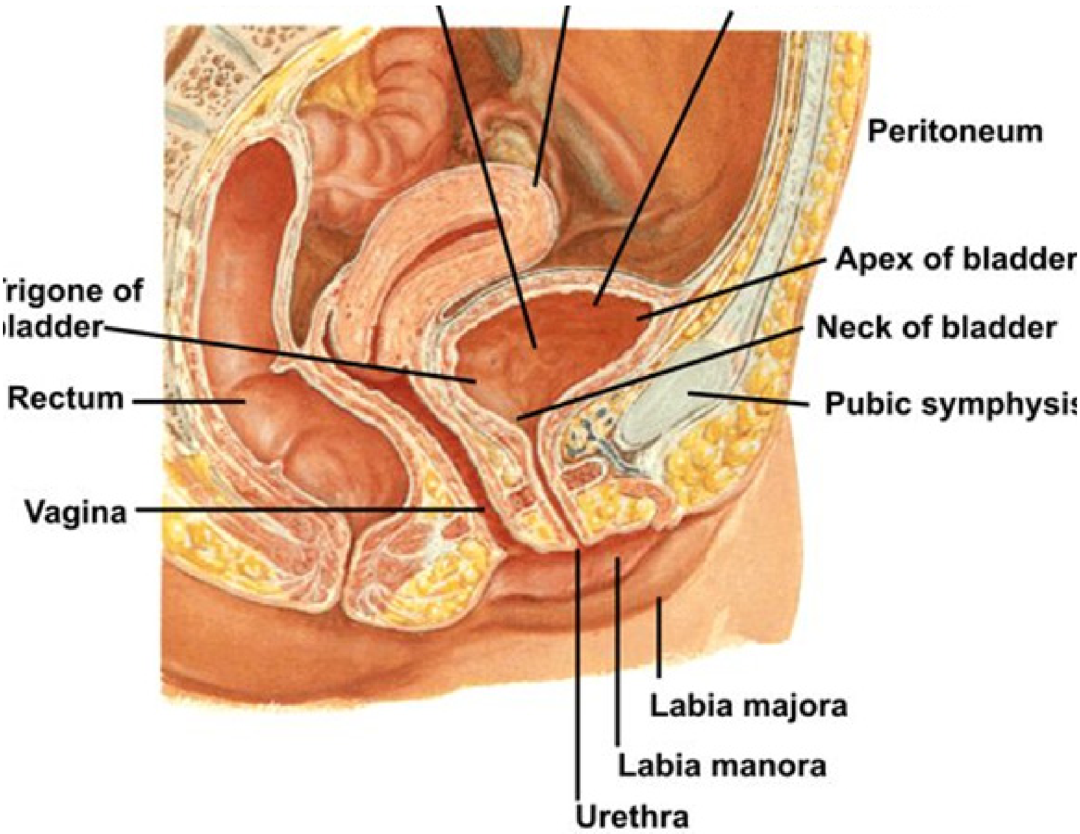
The Urinary Bladder

This is a fibro-muscular organ found mainly in the pelvis and stores urine. It lies posterior to the pubic symphysis.

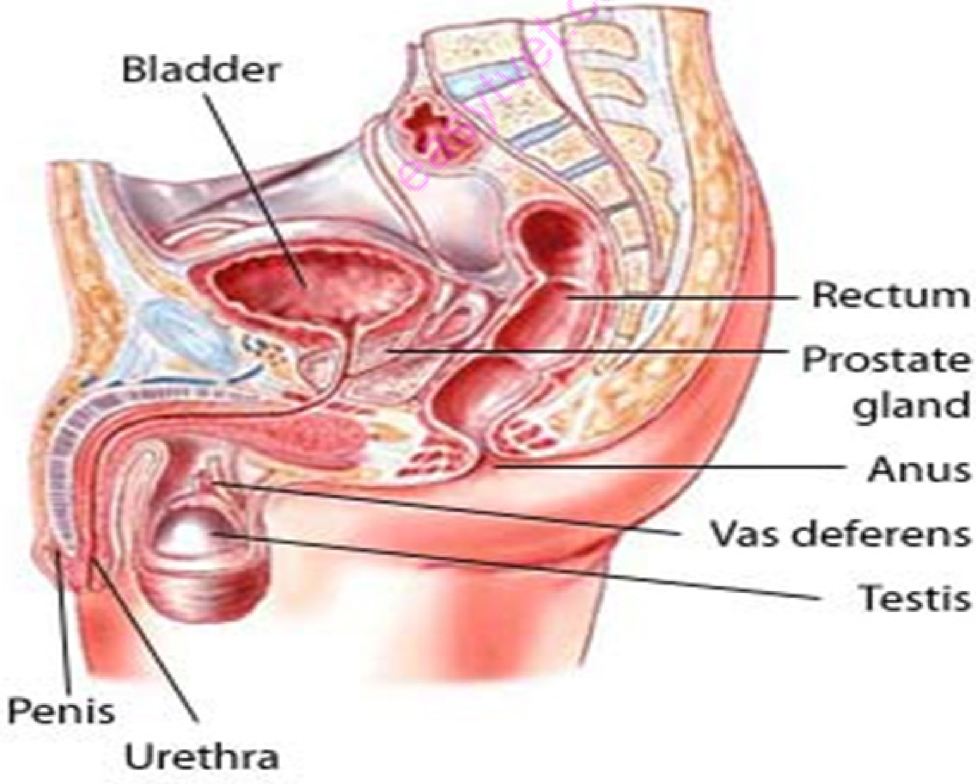
In the male it is found anterior to the rectum and the prostate surrounds the outlet of the bladder

In the female it is found anterior to the vagina and uterus

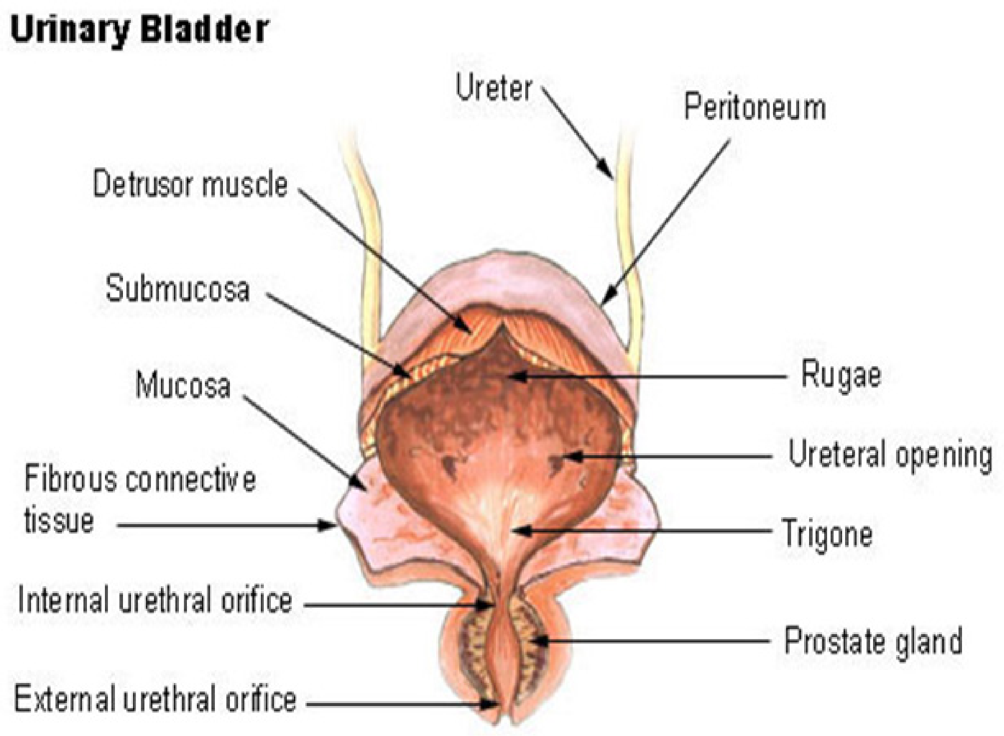
Internally it has three openings; two for the ureters and one for the urethra. The triangular area where these openings are found is known as the trigone.



Peritoneum
Apex of bladder
rigone of
ladder
Neck of bladder
Rectum
Pubic symphysis
Vagina
Labia majora
Labia manora
Urethra



Bladder
Rectum
Prostate
gland
Anus
Vas deferens
Testis
Penis
Urethra



Structure

- Pear shaped
- Oval when fills with urine
- Posterior surface is the base.
- It opens into the urethra at the neck.

Internal Structure

The urinary bladder wall is composed of three layers:

The inner mucosa consists of transitional epithelium

The middle muscularis contains the detrusor muscle which has outer and inner longitudinal and middle circular layers

The outer adventitia which on the superior surface is a serosa contains the lymphatic vessels and nerves.

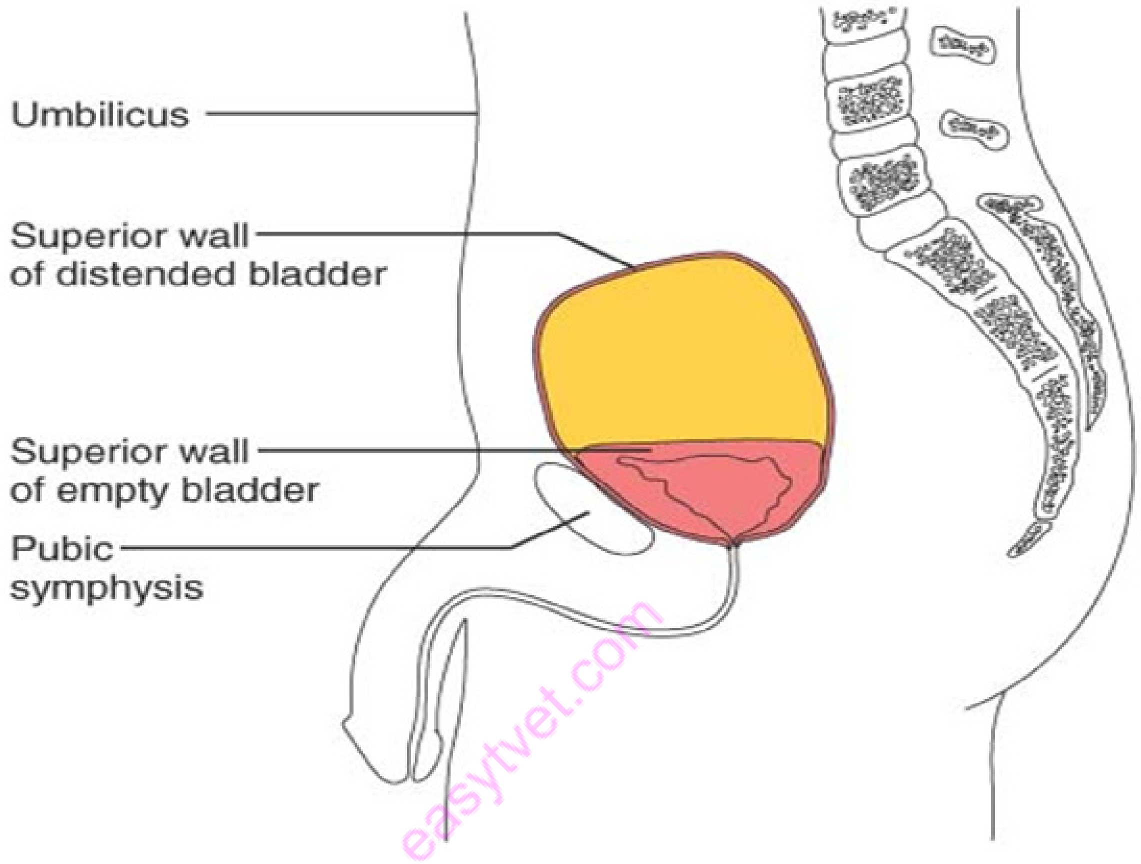
The bladder can expand to hold up to 1L of urine and expands superiorly into the abdominal cavity

The detrusor muscle is supplied by autonomic nerves from the sacral plexus.

The inner lining of an empty bladder is arranged in folds called rugae which disappears as the bladder fills.

The urinary bladder can distend to hold about 300-400 mls of urine. The total capacity is about 600mls.

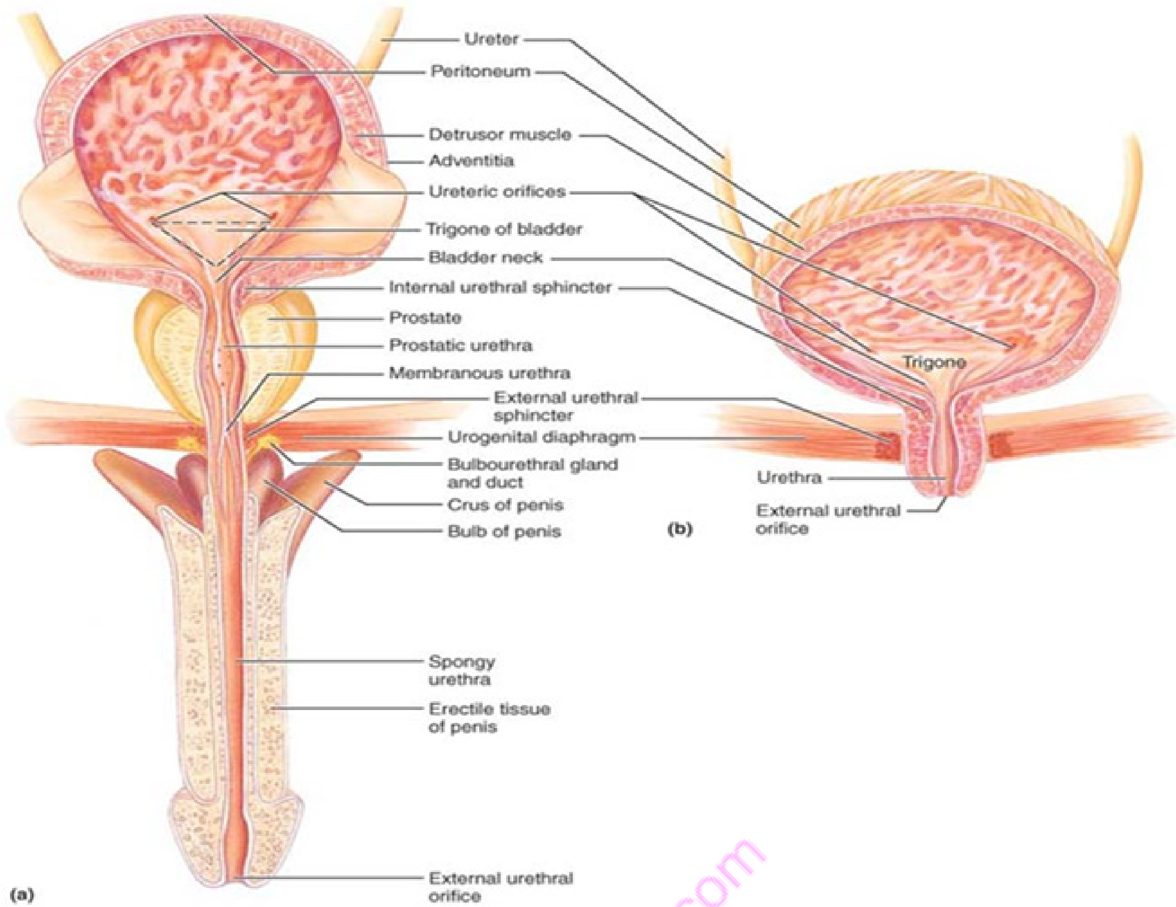
The three orifices (two ureters and the urethra) in the bladder wall have been arranged to form a trigone.



It is supplied by the superior and inferior vesical arteries from the internal iliac arteries and drains to the vesical plexus of veins which drain to the internal iliac vein

The inferior portion of the bladder at the beginning of the urethra is known as the bladder neck; the circular smooth muscle here is enlarged & thickened to form the involuntary internal urethra sphincter

More distal is found the voluntary external urethral sphincter.



The Urethra

This is a fibromuscular tube that conveys urine from the urinary bladder to the exterior.

It is lined by pseudostratified columnar epithelium that changes to transitional towards the urinary bladder and to stratified squamous towards the external urethral opening.

It is short in females measuring approx. 3-4 cm and tightly apposed to the anterior vaginal wall. It end in an external orifice that is found anterior to the vaginal opening and posterior to the clitoris in the vestibule.

Female Urethra

The wall is made up of the outer muscle layer: inner smooth muscle layer that is under involuntary control and an outer striated muscle layer that is under voluntary control

The mucosa is supported by loose connective tissue containing blood vessels and nerves.

Proximally it contains transitional epithelium and distally –stratified epithelium.

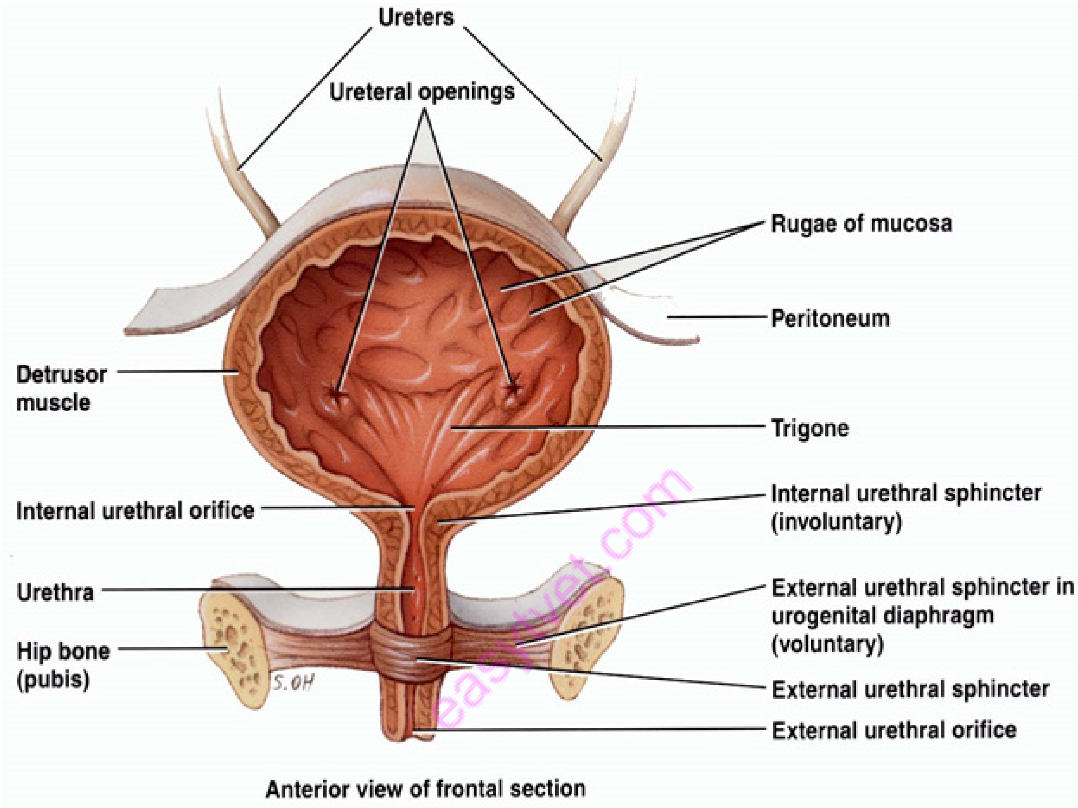
Male Urethra

In males it is approx. 20 cm long and is divided into three regions:

Prostatic 3 cm – surrounded by the prostate gland. The vas deferens opens into this portion of the urethra

Membranous 2cm – passes through the urogenital diaphragm

Spongy urethra 15cm – this is the rest of the urethra and is surrounded by the corpus spongiosum of the penis.



Micturition

Micturition is discharge of urine from the urinary bladder. It is also known as urination or voiding.

The micturition reflex occurs when volume within the bladder exceeds 200 – 400 mL and causes stretch of the bladder wall.

In infants: spinal reflex is initiated

PNS stimulates the bladder

Detrusor muscles contracts

Internal urethral sphincter relaxes

Urine is expelled from the bladder into the urethra before leaving the body.

For a fully developed nervous system, sensory impulses are sent to the brain for awareness of the need to pass urine.

For adults, the external urethral sphincter relaxes via voluntary control for micturation.

Micturition can also be assisted by increasing pressure in the pelvic cavity (lowering the diaphragm and abdominal muscles)- Valsalva's manoeuvre.

Over-distension of the bladder may cause involuntary relaxation of the external urethral sphincter allowing small amounts of urine to escape.

Urinary Incontinence

A lack of voluntary control over micturition is called urinary incontinence.

Types of Incontinence

Urge incontinence due to an overactive bladder

Stress incontinence due to poor closure of the bladder. Physical stresses that increase abdominal pressure such as coughing, sneezing, laughing, exercising, pregnancy, or walking can cause leakage of urine from the bladder.

Overflow incontinence due to either poor bladder contraction or blockage of the urethra

Functional incontinence due to medications or health problems making it difficult to reach the bathroom.

NB: Those who smoke have twice the risk or developing urinary incontinence.

Musculoskeletal System

Three (3) Types of Muscle Tissues

Skeletal Muscle

- Usually attached to bones
- Under conscious control
- Somatic nervous control
- Striated

Smooth Muscle

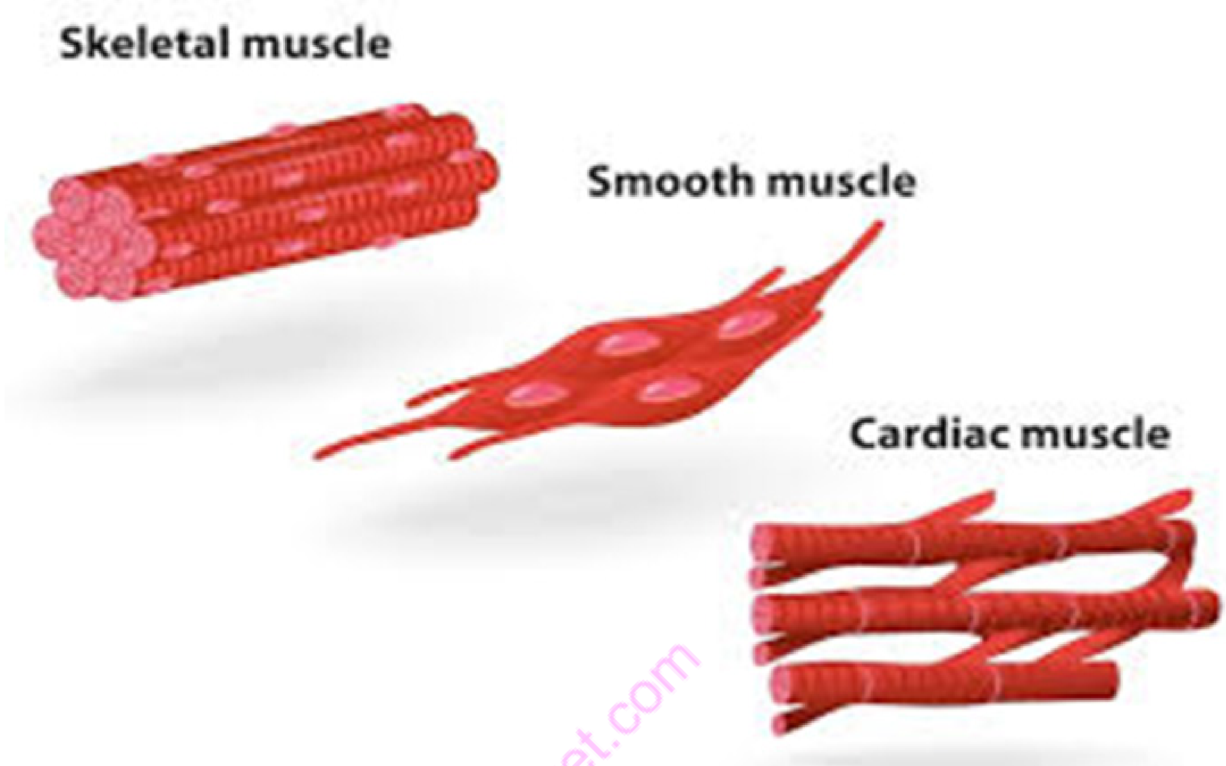
- Walls of most viscera, blood vessels and skin
- Not under conscious control
- Autonomic
- Not striated
- Spindle shaped

Cardiac Muscle

- Wall of heart
- Not under conscious control

- Autonomic nervous control
- Striated
- Have branches

Have intercalated discs



Structure of Skeletal Muscle

Skeletal Muscle

Organs of the muscular system

Skeletal muscle tissue

Nervous tissue

Blood

Connective tissues

Fascia-is a band or sheet of connective tissue, primarily collagen, beneath the skin that attaches, stabilizes, encloses, and separates muscles and other internal organs.

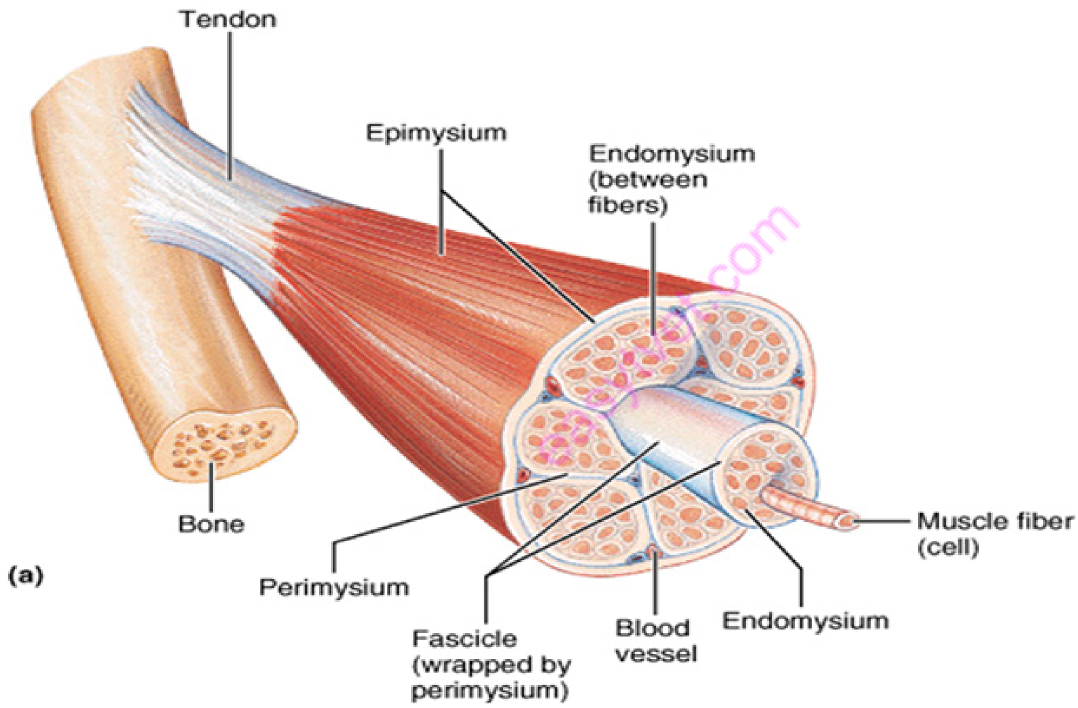
Tendons--- cord like end of muscle

Aponeuroses-a sheet of pearly white fibrous tissue which takes the place of a tendon in sheet-like muscles having a wide area of attachment.

Connective Tissue Coverings

Muscle Coverings:

- Epimysium-cover entire muscle
- Perimysium-cover muscle fascicle
- Endomysium-cover muscle fiber (muscle cell)
- Muscle organ
- Fascicles
- Muscle cells or fibers
- Myofibrils
- Thick and thin myofilaments
- Actin and myosin proteins



Skeletal Muscle Fibers

Sarcolemma—cell membrane of muscle cell or fiber

Sarcoplasm---the cytoplasm of striated muscle cells

Sarcoplasmic reticulum (SR)—is similar to endoplasmic reticulum in other cells and its function in muscle cell is to store calcium ions.

Transverse ('T') tubule– are extensions of the cell membrane that penetrate into the centre of skeletal and cardiac muscle cells.

Triad of skeletal muscle fiber

2 Cisternae of SR

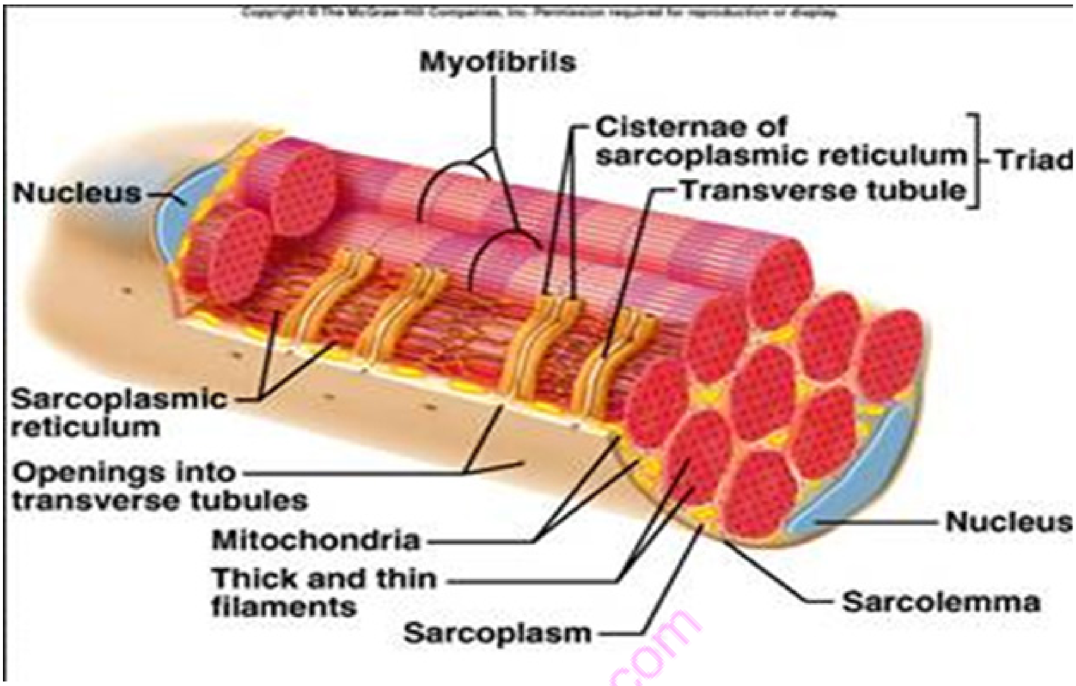
T tubule

Myofibril– any of the elongated contractile threads found in striated muscle cells

Actin myofilaments

Myosin myofilaments

Sarcomere—contractile unit of skeletal muscle



Skeletal Muscle Contraction

Movement within the myofilaments

I band (thin)

A band (thick and thin)

H zone (thick)

Z line (or disc)

M line- center of A band

Myofilaments

Thick myofilaments

Composed of myosin protein

Form the cross-bridges

Thin myofilaments

Composed of actin protein

Associated with troponin and tropomyosin proteins

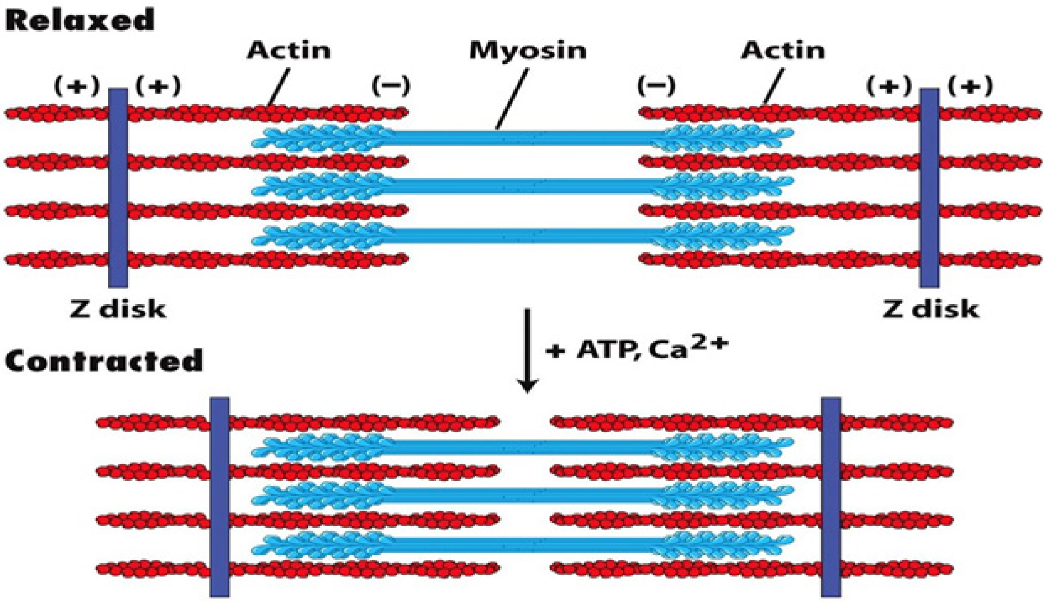


Figure 17-30
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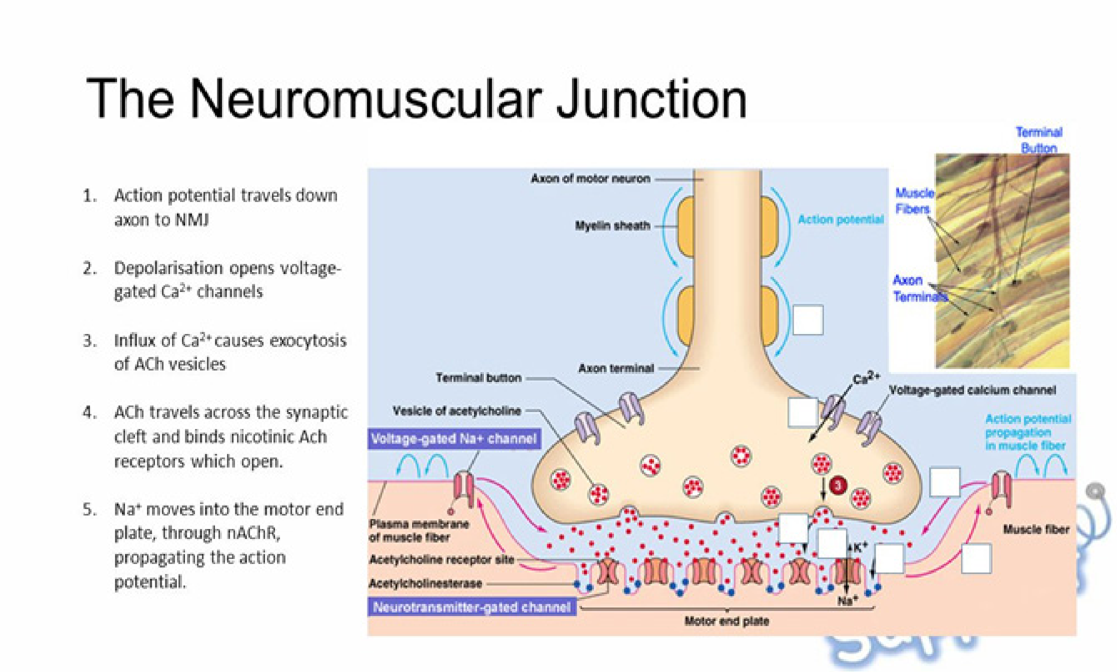
Neuromuscular Junction

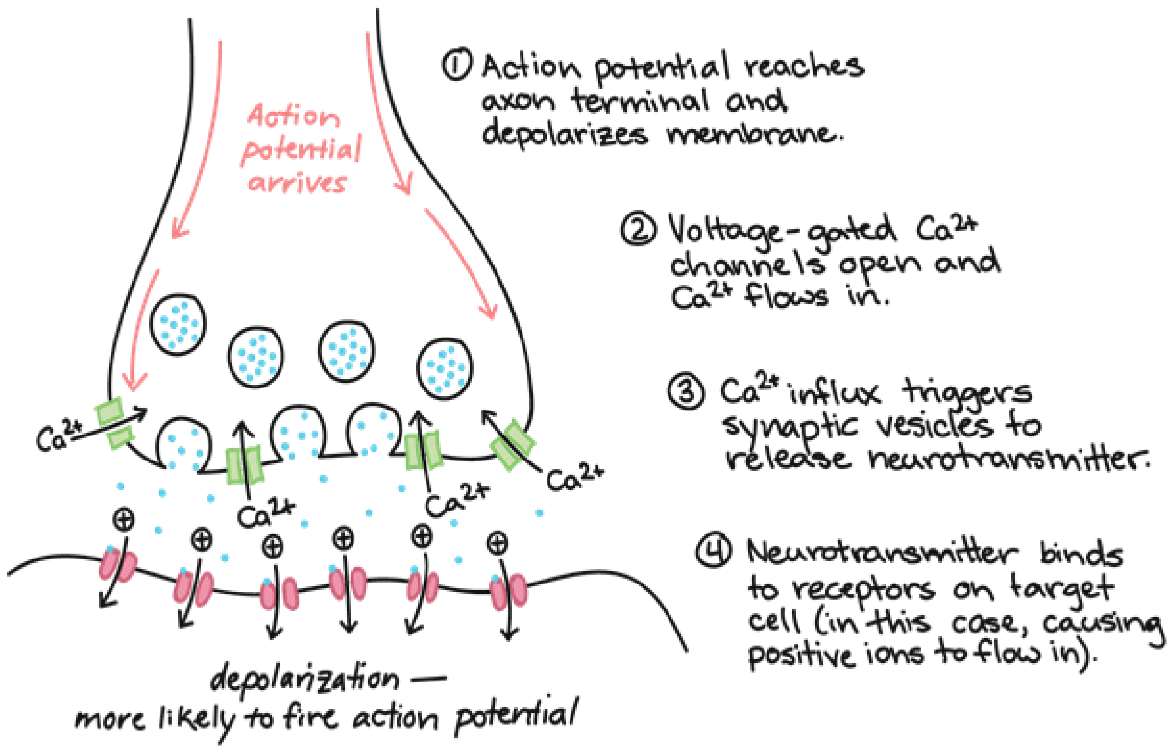
Also known as NMJ or myoneural junction.

Site where an axon and muscle fiber meet.

Parts to know:

- Motor neuron
- Synapse
- Synaptic vesicles
- Motor end plate
- Synaptic cleft
- Neurotransmitters





The Neuromuscular Junction Physiology

The action potential travels down the axon to the NMJ.

Arrival of the impulse causes depolarization of the pre-synaptic membrane causing opening of calcium gated channels resulting in the influx of calcium ions which causes the vesicles containing acetylcholine to fuse with the pre-synaptic membrane.

The vesicles then releases their content which is acetylcholine into the synaptic gap or cleft.

The neurotransmitter diffuses across the gap and attaches to the specific receptor protein on the post-synaptic membrane and opens them.

Sodium ions influx or enters into the post-synaptic membrane and it changes the membrane potential of the sarcolemma (the cell membrane of the muscle cell) generating an action potential.

The action potential moves through the T-tubules and sarcoplasmic reticulum which release calcium ions which cause contraction of the muscle fibers.

Motor Unit

Motor unit refers to all muscle fibers controlled by one motor neuron.

Single motor neuron

As few as four fibers

As many as 1000's of the muscle fibers

Stimulus for Contraction

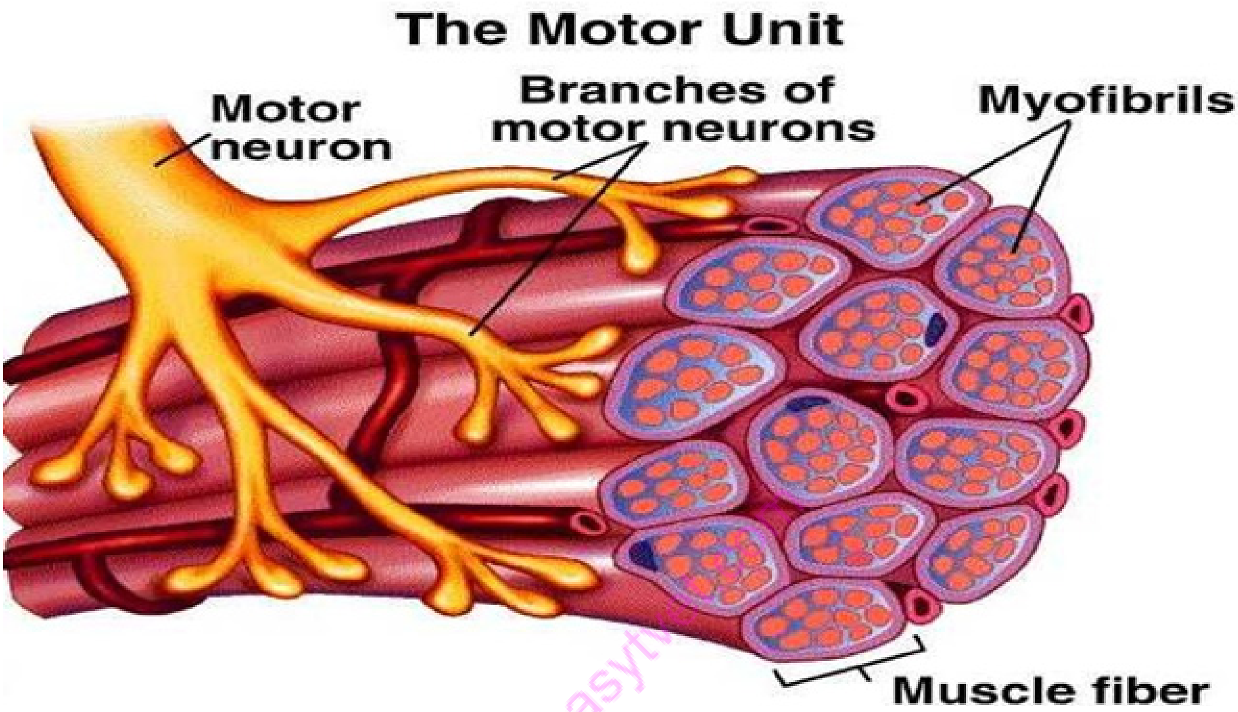
Acetylcholine (ACh)

Nerve impulse causes release of ACh from synaptic vesicles

ACh binds to ACh receptors on motor end plate.

Generates a muscle impulse

Muscle impulse eventually reaches the SR and the cisternae causing muscle contraction.



Excitation-Contraction Coupling

Muscle impulses cause SR to release calcium ions into cytosol

Calcium binds to troponin to change its shape.

The position of tropomyosin is altered.

Binding sites on actin are now exposed.

Actin and myosin molecules bind via myosin cross-bridges

Cross Bridge Cycling

The Four Steps of Cross Bridge Cycling

1. *The cross bridge formation*-the activated myosin head binds to actin forming a cross bridge. Inorganic phosphate is released from hydrolysis of ATP to ADP and the bond between myosin and actin become stronger.

2. *The power stroke*—ADP is released and the activated myosin head pivots sliding the thin myofilaments towards the center of the sarcomere.

3. *Cross bridge detachment*- when another ATP binds to the myosin head, the link between the myosin head and the actin weakens, and the myosin head detaches.
4. *Reactivation of myosin head*-ATP is hydrolyzed to ADP and inorganic phosphate. The energy released during hydrolysis reactivates the myosin head returning it to the cocked position.

The Sliding Filament Theory of Muscle Contraction

For a contraction to occur there must first be a stimulation of the muscle in the form of an impulse (action potential) from a motor neuron (nerve that connects to muscle).

Note that one motor neuron does not stimulate the entire muscle but only a number of muscle fibres within a muscle.

The individual motor neuron plus the muscle fibres it stimulates, is called a motor unit. The motor end plate (also known as the neuromuscular junction) is the junction of the motor neurons axon and the muscle fibres it stimulates.

When an impulse reaches the muscle fibres of a motor unit, it stimulates a reaction in each sarcomere between the actin and myosin filaments. This reaction results in the start of a contraction and the sliding filament theory.

The reaction, created from the arrival of an impulse stimulates the 'heads' on the myosin filament to reach forward, attach to the actin filament and pull actin towards the centre of the sarcomere.

This process occurs simultaneously in all sarcomeres, the end process of which is the shortening of all sarcomeres.

Troponin is a complex of three proteins that are integral to muscle contraction.

Troponin is attached to the protein tropomyosin within the actin filaments.

When the muscle is relaxed tropomyosin blocks the attachment sites for the myosin cross bridges (heads), thus preventing contraction.

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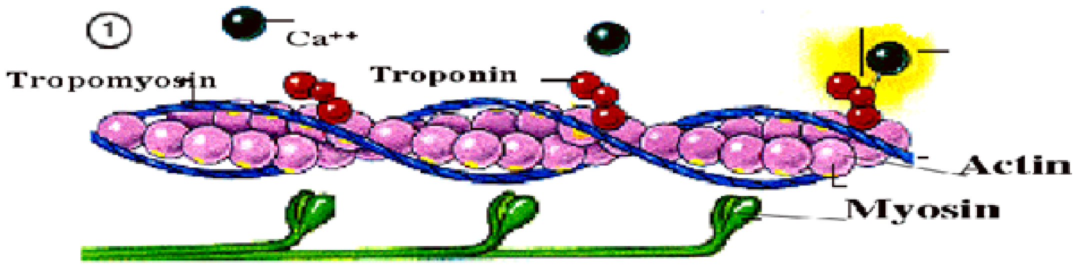
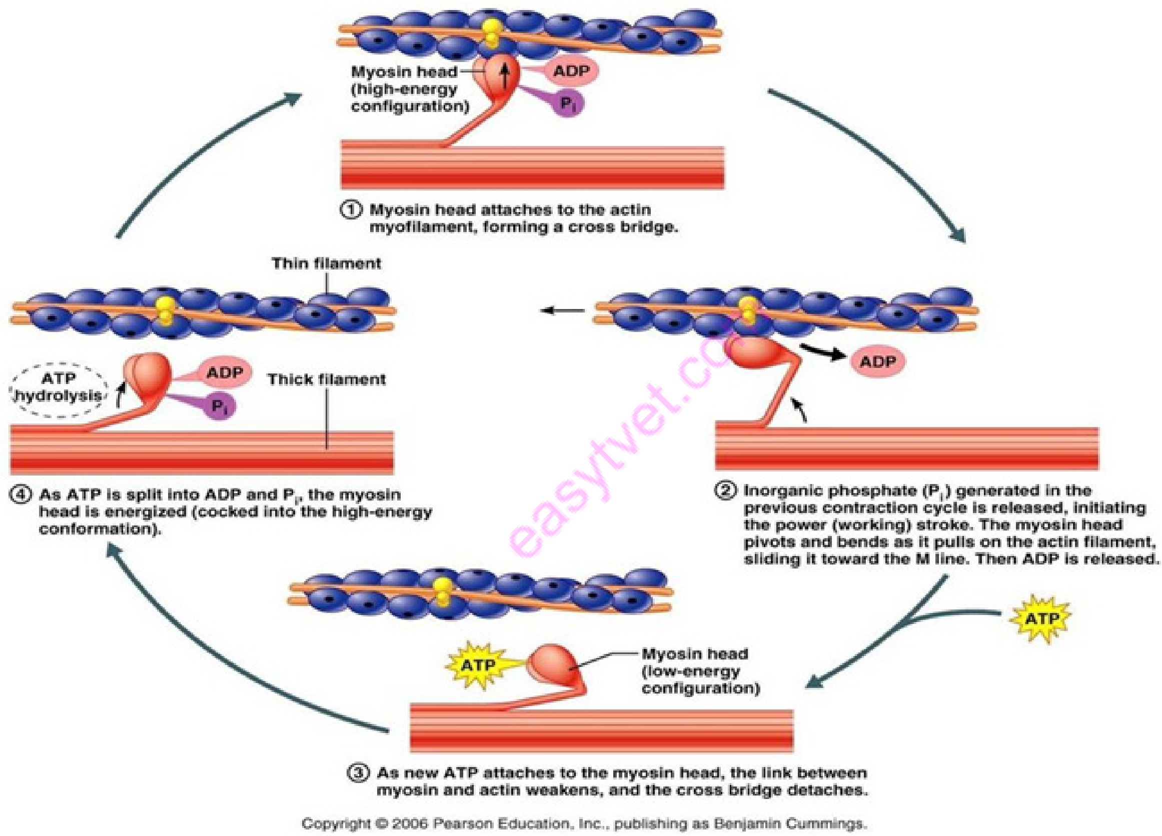




A Few Things Can Stop a Contraction;

Energy system fatigue: There is no more ATP left in the muscle cell so it can't keep contracting.

Nervous system fatigue: The nervous system is not able to create impulses sufficiently or quickly enough to maintain the stimulus and cause calcium to release.

Voluntary nervous system control: The nerve that tells the muscle to contract stops sending that signal because the brain tells it to, so no more calcium ions will enter the muscle cell and the contraction stops.

Sensory nervous system information: For example, a sensory neuron (nerves that detect stimuli like pain or how heavy something is) provides feedback to the brain indicating that a muscle is injured while you are trying to lift a heavy weight and consequently the impulse to that muscle telling it to contract is stopped.

Relaxation

Acetylcholinesterase – rapidly decomposes Ach remaining in the synapse

Muscle impulse stops

Stimulus to sarcolemma and muscle fiber membrane ceases

Calcium moves back into sarcoplasmic reticulum (SR)

Myosin and actin binding prevented

Muscle fiber relaxes.

Energy Sources for Contraction

1) Creatine phosphate and 2) Cellular respiration

Creatine phosphate – stores energy that quickly converts ADP to ATP

Oxygen Supply and Cellular Respiration

Cellular respiration:

Anaerobic Phase

- Glycolysis
- Occurs in cytoplasm
- Produces little ATP

Aerobic Phase

- Citric acid cycle
- Electron transport system
- Occurs in the mitochondria
- Produces most ATP
- Myoglobin stores extra oxygen

Oxygen Debt

Oxygen debt – amount of oxygen needed by liver cells to use the accumulated lactic acid to produce glucose.

- Oxygen not available
- Glycolysis continues

- Pyruvic acid converted to lactic acid
- Liver converts lactic acid to glucose

Muscle Fatigue

Inability to contract muscle

- Commonly caused by:
- Decreased blood flow
- Ion imbalances across the sarcolemma
- Accumulation of lactic acid
- Cramp – sustained, involuntary muscle contraction

Heat Production

By-product of cellular respiration.

Muscle cells are major source of body heat. Blood transports heat throughout body core

Muscular Responses

Muscle contraction can be observed by removing a single skeletal muscle fiber and connecting it to a device that senses and records changes in the overall length of the muscle fiber.

Threshold Stimulus--Minimal strength required to cause contraction.

Recording of a Muscle Contraction

Recording a Muscle Contraction

- ***Twitch***-small muscle contractions
- Latent period
- Period of contraction
- Period of relaxation

Refractory period

All-or-none response-The principle that the strength by which a nerve or muscle fiber responds to a stimulus is not dependent on the strength of the stimulus. If the stimulus is any strength above threshold, the nerve or muscle fiber will either give a complete response or no response at all.

Recording of a Muscle Contraction

A **twitch** is a single contractile response to a stimulus

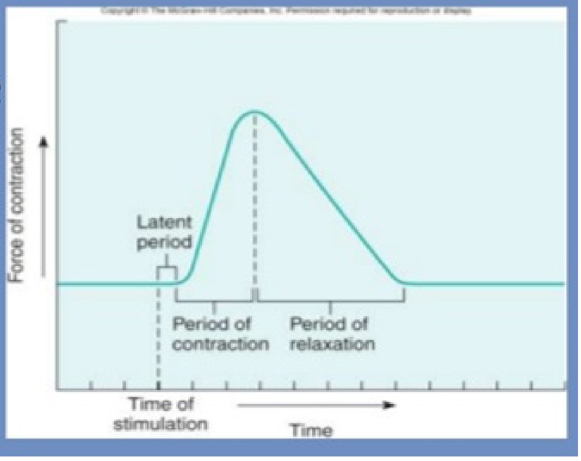
A **twitch** can be divided into three periods.

1. Latent period
   brief delay between the stimulus and the muscle contraction

   The latent period is less than 2 milliseconds in humans

2. Period of contraction

3. Period of relaxation



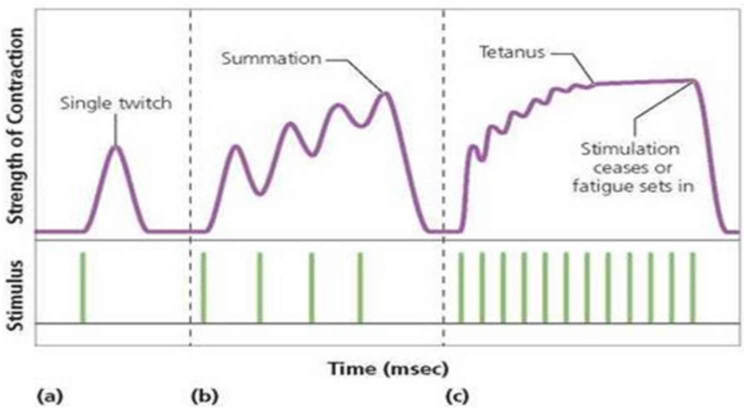
Summation

Process by which individual twitches combine.

Temporal Summation-the sum of all muscle tension produced by a single motor unit at different time.

Produces sustained contractions

Can lead to tetanic contractions



Recruitment of Motor Units

Recruitment - increase in the number of motor units activated

Muscle recruitment-the sum of all tensions produced by different motor units at the same time.

Whole muscle composed of many motor units

More precise movements are produced with fewer muscle fibers within a motor unit.

As intensity of stimulation increases, recruitment of motor units continues until all motor units are activated.

Sustained Contractions

Smaller motor units (smaller diameter axons) - recruited first

Larger motor units (larger diameter axons) - recruited later

Produce smooth movements

Muscle tone – continuous state of partial contraction

Types of Contractions

Isotonic – muscle contracts and changes length

Eccentric – lengthening contraction

Concentric – shortening contraction

Isometric – muscle contracts but does not change length

Fast Twitch and Slow Twitch Muscle Fibers

Slow-twitch fibers (Type I)

- Always oxidative
- Resistant to fatigue
- Red fibers
- Most myoglobin
- Good blood supply

Fast-twitch glycolytic fibers (Type IIa)

- White fibers (less myoglobin)
- Poorer blood supply
- Susceptible to fatigue

Fast-twitch fatigue-resistant fibers (Type IIb)

Intermediate fibers

Oxidative

Intermediate amount of myoglobin

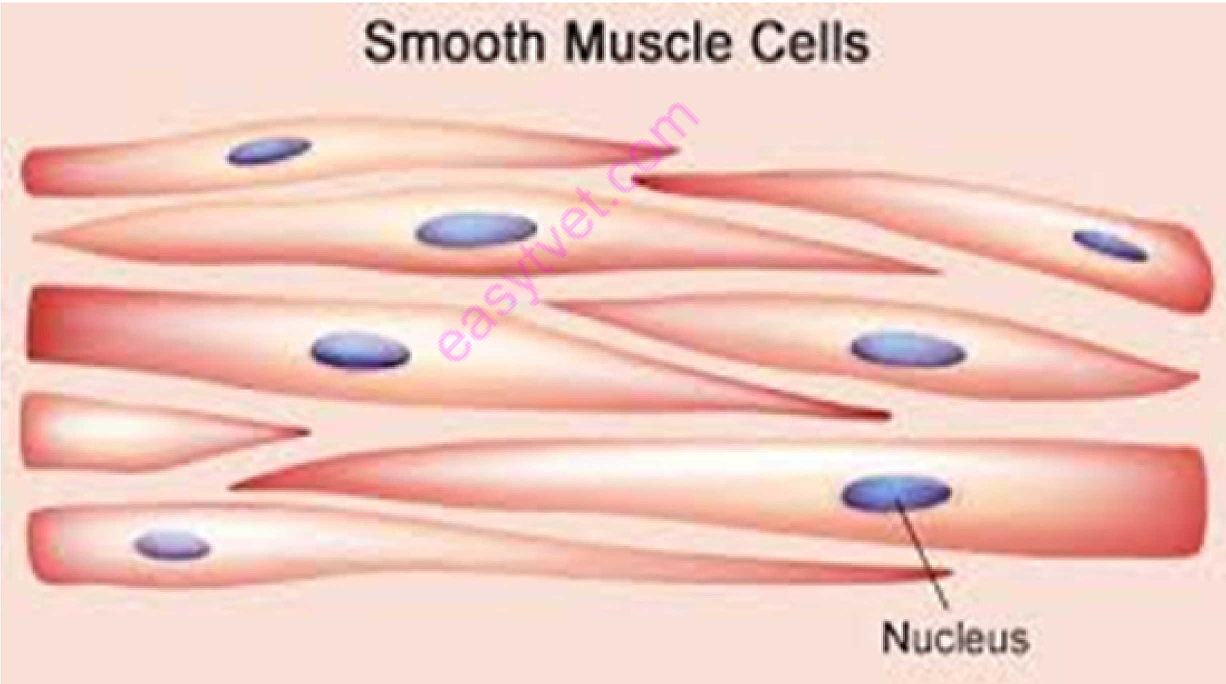
Pink to red in color

Resistant to fatigue

Smooth Muscles

Compared to skeletal muscle fibers, smooth muscle fibers are:

- Shorter
- Single, centrally located nucleus
- Elongated with tapering ends
- Myofilaments randomly organized
- Lack striations
- Lack transverse tubules
- Sarcoplasmic reticula (SR) not well developed.



Smooth Muscle Fibers

Visceral Smooth Muscle

- Single-unit smooth muscle
- Fibers held together by gap junctions
- Exhibit peristalsis
- Sheets of muscle fibers
- Exhibit rhythmicity
- Walls of most hollow organs

Multi-Unit Smooth Muscle

- Less organized
- Fibers function separately
- Walls of blood vessels
- Function as separate units
- Iris of eye

Smooth Muscle Contraction

Resembles skeletal muscle contraction in that:

- Interaction between actin and myosin
- Both use calcium and ATP
- Both are triggered by membrane impulses

Different from skeletal muscle contraction in that:

- Smooth muscle lacks troponin
- Smooth muscle uses calmodulin

Two neurotransmitters affect smooth muscle

  - Acetlycholine (Ach) and norepinephrine (NE)

- Hormones affect smooth muscle e.g. gastrin hormone
- Stretching can trigger smooth muscle contraction
- Smooth muscle slower to contract and relax
- Smooth muscle more resistant to fatigue
- Smooth muscle can change length without changing tautness

Cardiac Muscle

- Located only in the heart
- Muscle fibers joined together by intercalated discs
- Fibers branch
- Network of fibers contracts as a unit
- Self-exciting and rhythmic
- Longer refractory period than skeletal muscle

Skeletal Muscle Actions

Skeletal muscles generate a great variety of body movements.

The action of each muscle mostly depends upon the kind of joint it is associated with and the way the muscle is attached on either side of that joint.

Origin and Insertion

Origin – immovable end

Insertion – movable end

Interaction of Skeletal Muscles

Prime mover (agonist) – primarily responsible for movement

Synergists – assist prime mover

Antagonist – resist prime mover's action and cause movement in the opposite direction of the prime mover

Lifespan Changes

Myoglobin, ATP, and creatine phosphate decline

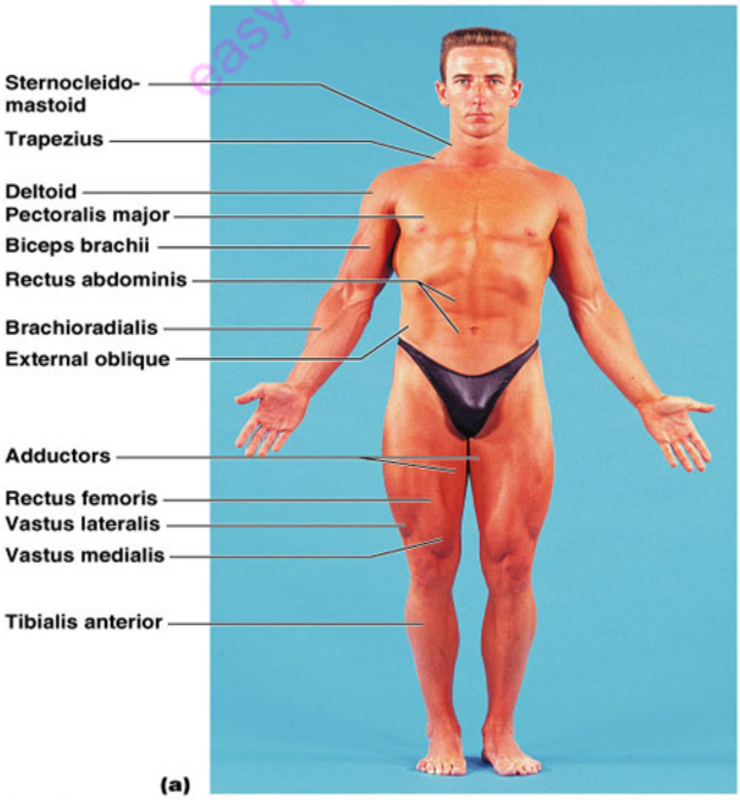
By age 80, half of muscle mass has atrophied

Adipose cells and connective tissues replace muscle tissue

Exercise helps to maintain muscle mass and function

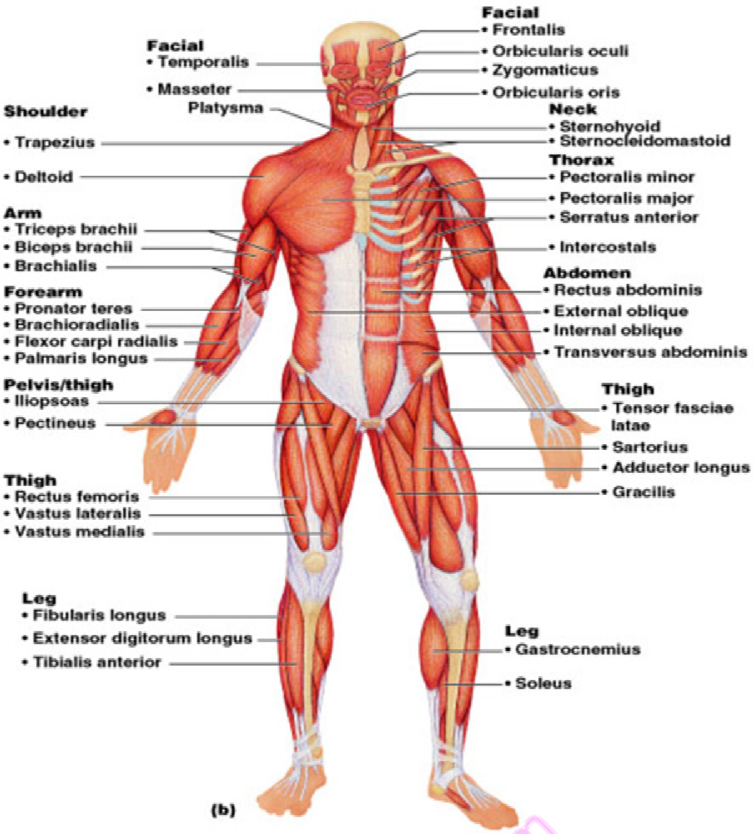
Skeletal Muscles

They are ver 600, Book only list approximately 125 pairs of them

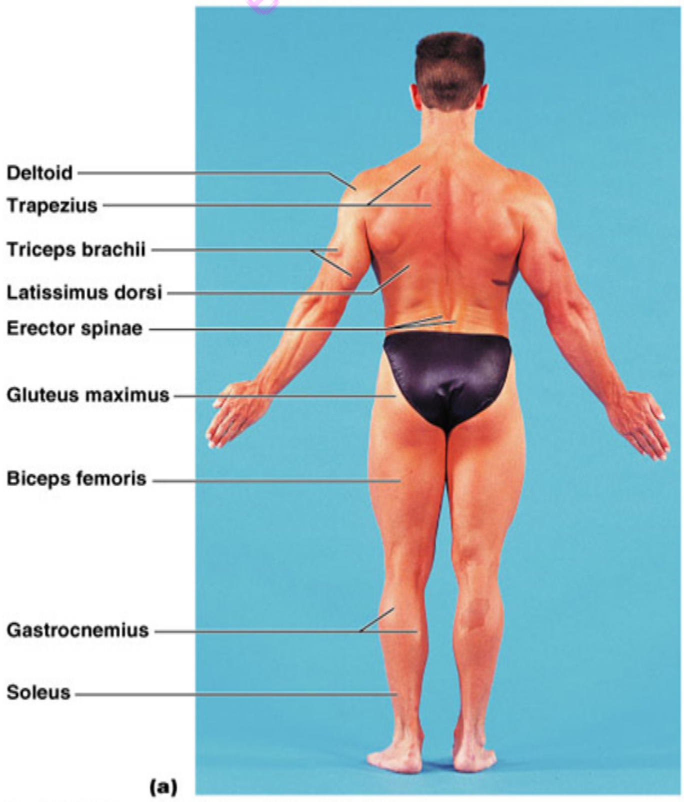


ANTERIOR SUPERFICIAL MUSCLES

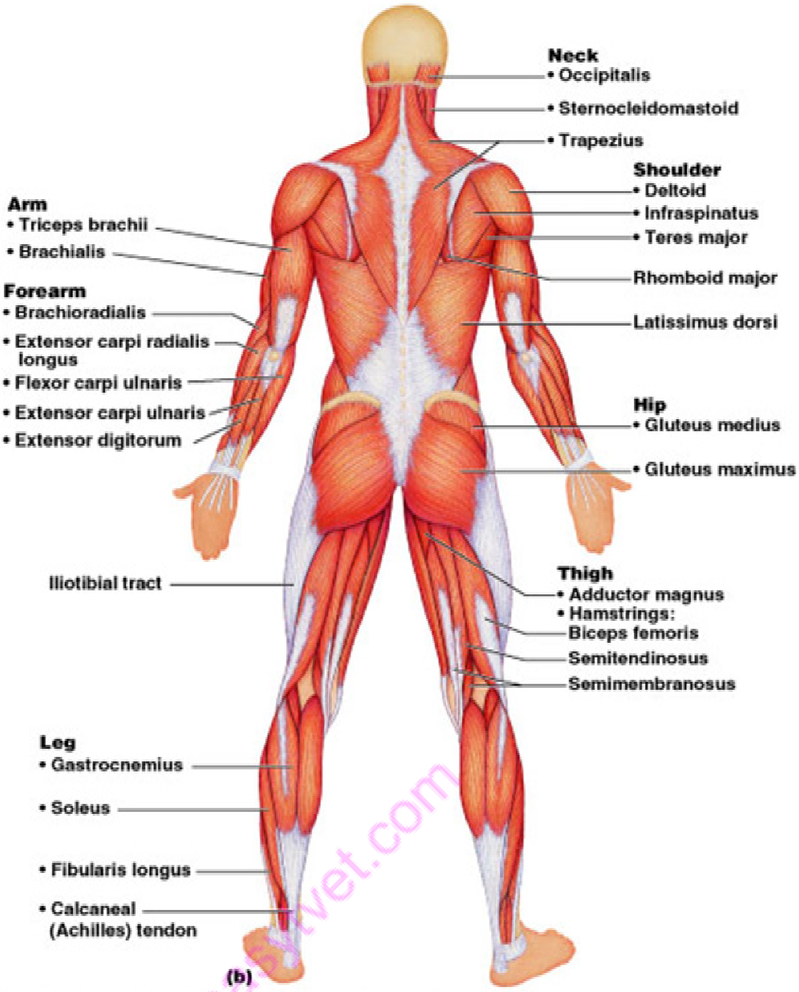
Diagrammatic view ofanterior muscles



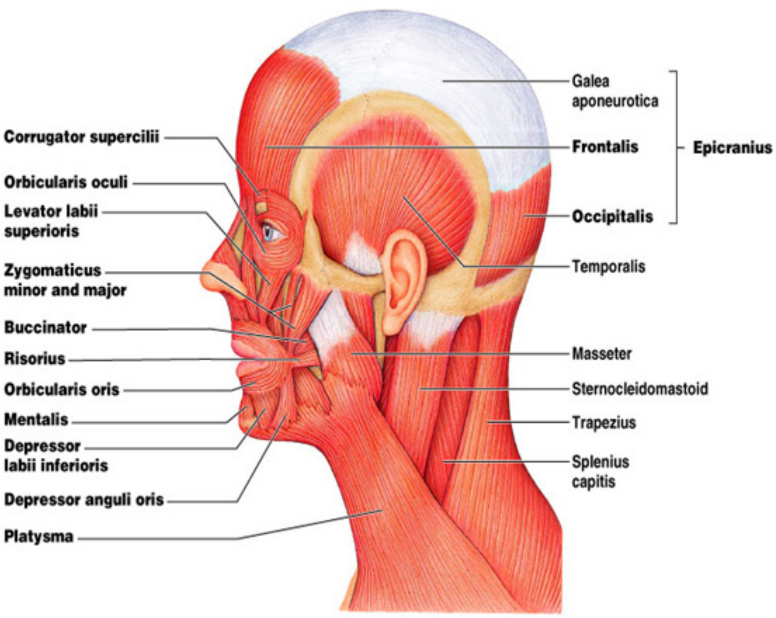
Posterior view of superficial muscles



Diagrammatic view of posterior muscles



Major skeletal muscles of the face



Frontalis: Cranial (facial nerve) VII

- Raises the eyebrows (as in surprise)
- Wrinkles forehead skin horizontally
- Cranial nerve VII

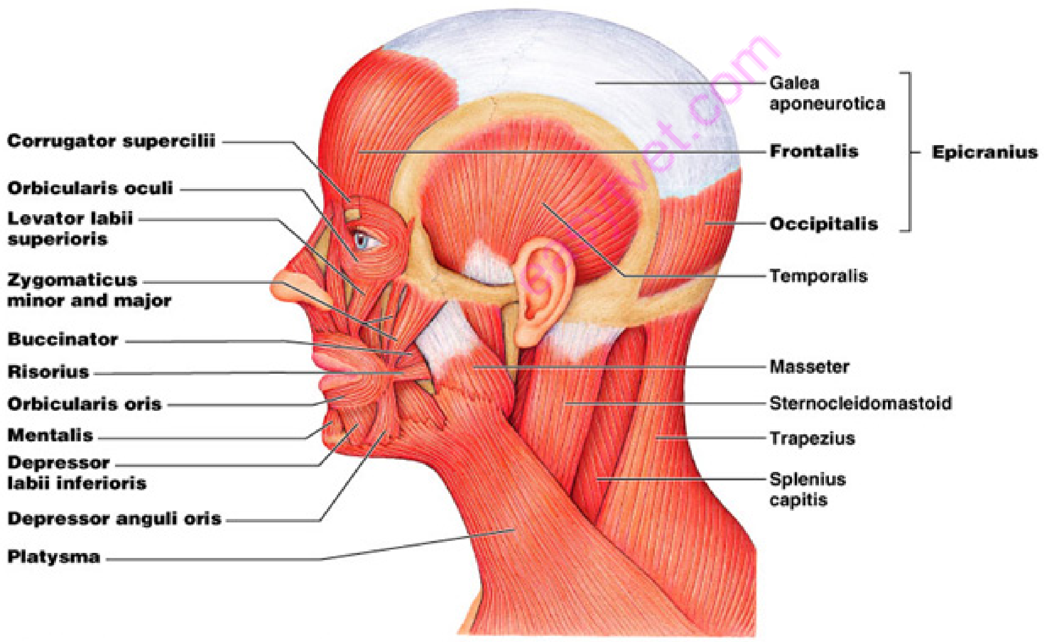
Orbicularis Oculi: Cranial (facial nerve) VII

- Protects eyes from intense light and injury
- Produces blinking, squinting
- Draws the eyebrows inferiorly

Orbicularis Oris: Cranial (facial nerve) VII

- Closes lips
- Purses (pucker) and protrudes (stick out) lips
- Kissing and whistling muscle

HEAD MUSCLES

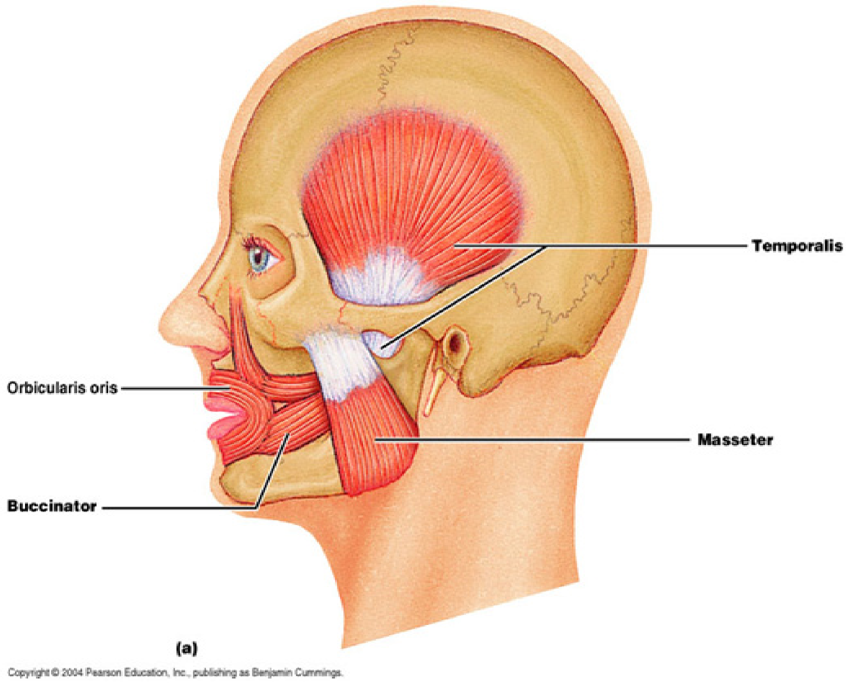


Mastication and Tongue Movement:

Muscles of mastication include the masseter, temporalis, medial pterygoid, lateral pterygoid, and the buccinator

Muscles promoting tongue movement are the genioglossus, hypoglossus, and the styloglossus.

Mastication Muscles



Masseter: Temporalis: Cranial (trigeminal) nerve V

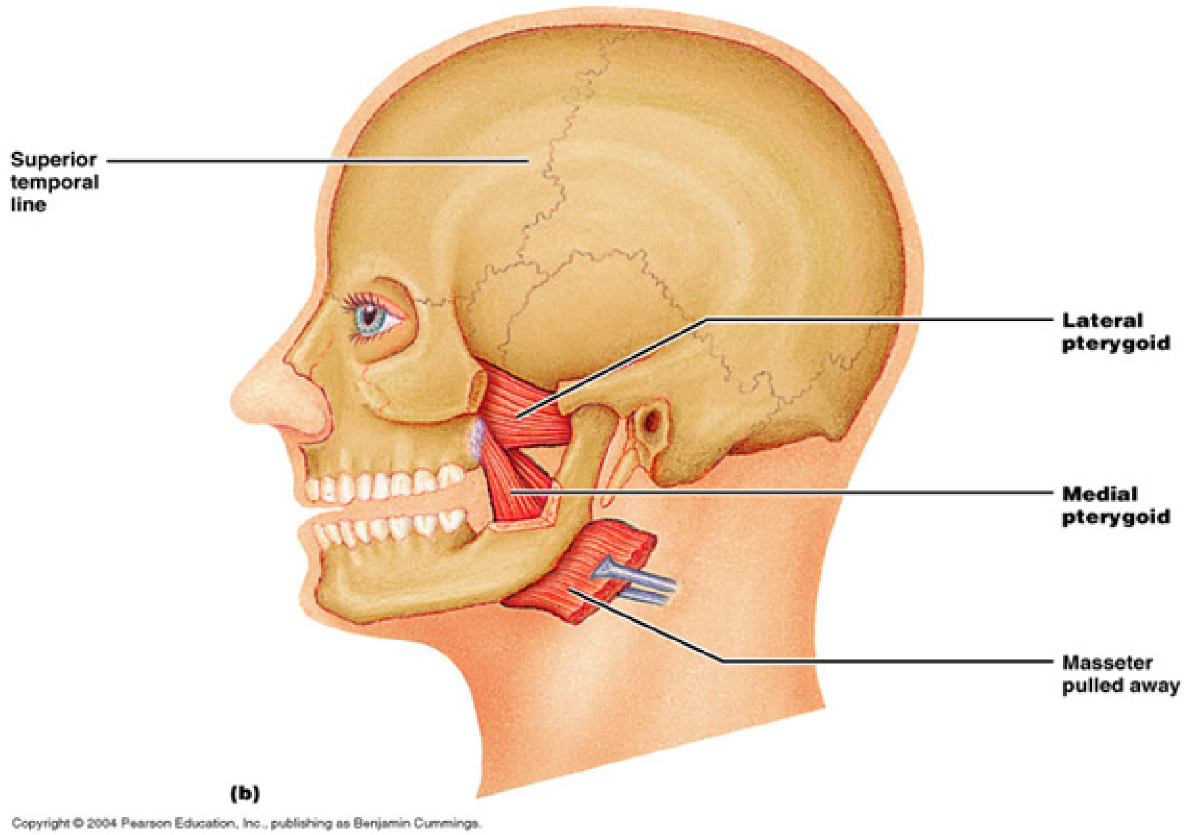
- Prime mover of jaw closure
- Elevates mandible

Temporalis: Cranial (trigeminal) nerve V

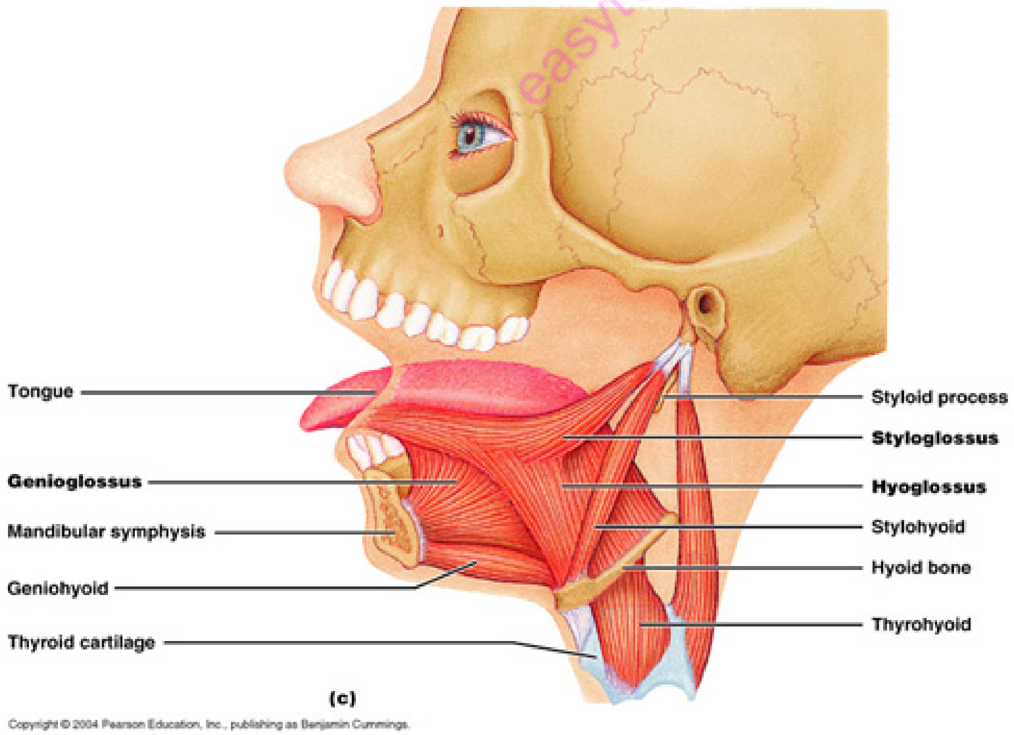
- Closes jaw
- Elevates and retracts mandible

Buccinator: Cranial (facial) nerve VII

- Trampoline-like action
- Keeps food between grinding surfaces of teeth during chewing



Tongue Muscles



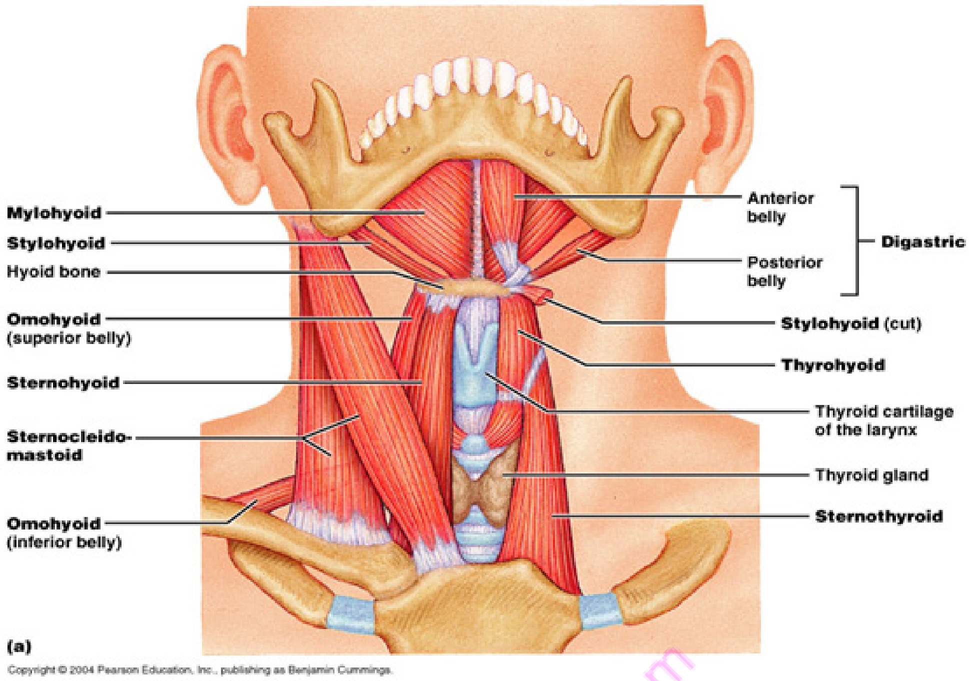
Genioglossus: Cranial (hypoglossal) nerve XII

Primarily protrudes tongue, but in concert with other extrinsic muscles to retract tongue.

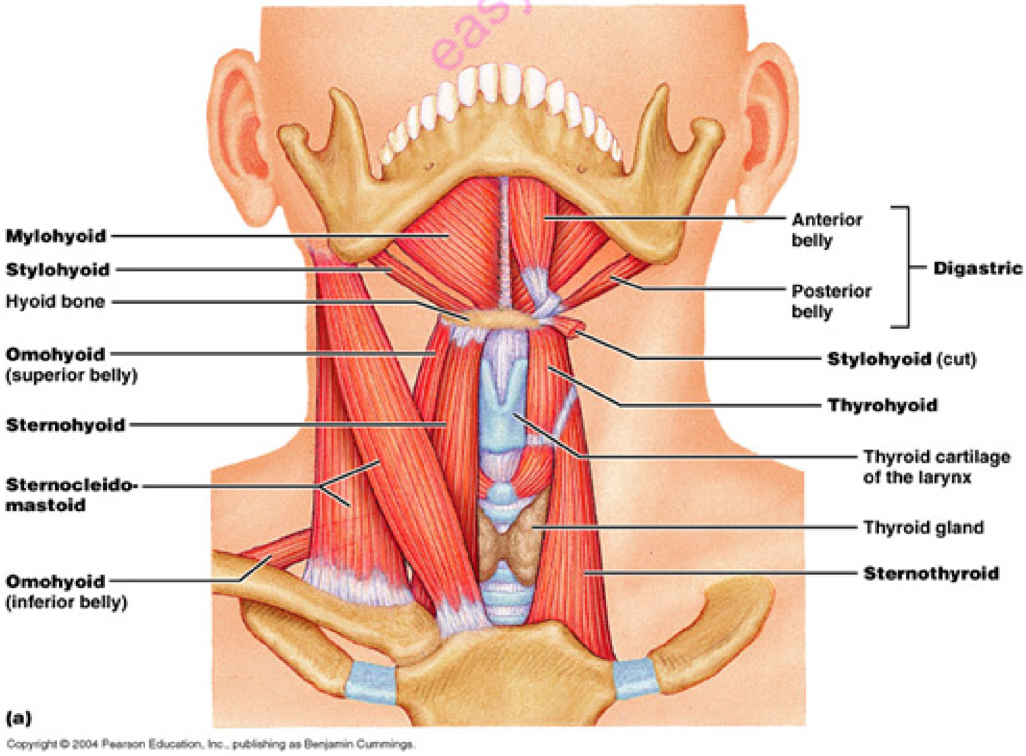
Muscles of the Anterior Neck and Throat: Swallowing

Suprahyoid muscles include digastric, stylohyoid, mylohyoid, and geniohyoid

Infrahyoid muscles include sternohyoid, sternothyroid, omohyoid, thyrohyoid, and the pharyngeal constrictor muscles (superior, middle, and inferior)



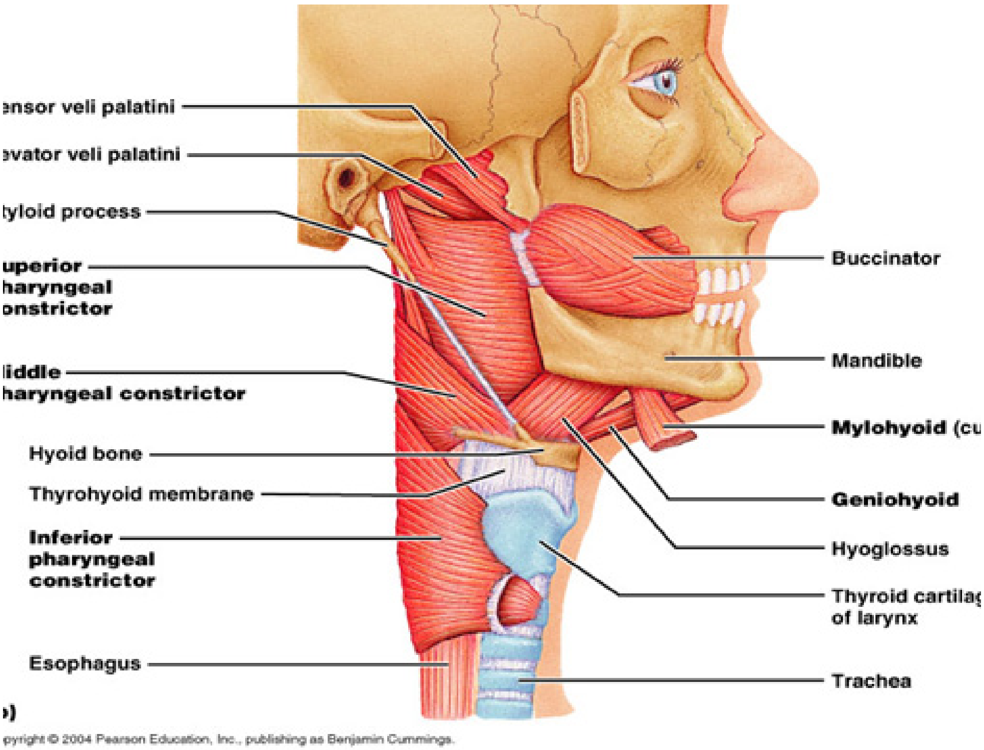
Neck and Throat Muscles



Mylohyoid:cranial (trigeminal) nerve V

Elevates hyoid bone and floor of mouth

Enables the tongue to exert backward and upward pressure that forces food bolus into pharynx.



Pharyngeal constrictor muscles (superior, middle, and inferior): Cranial (vagus) nerve X

Working as a group and in sequence, all constrict pharynx during swallowing

Propels food bolus to esophagus

Peristalsis

MAJOR SKELETAL MUSCLES OF THE BODY

Muscles of the Neck and Vertebral Column: Head and Trunk Movement.

Anterolateral neck muscles include the sternocleidomastoid, and scalenes (anterior, middle, and posterior)

Intrinsic muscles of the back include: splenius capitis, erector spinae or sacrospinalis, iliocostals, longissimus, spinalis, semispinalis, and the quadratus lumborum

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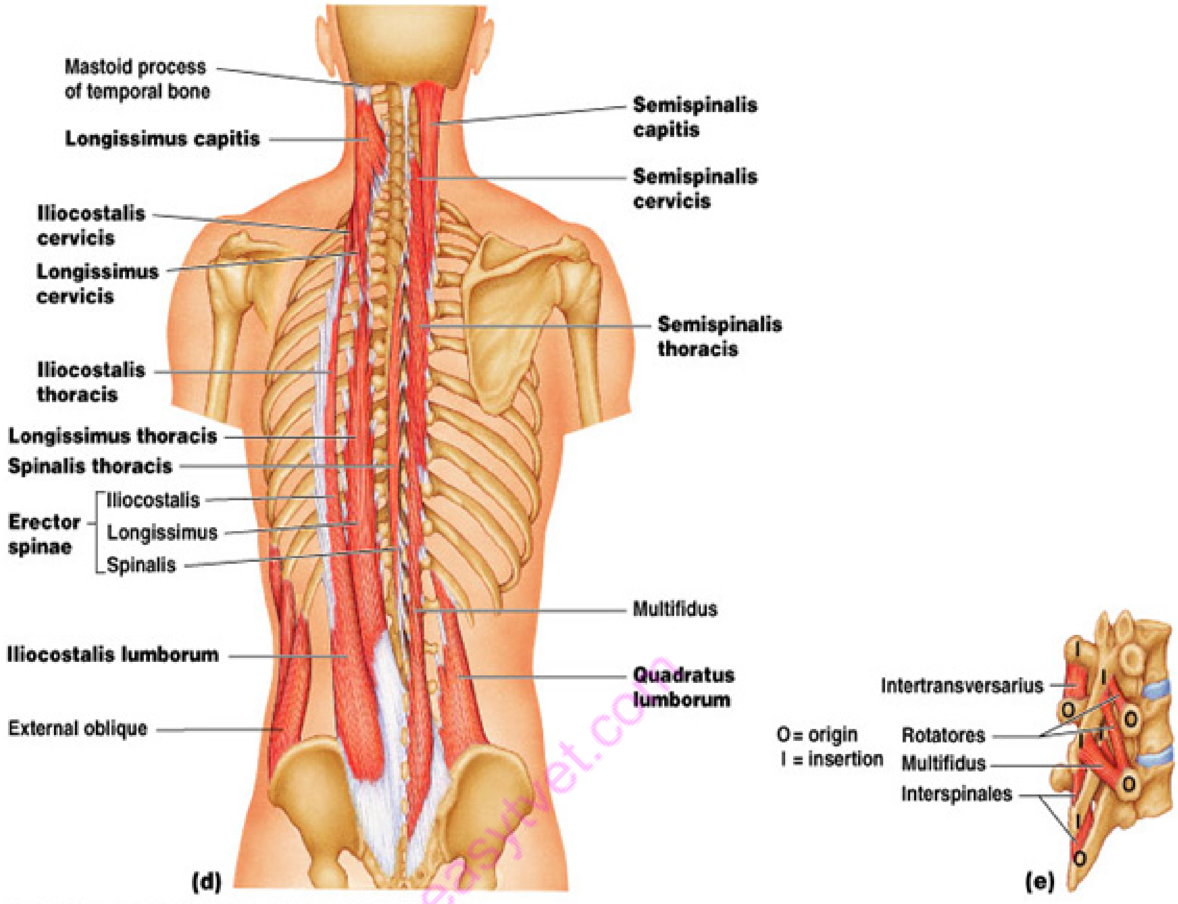
Sternocleidomastoid: cranial (accessory) nerve XI and branches of cervical nerves 2-4:

Prime mover of head flexion

Neck flexion

Head movement side-to-side



Longissimus: thoracis, cervicis, and capitis: spinal nerves:

Capitis: extends head and turns face side to side

Thoracis and cervicis: extend vertabral column side to side

Thorax and Abdominal Muscles

Muscles of the Thorax: Breathing

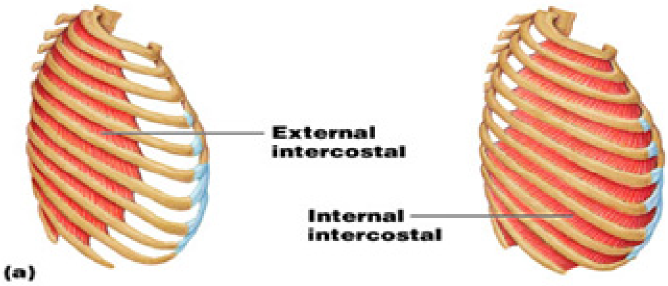
Muscles of the thorax include the external intercostals, internal intercostals, and the diaphragm

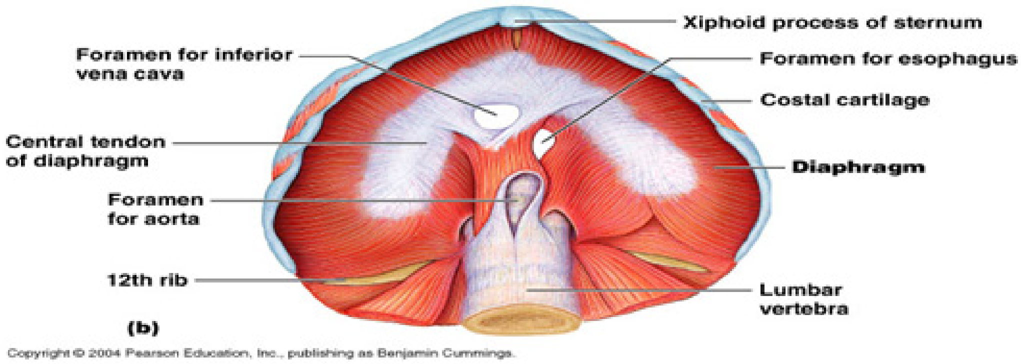
Muscles of the Abdominal Wall: Trunk Movement and Compression of Abdominal Viscera

Muscles of the anterolateral abdominal wall include the

- Rectus abdominis
- External oblique
- Transversus abdominis

Thorax Muscles





External intercostals: intercostal nerves:

Elevate rib cage | Aids in inspiration

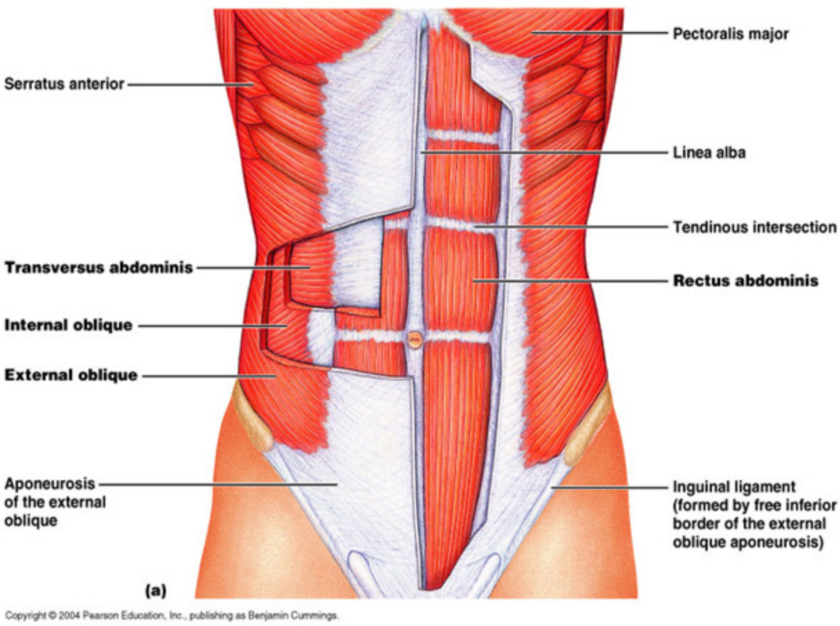
Internal intercostals: intercostal nerves:

Depress rib cage | Aids in expiration

Diaphragm:Cervical (phrenic) nerve (C_3-C_5)

Breathing

Abdominal Muscles



Rectus abdominis: Intercostal (thoracic) nerves:

Flex and rotate lumbar region

External oblique: Intercostal (thoracic) nerves:

Compression of abdominal wall

Transversus abdominis: Intercostal (thoracic) nerves:

Compression of abdominal wall

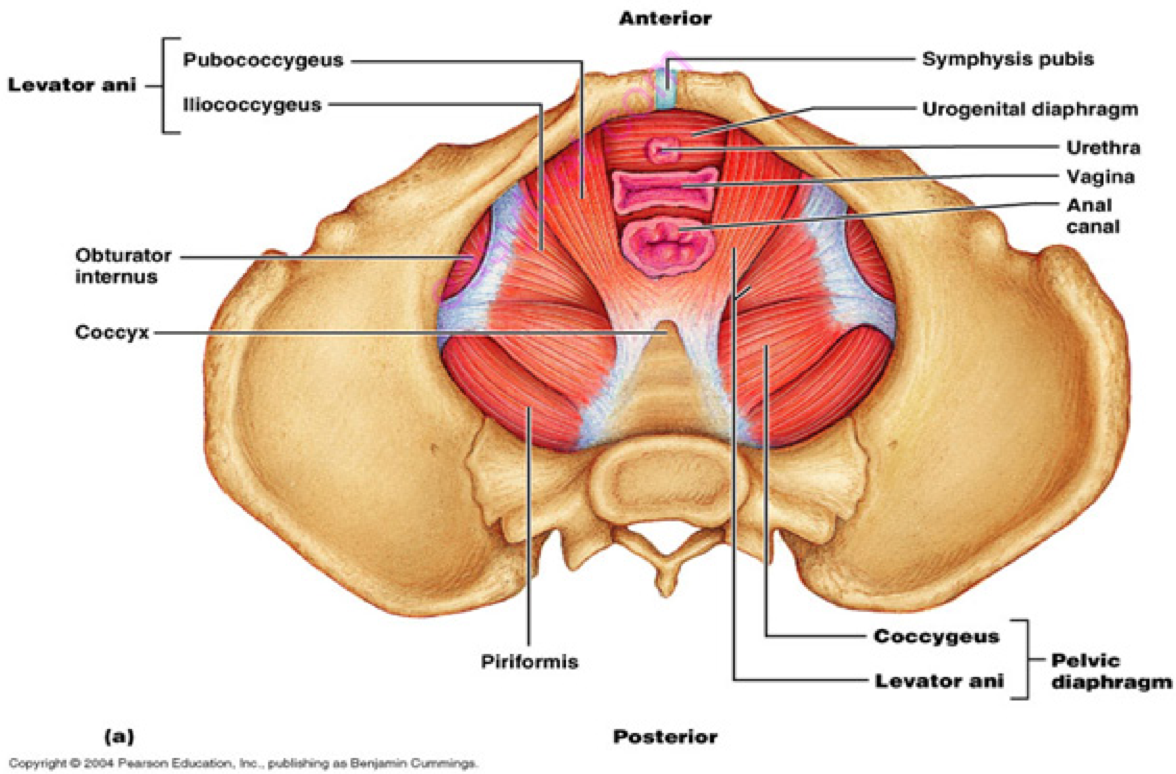
Muscles of the Pelvic Floor and Perineum

Muscles of the Pelvic Floor and Perineum: Support of Abdominopelvic Organs:

Muscles of the pelvic diaphragm include the levator ani and the coccygeus

Muscles of the urogenital diaphragm include the deep transverse perineus and the sphincter urethrae

Muscles of the superficial space include the ischiocavernosus, bulbospongiosus, and the superficial transverse perineus.



Pelvic Floor Muscles

Ischiocavernosus: pudendal (sacral) nerve:

Retards venous drainage and maintains erection of penis or clitoris

Bulbospongiosus: pudendal (sacral) nerve:

Empties male urethra

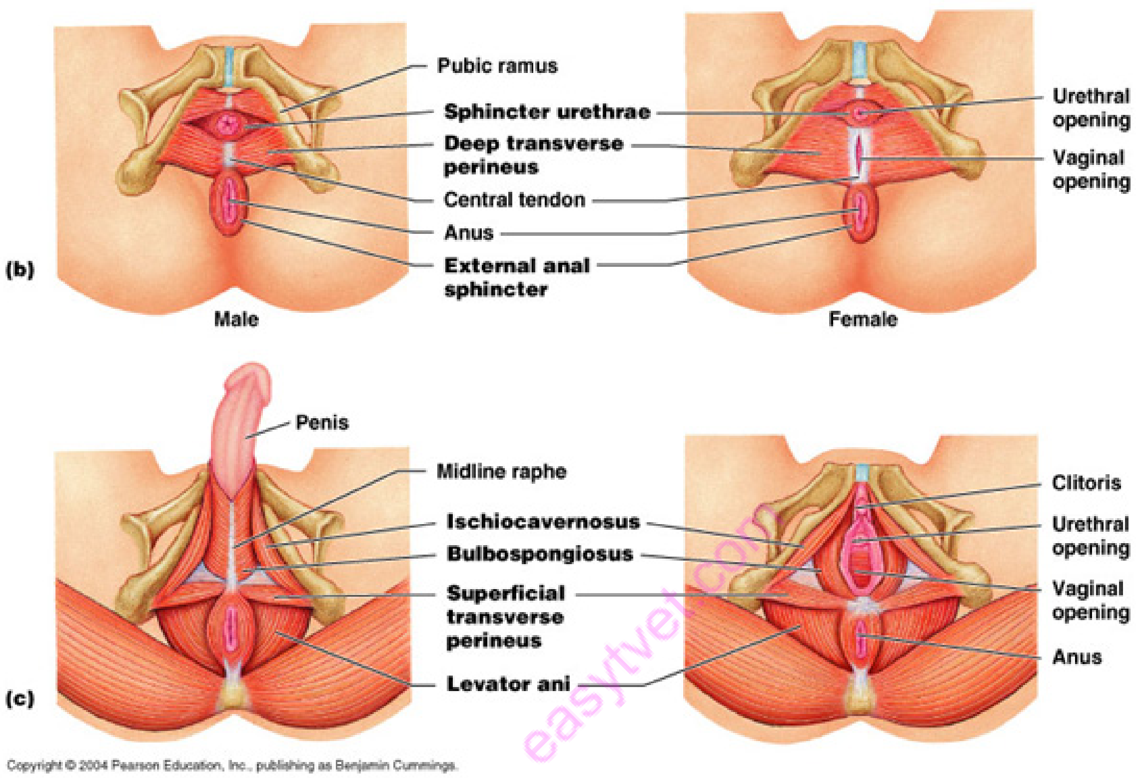
Assist in erection of penis in males and of clitoris in females

Superficial Muscles of the Anterior and Posterior Thorax

Superficial Muscles of the Anterior and Posterior Thorax: Movements of the Scapula

Muscles of the anterior thorax include the pectoralis minor, serratus anterior, and the subclavius

Muscles of the posterior thorax include the trapezius, levator scapulae, and the rhomboids (major and minor)

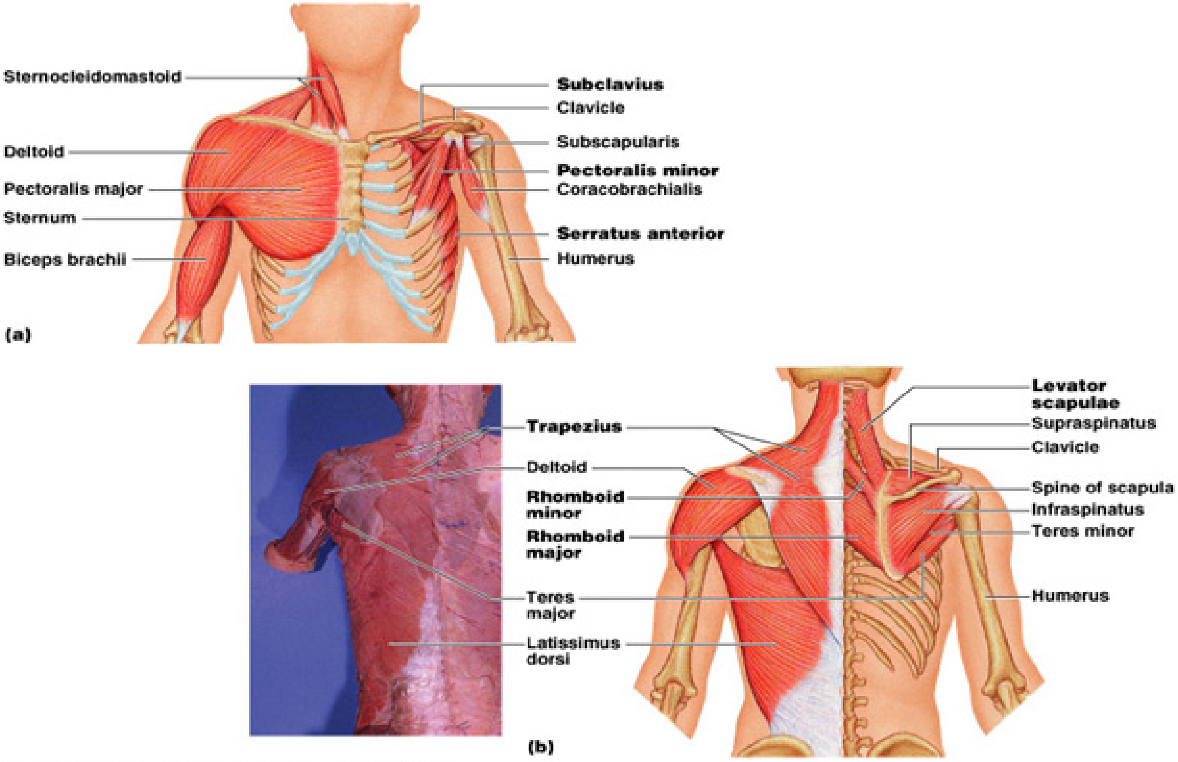


Muscles Crossing the Shoulder Joint

Muscles Crossing the Shoulder Joint: Movement of the Arm

Muscles moving the arm include the pectoralis major, latissimus dorsi, deltoid, subscapularis, supraspinatous, infraspinatous, teres minor, teres major, and the coracobrachialis

Thorax Muscles



Deltoid: cervical nerves:

Prime mover of arm abduction

Antagonists of pectoralis major and latissimus dorsi

Pectoralis major: cervical and thoracic nerves:

Prime mover of arm flexion

Adduction

Trapezius: cervical nerves:

Stabilizes, raises, retracts, and rotates scapula

Latissimus dorsi: cervical nerves

Prime mover of arm extension

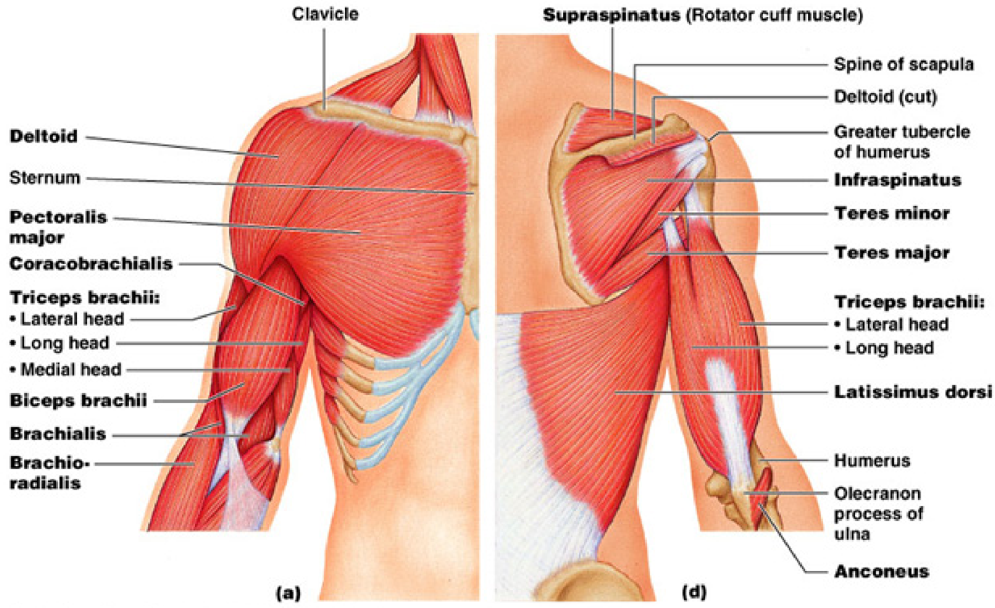
Powerful arm adductor

Striking a blow

Swimming

Rowing

SHOULDER MUSCLES



Muscles Crossing the Elbow Joint

Muscles crossing the Elbow Joint: Flexion and Extension of the Forearm

Posterior muscles include the triceps brachii, and the anconeus

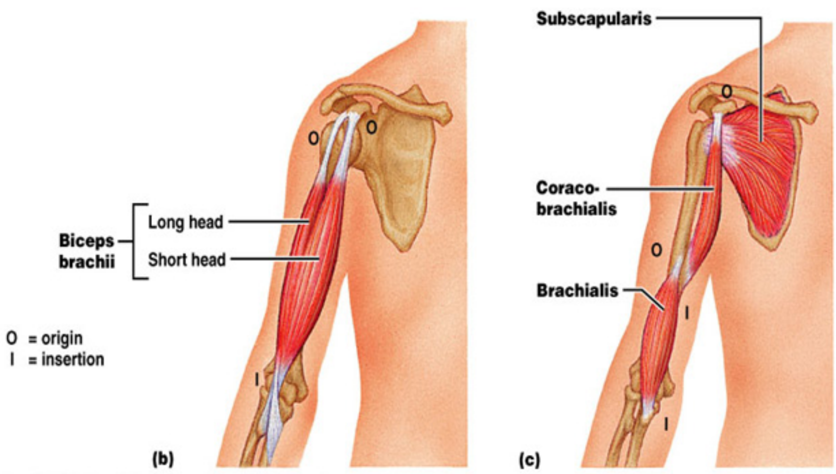
Anterior muscles include the biceps brachii, brachialis, and the brachioradialis

Triceps brachii: cervical nerves: Powerful forearm extensor

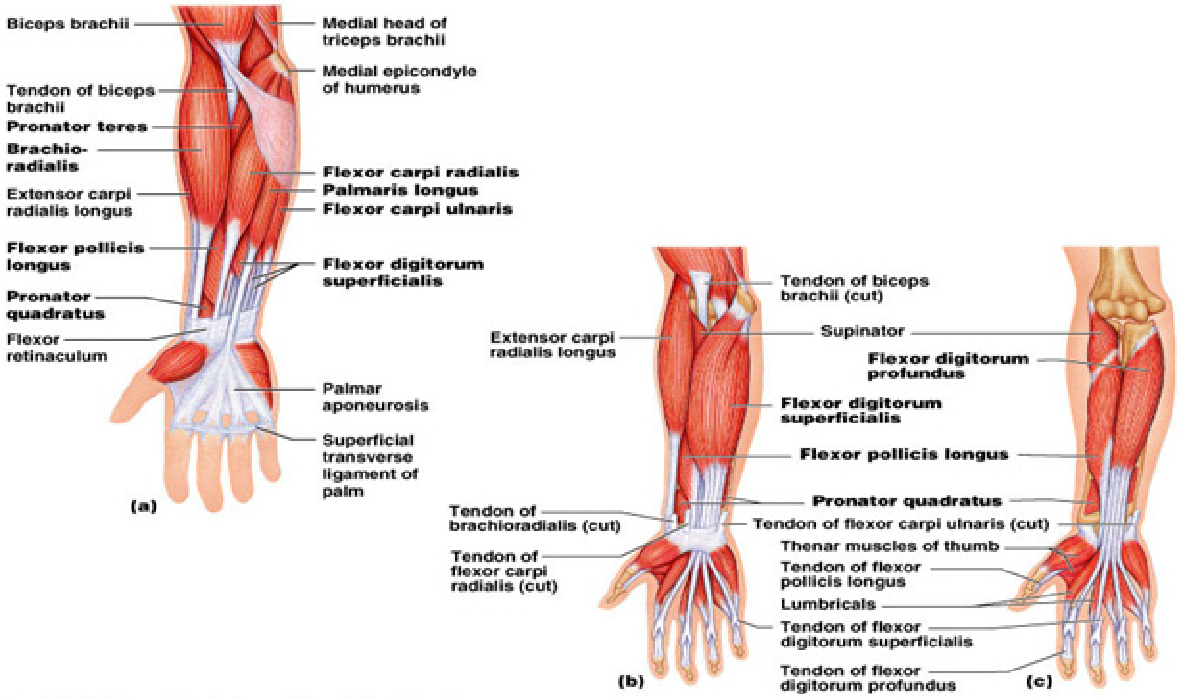
Biceps brachii: cervical nerves: Flexes elbow joint and supinates forearm

Brachialis: musculocutaneous nerve: Major forearm flexor. Lifts ulna as biceps lifts the radius

Brachioradialis: radial nerve: Synergist in forearm flexion



Forearm Muscles



Flexor carpi radialis: median nerve:

Powerful flexor of wrist

Flexor carpi radialis: median nerve:

Powerful flexor of wrist

Abducts hand

Flexor carpi ulnaris: ulnar nerve:

Powerful flexor of wrist

Adducts hand

Extensor carpi radialis brevis: radial nerve:

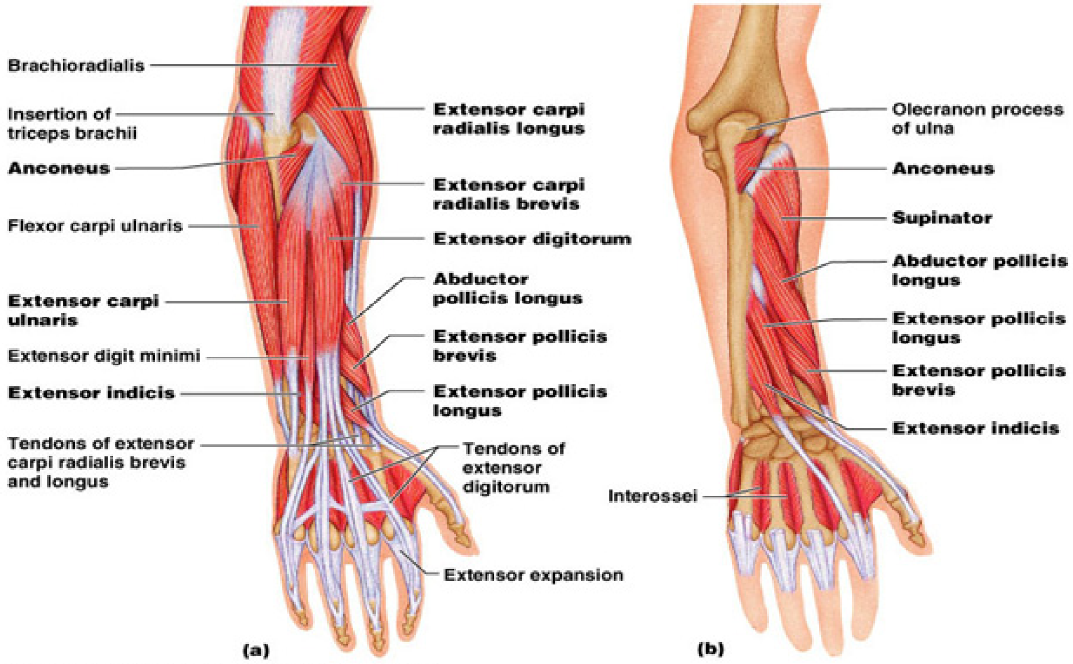
Extends and abducts wrist

Extensor digitorum: branch of radial nerve:

Prime mover of finger extension

Extends wrist

POSTERIOR ARM MUSCLES



MAJOR SKELETAL MUSCLES OF THE BODY

Muscles of the Forearm: Movements of the Wrist, Hand, and Fingers

Anterior superficial muscles include the pronator teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris, and the flexor digitorum superficialis

Anterior deep muscles include the flexor pollicis longus, flexor digitorum profundus, and the pronator quadratus

Posterior superficial muscles include the brachioradialis, extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum, and the extensor carpi ulnaris

Posterior deep muscles include the supinator, abductor pollicis longus, extensor pollicis longus, and the extensor pollicis brevis

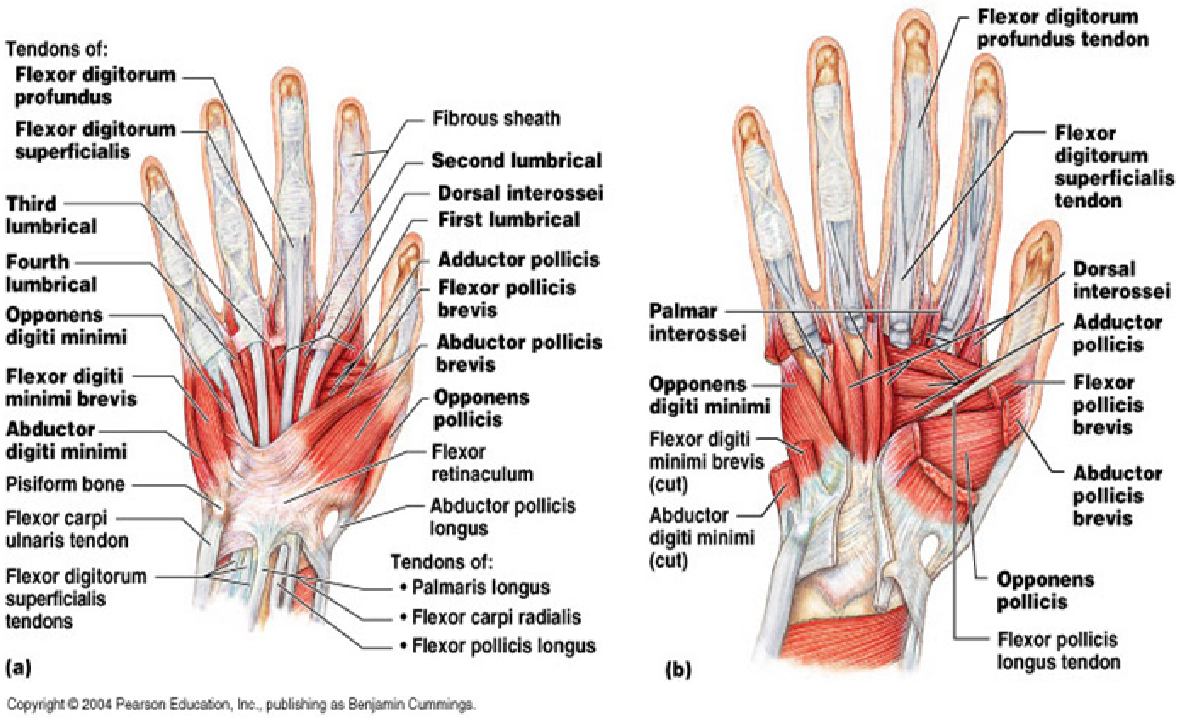
Intrinsic muscles of the Hand: Fine Movements of the Fingers

Thenar muscles in ball of thumb include the abductor pollicis brevis, flexor pollicis brevis, opponnens pollicis, and the adductor pollicis

Hypothenar muscles in ball of little finger include the abductor digiti minimi, flexor digiti minimi brevis, and the opponens digiti minimi

Midpalmar muscles include the lumbricals, palmar interossei, and the dorsal interossei

Hand Muscles



Abductor pollicis brevis: median nerve (cervical.thoracic)

Abducts thumb

Flexor digiti minimi brevis: ulnar nerve:

Flexes little finger

Muscles Crossing the Hip and Knee Joints: Movements of the Thigh and Leg

Anteromedial muscles include the iliopsoas, which is composed of the iliacus, the psoas major, and the sartorius

Muscles of the medial compartment of the thigh include the adductor group, which is made up of the adductor magnus, adductor longus and the adductor brevis, the pectineus, and the gracilis

Muscles of the anterior compartment of the thigh include the quadriceps femoris group, which is made up of the rectus femoris, vastus lateralis, vastus medialis and vastus intermedius, and the tensor fasciae latae

Posterior Muscles: gluteal muscles (origin on pelvis) include the gluteus maximus, gluteus medius, and the gluteus minimus

Lateral rotators include the piriformis, obturator externus, obturator internus, gemellus, and the quadratus femoris

Muscles of the posterior compartment of the thigh include the hamstring group, which consist of the biceps femoris, semitendinosus, and the semimembranosus.

NB: Highly examinable especially the quadriceps and hamstring group of muscles.

Thigh Muscles

Adductor longus: obturator nerve:

Adducts, flexes, and medially rotates thigh

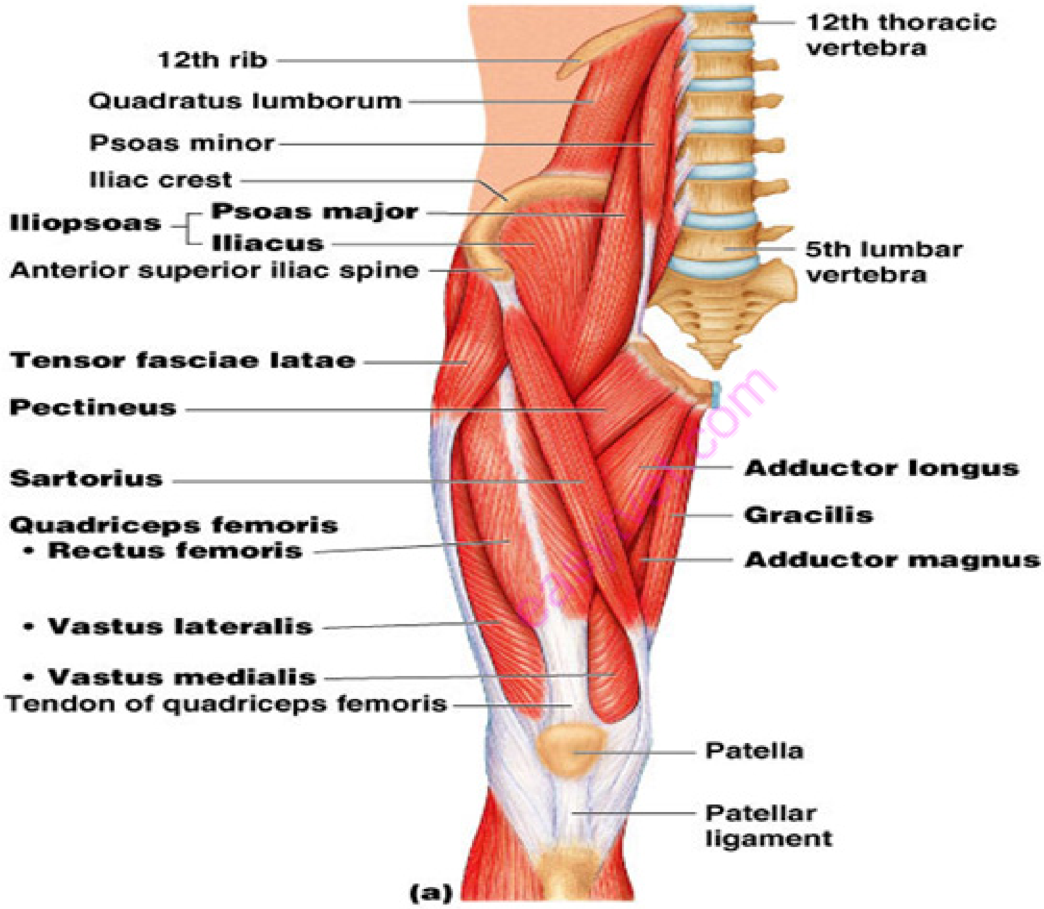
Gracilis: obturator nerve:

Adducts thigh, flexes, and medially rotates thigh, especially during walking

Quadriceps femoris:

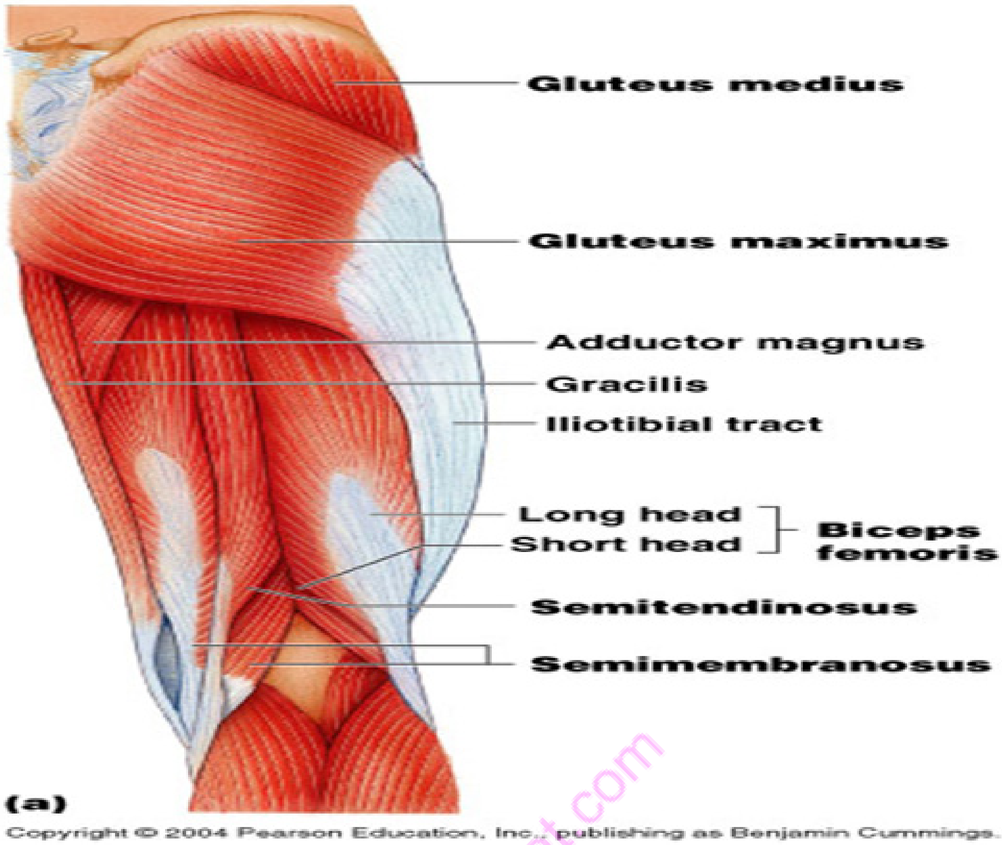
Rectus femoris: femoral nerve:

Extends knee and flexes thigh at hip.



ANTERIOR THIGH MUSCLES

Hip Muscles



Gluteus maximus: inferior gluteal nerve:

Major extensor of thigh

Complex, powerful, and most effective when thigh is flexed and force is necessary, as in rising from a forward flexed position and in thrusting the thigh posteriorly in climbing stairs and running

Inactive during standing

Muscles of the Leg: Movements of the Ankle and Toes

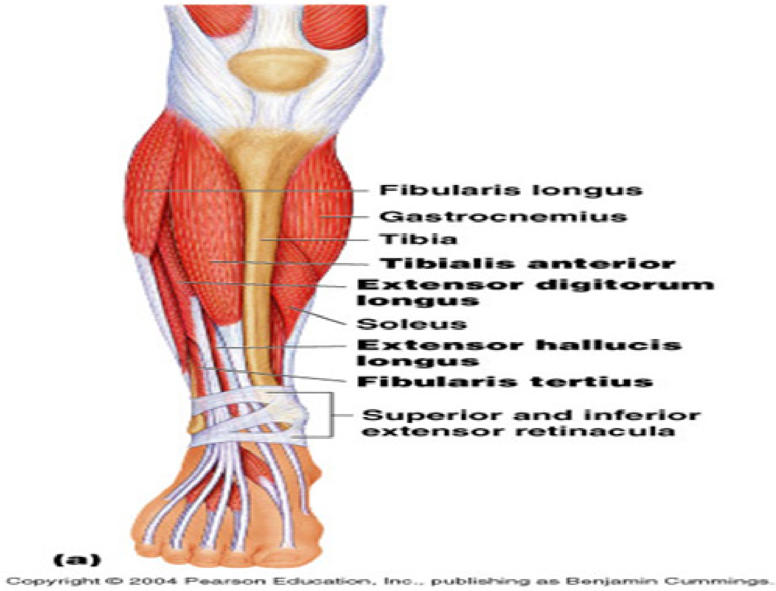
Muscles of the anterior compartment include the tibialis anterior, extensor digitorum longus, fibularis (peroneus) tertius, and the extensor hallucis longus

Muscles of the lateral compartment include the fibularis (peroneus) longus and the fibularis (peroneus) brevis

Superficial muscles of the posterior compartment include the triceps surae, which is composed of the gastrocnemius and the soleus, and the plantaris

Deep muscles of the posterior compartment include the popliteus, flexor digitorum longus, flexor hallucis longus, and the tibialis posterior

ANTERIOR LEG MUSCLES



Tibialis anterior: fibular nerve (lumbar):

Prime mover of dorsiflexion

Inverts foot

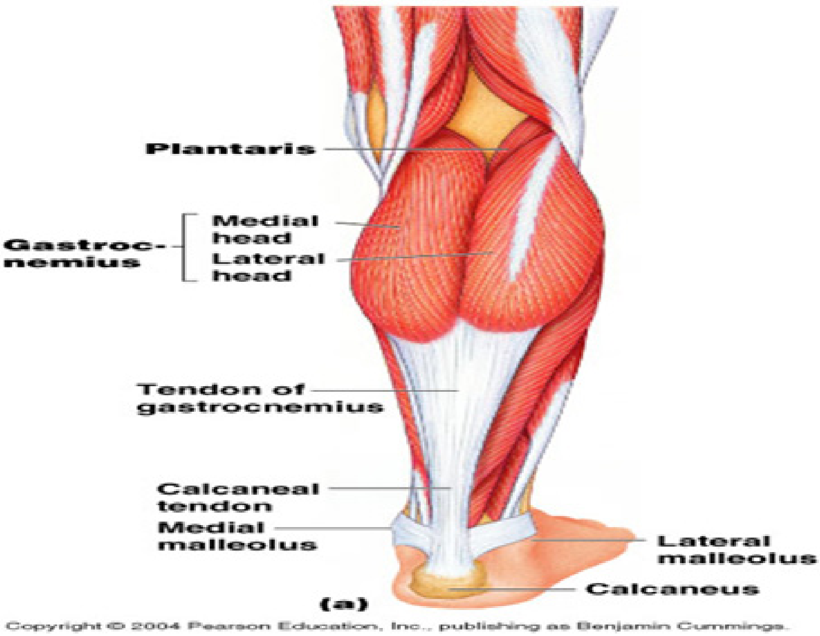
Assists in supporting medial longitudinal arch of foot

Fibularis longus: fibular nerve (lumbar):

Plantar flexes and everts foot

May help keep foot flat on ground

POSTERIOR LEG MUSCLES



Gastrocnemius: tibial nerve (sacral):

Plantar flexes foot when knee is extended

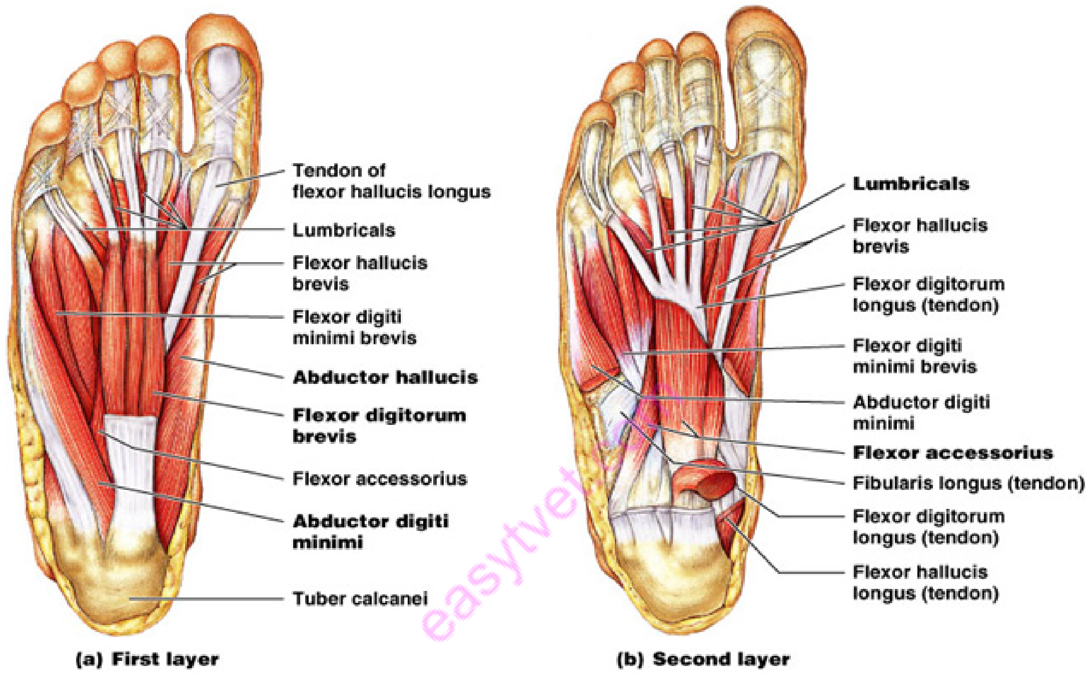
Since it also crosses knee joint, it can flex knee when foot is dorsiflexed

Soleus: tibial nerve (sacral):

Plantar flexes foot

Important locomotor and postural muscle during walking, running, and dancing

FOOT MUSCLES



THE SKELETON

The Bone

A strong and durable type of connective tissue.

Consists of:

- Water (25%)
- Organic constituents including osteoid (the carbon containing part of the matrix) and bone cells (25%)
- Inorganic constituents, mainly calcium phosphate (50%).

Functions of bones

- Provide the framework of the body
- Give attachment to muscles and tendons

- Permit movement of the body as a whole and of parts of the body, by forming joints that are moved by muscles
- Form the boundaries of the cranial, thoracic and pelvic cavities, protecting the organs they contain
- Contain red bone marrow in which blood cells develop; haematopoiesis
- Provide a reservoir of minerals, especially calcium phosphate.

Types of Bones

Bones are classified as long, short, irregular, flat and sesamoid.

Long bones consist of a shaft and two extremeties.Examples include the femur, tibia and fibula

Short, irregular, flat and sesamoid bones have no shafts or extremities and are diverse in shape and size e.g. short bones-carpals(wrist), irregular bones-vertebrae and some skull bones, flat bones-sternum, ribs and most skull bones, sesamoid bones-patella(knee cap)

1. Long Bones

Tubular shell with cavity in the middle.

Found in: Arms, legs, hands, etc. E.g. humerus & femur

Has the following layers:

- Periosteal layer for oppositional growth
- Compact layer for rigidity
- Cancellous/spongy layer for inner support
- Marrow support for blood forming cells

Growth takes place at the epiphyseal disc

Blood supply is from nutritional arteries, periosteal arteries supplying periosteum, epiphyseal arteries supplying epiphyses and around.

2. Short Bones

No marrow cavity; don’t contain epiphysis. They are cuboidal than tubular in shape

Found in: Wrist & ankle E.g. carpals and tarsals.

3. Flat Bones

Flat and thin, (protection, broad surface for muscle attachment)

Found in: Cranium, pectoral & pelvic girdles e.g. parietal, scapula, ilium, sternum.

4. Irregular Bones

Specialized shape & function (support weight, dissipate loads, protect spinal cord)

Found in: Spinal column E.g. vertebral bodies.

5. Sesamoid Bones

Small bones embedded within a tendon or joint capsule (alters angle of insertion, reduces friction). Found in: Knee, hand, thumb & big toe E.g. patella & Pisiform

Bone Structure

General structure of a long bone

Have a diaphysis or shaft & two epiphyses or extremities.

Diaphysis; composed of compact bone with a central medullary canal, containing fatty yellow bone marrow.

Epiphyses; Consist of an outer covering of compact bone with cancellous bone inside.

Diaphysis & epiphyses are separated by epiphyseal cartilages, which ossify when growth is complete.

Thickening of a bone occurs by the deposition of new bone tissue under the periosteum.

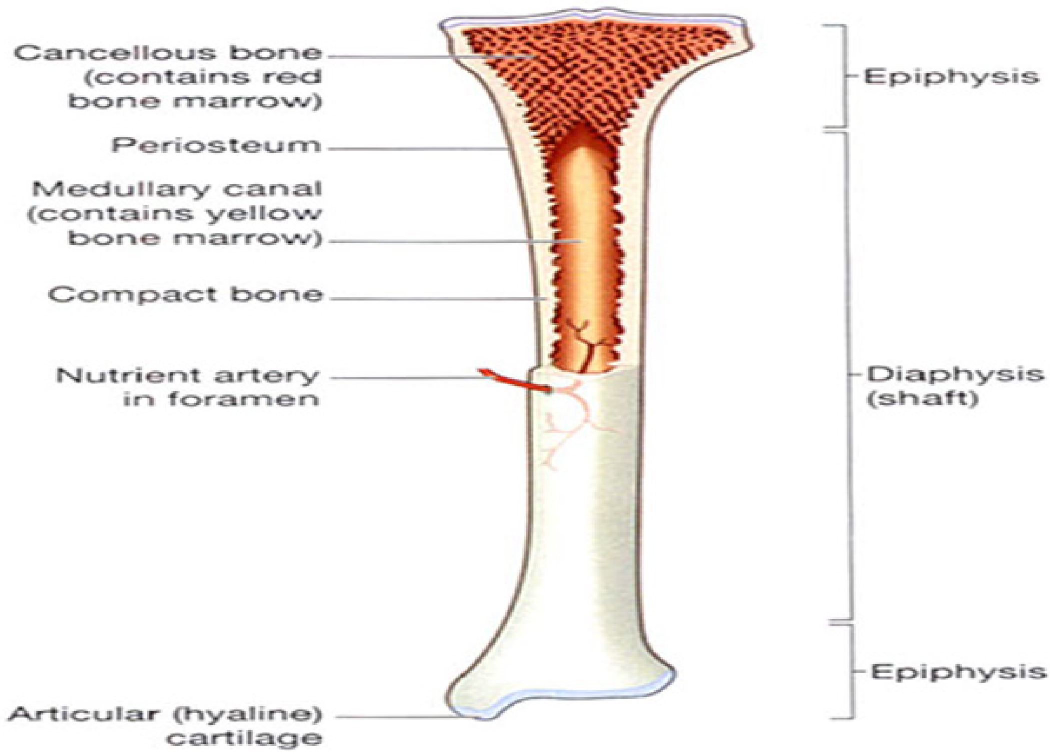
Long bones are almost completely coverd by, the periosteum.

Periosteum:

Has an outer layer, fibrous & the inner layer, osteogenic, containing osteoblasts & osteoclasts which are involved in maintenance & remodelling of bones; gives attachment to muscles & tendons, and protects bones from injury.

Hyaline cartilage replaces periosteum on the articular surfaces of bones forming synovial joints.

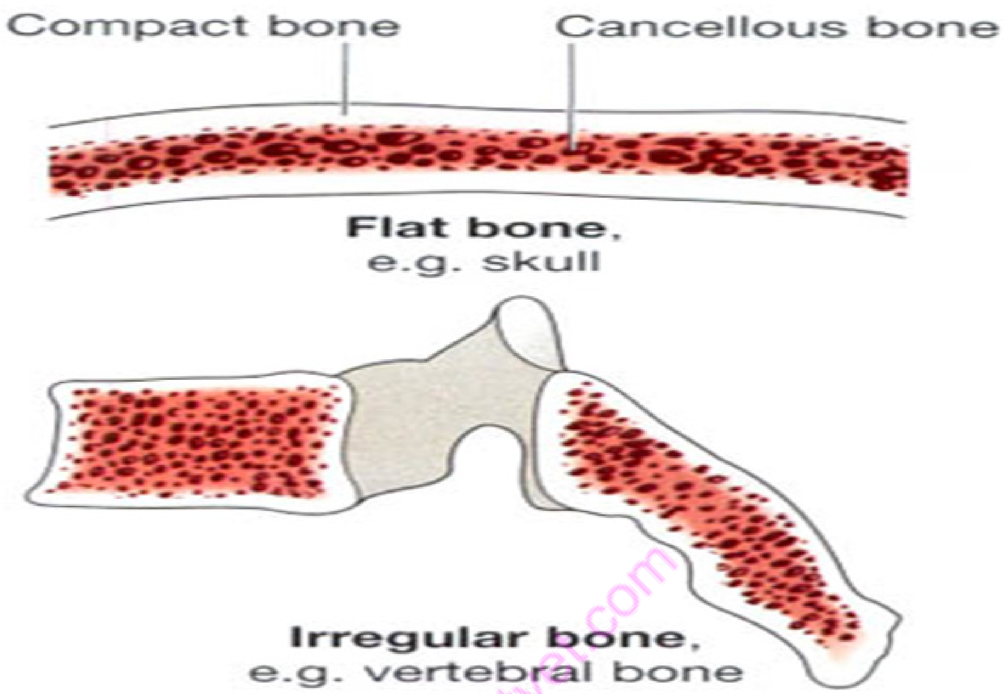
Structure of a mature long bone



Structure of short, irregular, flat & sesamoid bones

Relatively thin outer layer of compact bone with cancellous bone inside containing red bone marrow.

Enclosed by periosteum except the inner layer of the cranial bones where it is replaced by dura mater.



Flat & irregular bones

Microscopic structure of bone

a) Compact (cortical) bone

Large numbers of Haversian systems or osteons.

Consist of a central Haversian canal, containing blood & lymph vessels & nerves, surrounded by concentric rings or plates of bone (lamellae).

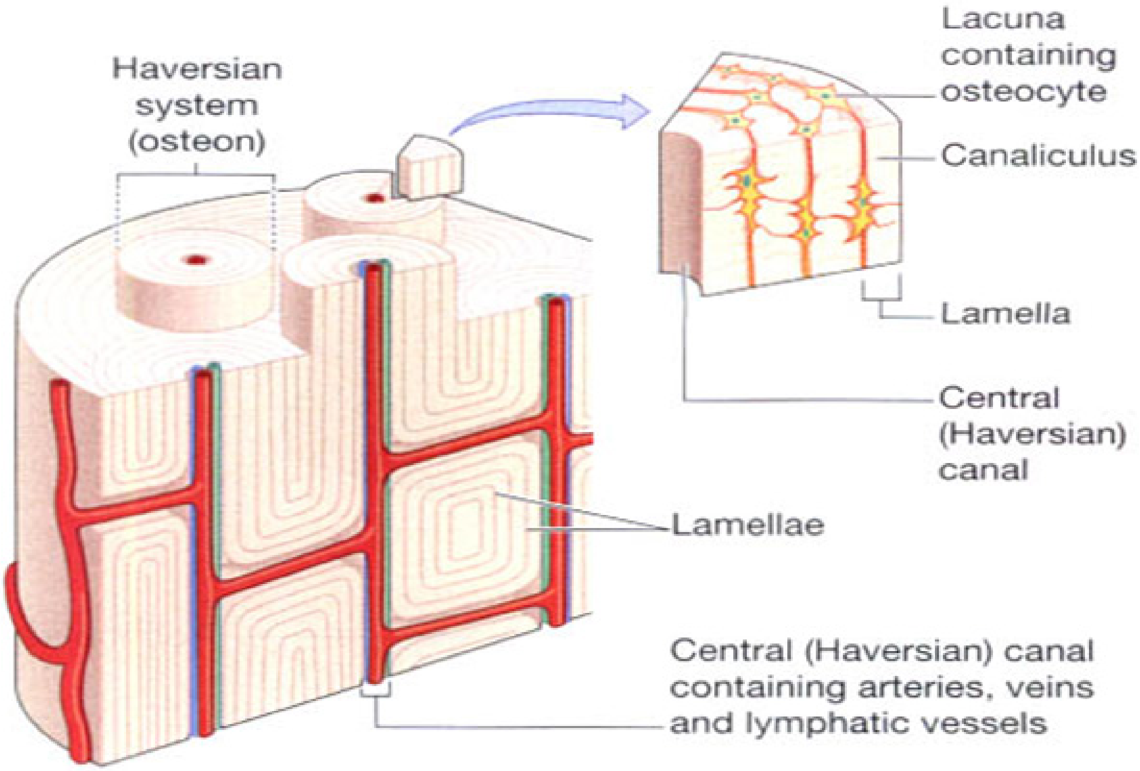
Between these are lacunae, tiny spaces, containing tissue fluid & spider-shaped osteocytes.

Canaliculi link the lacunae with each other and with the central Haversian canal.

Tissue fluid nourishes the bone cells.

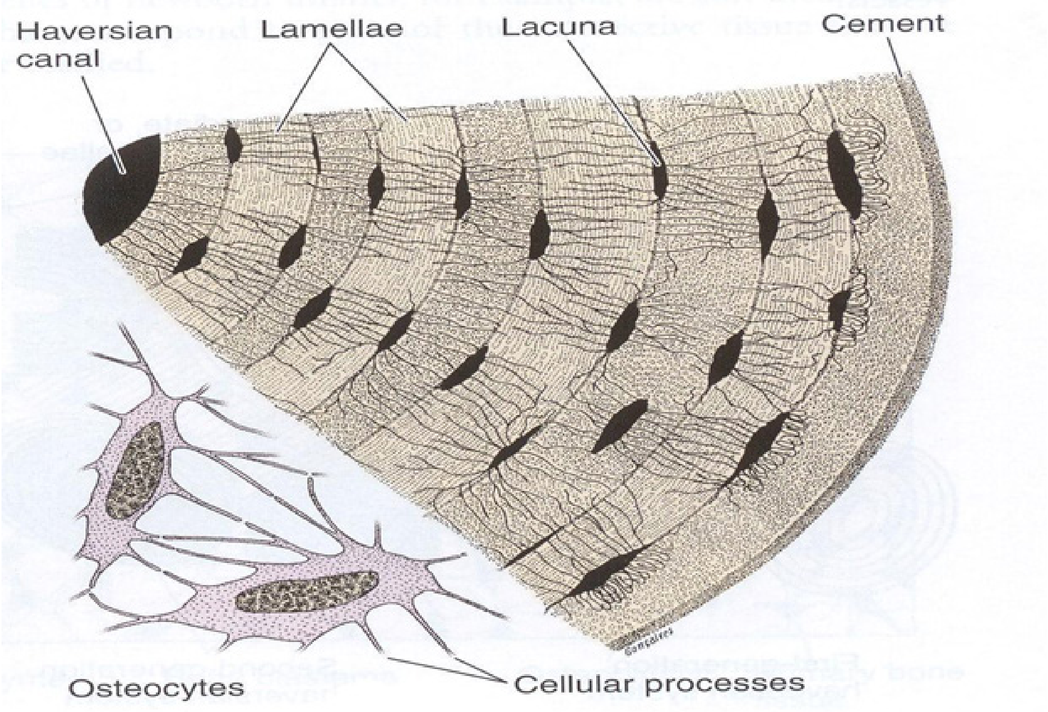
Areas between Haversian systems contain interstitial lamellae, remains of older systems partially broken down during remodelling or growth of bone.

The ‘tubular’ arrangement of lamellae gives bone greater strength than a solid structure of the same size.



Microscopic structure of compact bone

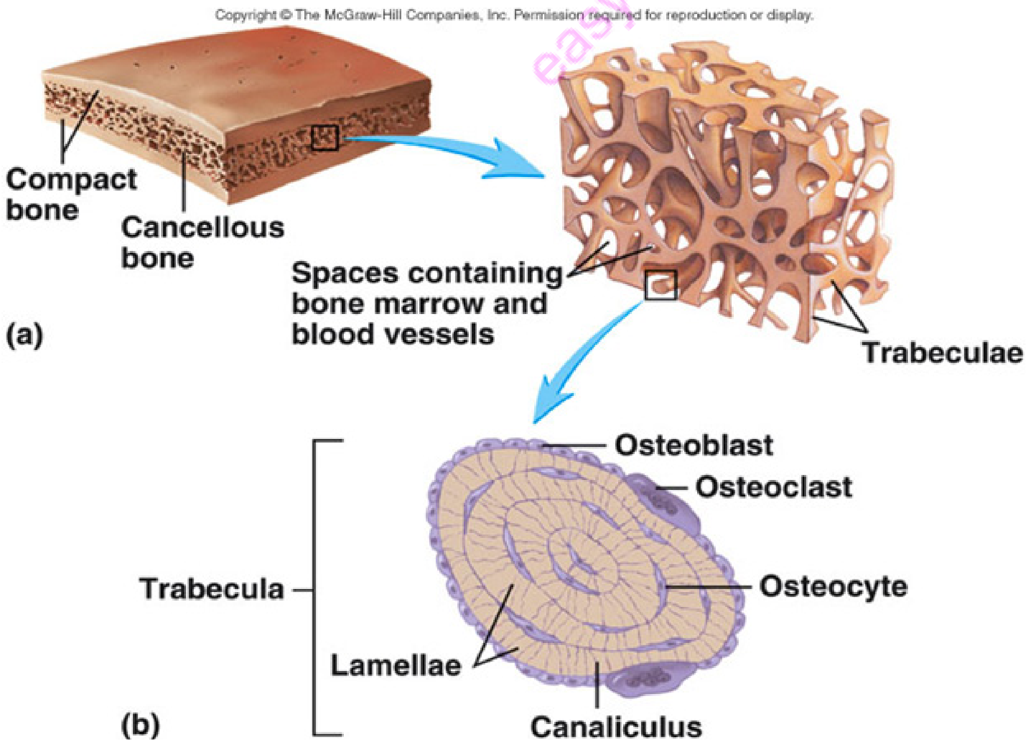
Compact Bone, Dried: An Osteon (transverse section). High magnification.



b) Cancellous (trabecular, spongy) bone

Has a framework formed from trabeculae (bony plates) which consist of a few lamellae & osteocytes interconnected by canaliculi.

Spaces between the trabeculae contain red bone marrow that nourishes the osteocytes.

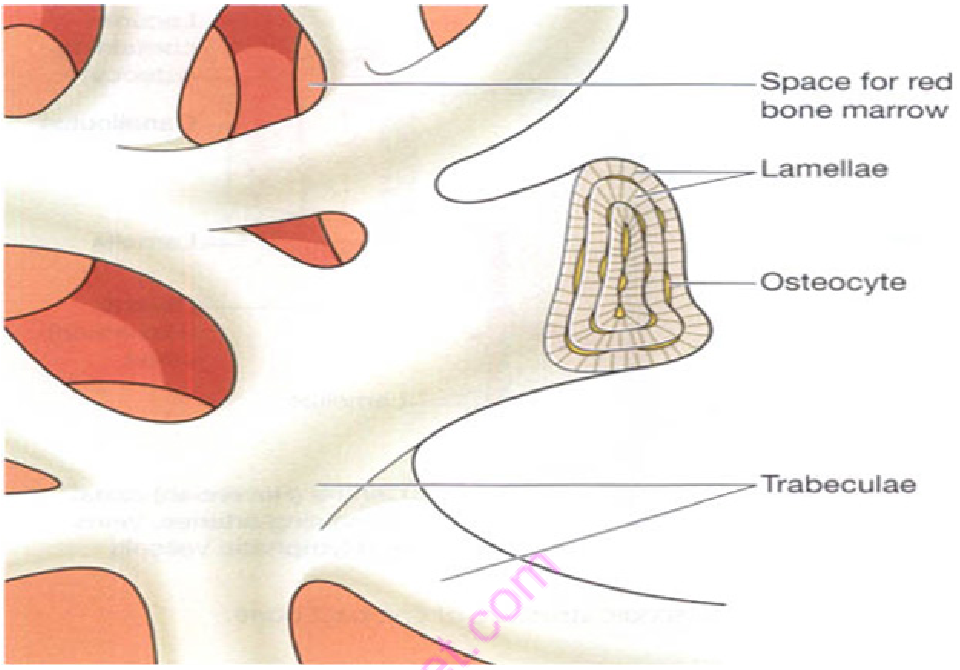


Bone Cells

Osteoblasts: cells responsible for bone formation (later mature into osteocytes).

Osteoblasts & chondrocytes (cartilage-forming cells) develop from the same parent fibrous tissue cells.

Differentiation into osteogenic cells, rather than chondroblasts, depends upon an adequate oxygen supply.



Microscopic structure of cancellous bone

1. Osteoblasts

Bone-forming cells that secrete collagen & other constituents of bone tissue.

Present:

- In the deeper layers of periosteum
- In the centres of ossification of immature bone
- At the ends of the diaphysis adjacent to the epiphyseal cartilages of long bones
- At the site of a fracture.

2. Osteocytes

As bone develops, osteoblasts become trapped and remain isolated in lacunae. They stop forming new bone at this stage and are called osteocytes.

Osteocytes are nourished by tissue fluid in the canaliculi that radiate from the Haversian canals.

3. Osteoclasts

Function: resorption of bone to maintain the optimum shape.

Takes place at bone surfaces:

under the periosteum, to maintain the shape of bones during growth and to remove excess callus formed during healing of fractures

round the walls of the medullary canal during growth and to canalise callus during healing.

A fine balance of osteoblast & osteoclast activity maintains normal bone structure and functions.

Development of Bone Tissue (Osteogenesis or Ossification)

Begins before birth & is not complete until about the 21st year of life.

Long, short & irregular bones develop from rods of cartilage, cartilage models.

Flat bones develop from membrane models and sesamoid bones from tendon models.

Bone development consists of 2 processes:

- Secretion by osteoblasts of osteoid, i.e. collagen fibres in a mucopolysaccharide matrix which gradually replaces the original cartilage and membrane models.
- Calcification of osteoid immediately after its deposition.

Two Types of Arrangement of Collagen in Osteoid

1. Woven (non-lamellar) bone--Collagen fibres are deposited in irregular bundles, then ossified.

Occurs during ossification of bones that originate as membrane models, e.g. skull bones.

In adults it is also present in bone tumors & healing fractures.

2. Lamellar bone--Collagen fibres are deposited as in woven bone, organized into characteristic lamellae found in compact and cancellous bone then ossified.

Occurs when cartilage models are replaced by bone and in healing of fractures.

Development of Long Bones

Ossification begins in small areas of osteogenic cells, or centres of ossification in the cartilage model.

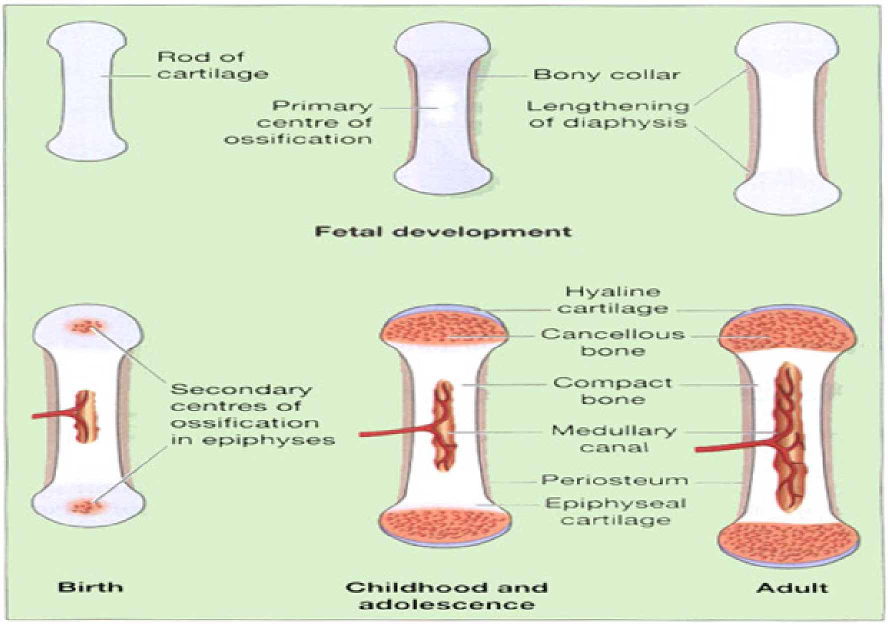
This is accompanied by development of a bone collar at about 8 weeks of gestation.

Later blood supply develops & bone tissue replaces cartilage as osteoblasts secrete osteoid components in the shaft.

Bone lengthens as ossification continues & spreads to the epiphyses.

Around birth, secondary centres of ossification develop in the epiphyses & the medullary canal forms when osteoclasts break down the central bone tissue in the middle of the shaft.

After birth, the bone grows in length by ossification of the diaphyseal surface of the epiphyseal cartilages and growth is complete when the cartilages become completely ossified.

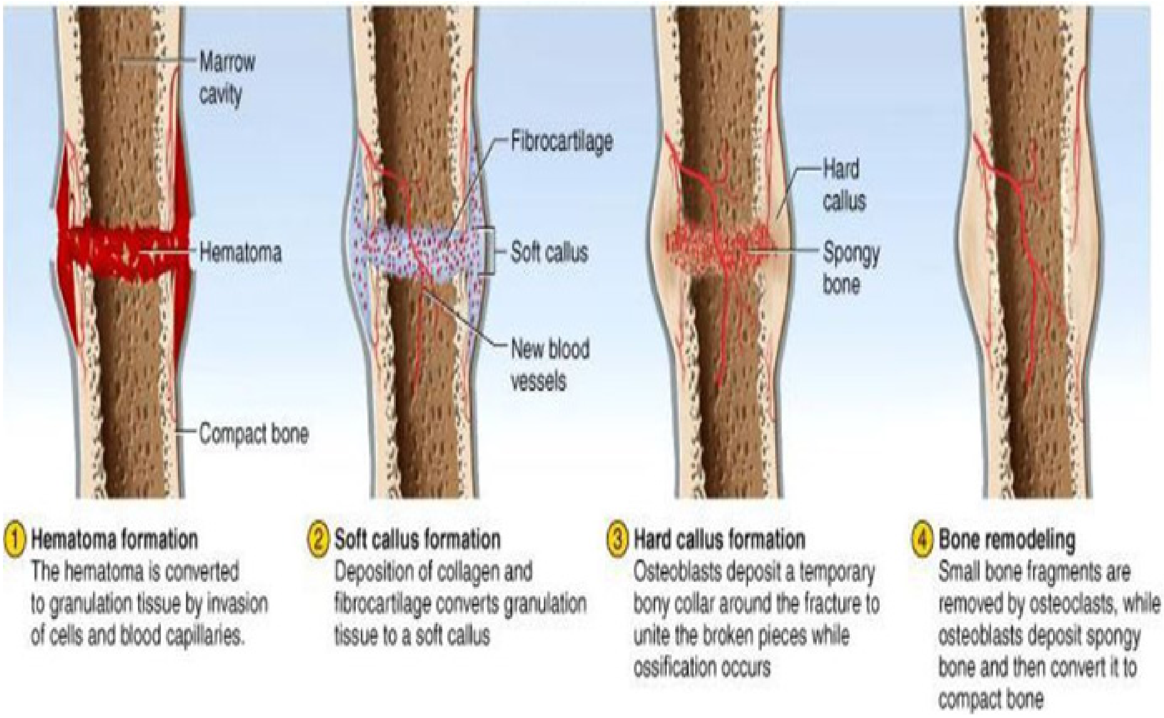


Stages in long bone development

Hormonal Regulation of Bone Growth

1. Growth hormone & thyroid hormones, are especially important during infancy & childhood.
2. Testosterone & oestrogens influence the physical changes that occur at puberty.
3. Calcitonin & Parathyroid hormone; homeostasis of blood & bone calcium levels required for bone development.

THE BONE HEALING PROCESS



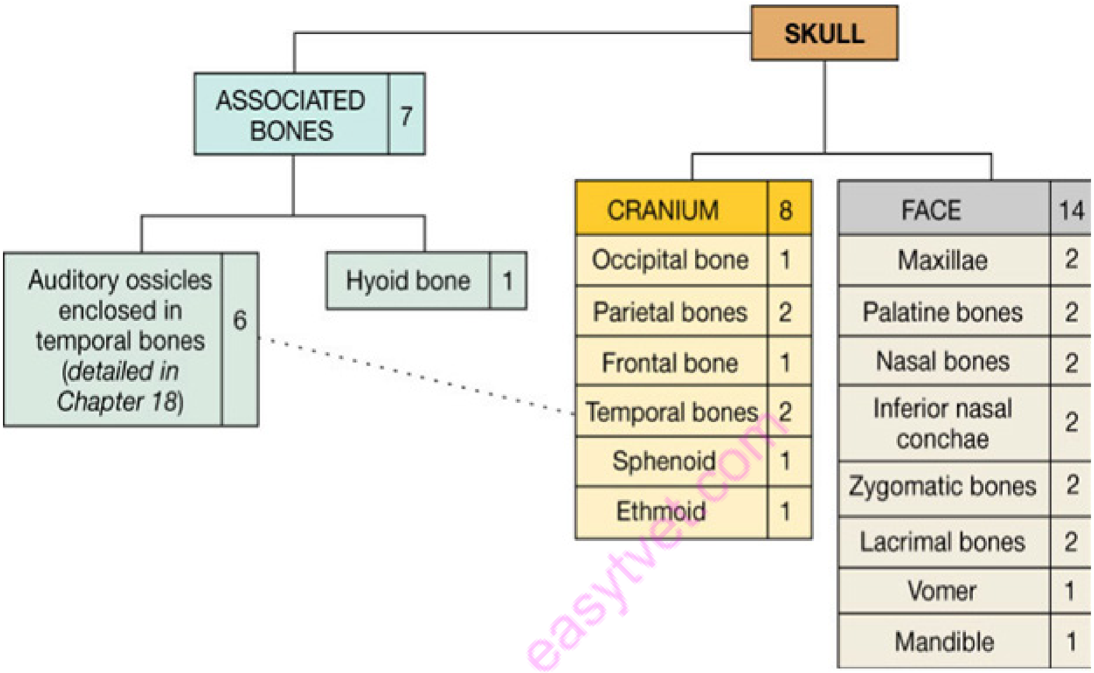
The Axial Skeleton (Part 1):

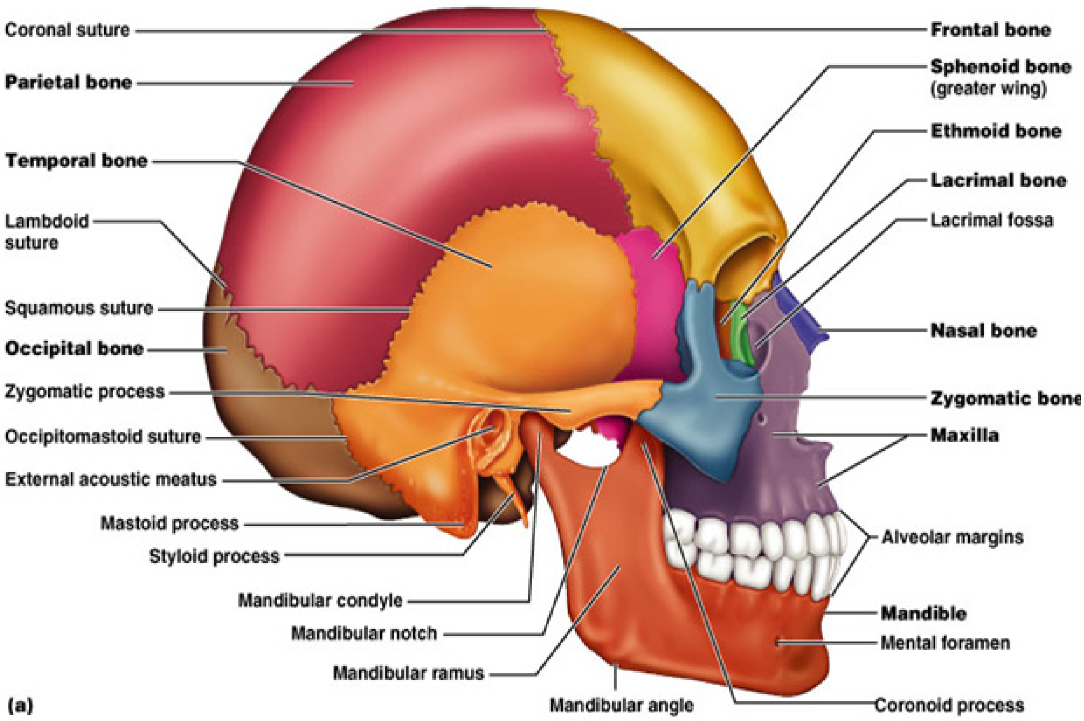
1. Skull
2. Spine
3. Sternum thorax
4. Ribs
5. Auditory ossicles—maleus, incus & stapes
6. Hyoid Bone

The Appendicular Skeleton (Part 2):

The appendages, i.e., everything else

Bones of the Skull.





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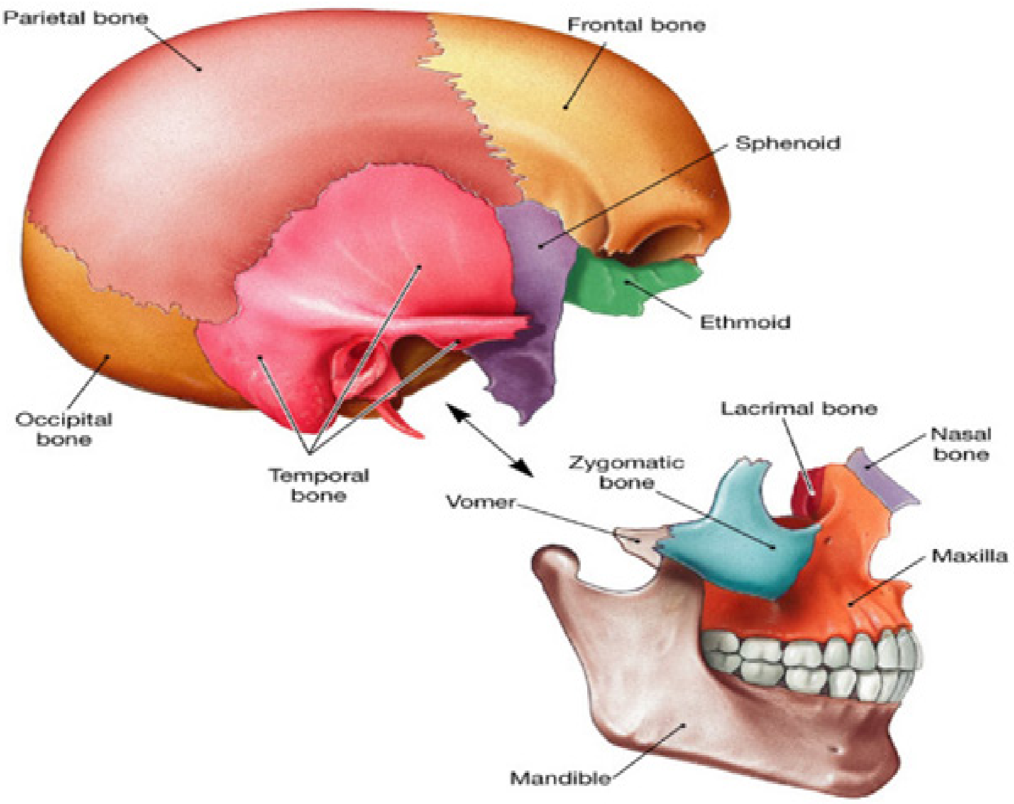


Bones of the Calvarium

Frontal (forehead)

Anterior fossa of base of skull

Frontal Crests

More prominent in male

Frontal sinuses

Parietal (2)

Sutures

Occipital

Foramen Magnum

Occipital Condyles articulate with C1

Occipital Crest

Temporal (4 parts):

Squamous (very thin),

Mastoid (means breast-like) process

Small sinus

Petrous

Houses inner ear

Acoustic meatus

Jugular foramen

Zygomatic process

Styloid Process

Sphenoid

Sella turcica houses pituitary gland

Ethmoid (sieve)

Cribriform plate for olfactory nerve

Crista galli

Part of nasal septum

Frontal

Temporal

Petrous part

Occipital

Foramen magnum

Facial bones Maxilla (2)

Alveolar margin for teeth

Maxillary sinus

Anterior portion of hard palate

Palatine (2)

Posterior aspect of hard palate

Nasal (2)

Inferior Nasal conchae (2)

Will be covered in Respiratory System

Zygomatic (2) AKA cheek bones

Zygomatic process of temporal bone

Lacrimal (2)

Lacrimal sac

Vomer

Separate the right and left nasal cavities

Mandible

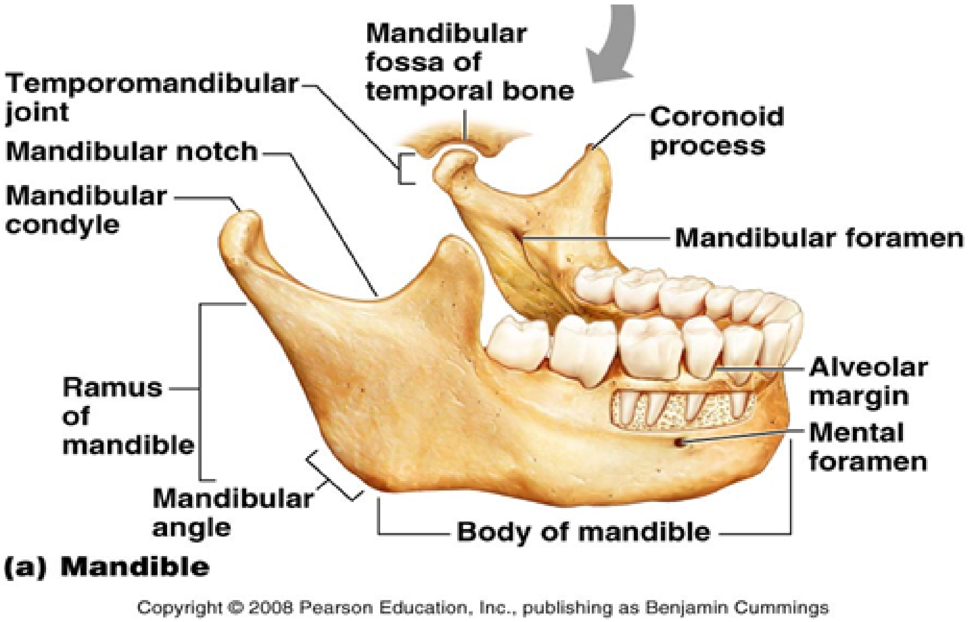
Mandibular condyles (TMJ)

Mandibular notch

Coronoid process

Ramus

Angle



Sutures and Fontanels

Sutures are fibrous Articulation, no movement, fused in adulthood

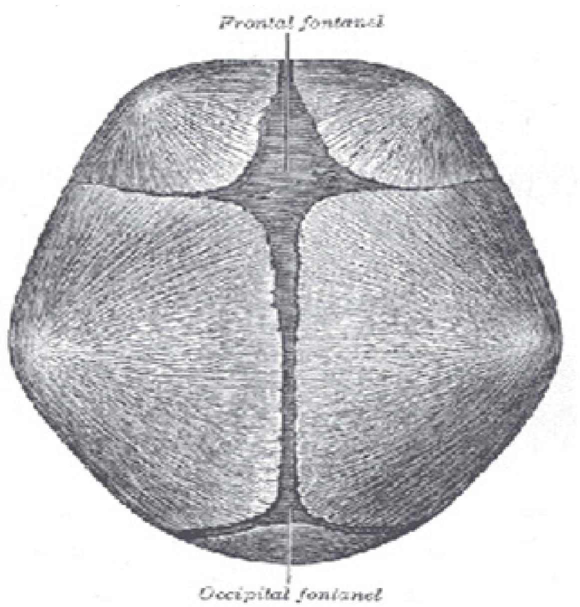
Lambdoidal—between occipital and parietal

Saggital --- between parietals

Coronal– between frontal and parietals

Squamous – between parietals and temporals

Anterior and Posterior Fontanels

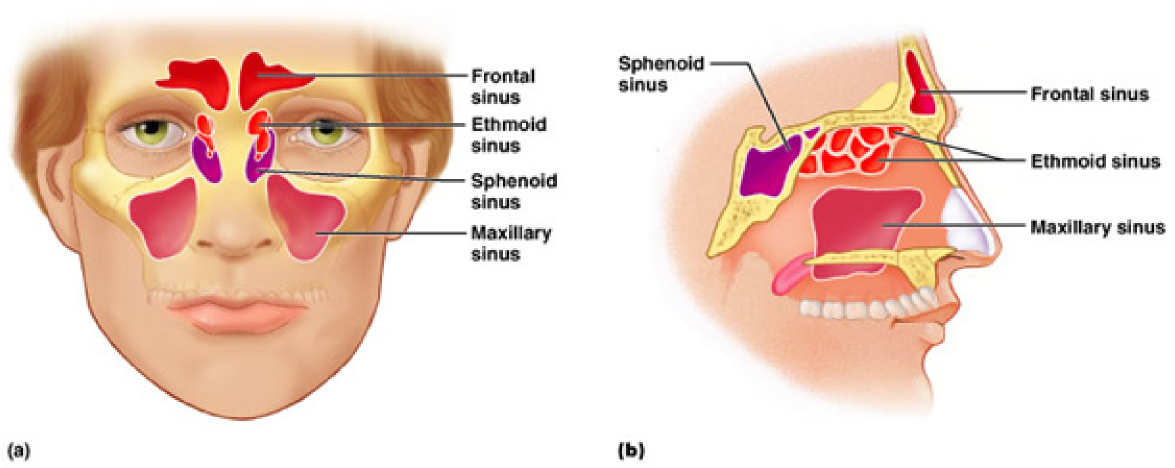


Paranasal Sinuses

Sinus—Is an air filled cavity inside the skull bones. It makes the skull lighter and also help to resonate sound.

Frontal	Ethmoid
Sphenoid	Maxillary

Narrow passageways from each sinus provide communication with nasal cavity



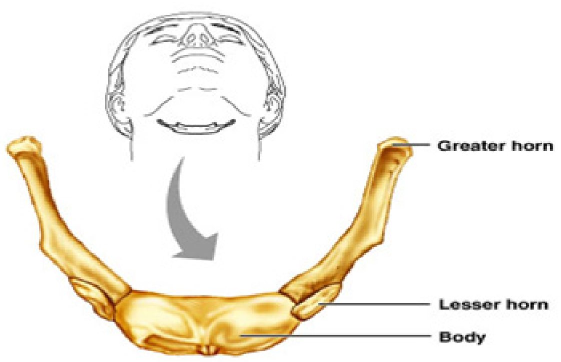
Sinusitis

-itis = inflammation

- Bacterial, viral, fungal, allergic
- Swelling causes poor drainage and pressure differentials
- Sinus headache
- Treatment might include decongestants, e.g., pseudephedrine

Hyoid Bone

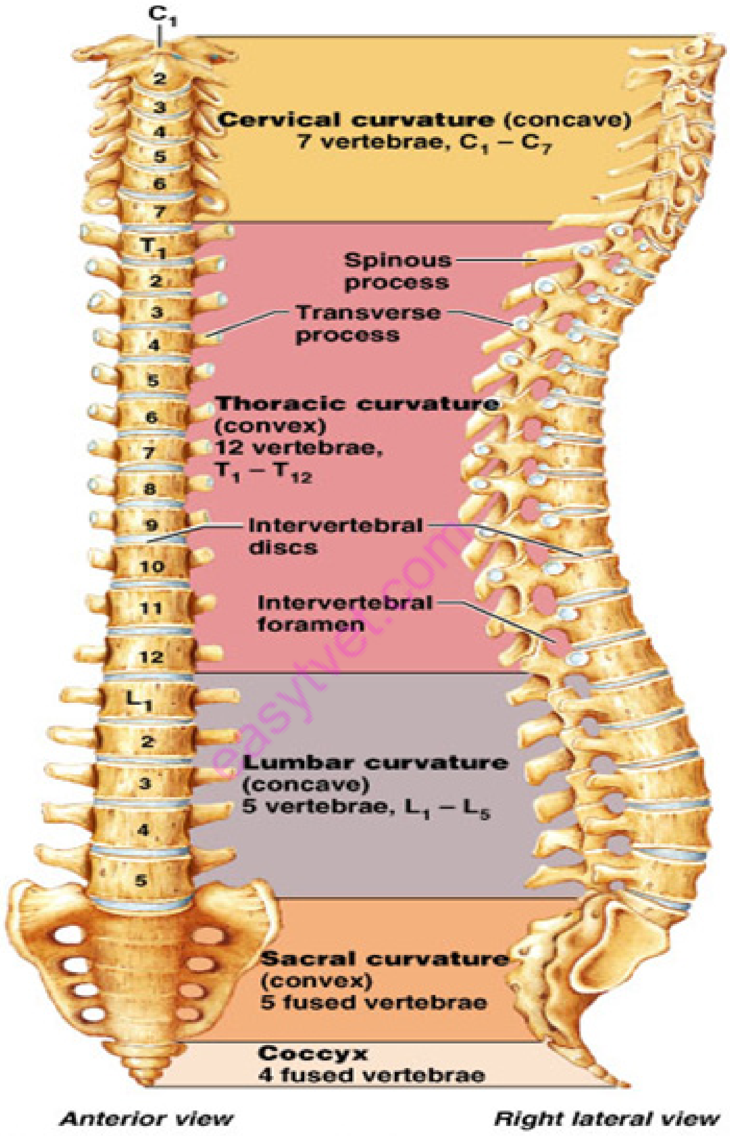
- Inferior to the mandible
- Superior to the larynx
- Supports many cervical muscles
- Supports the larynx.



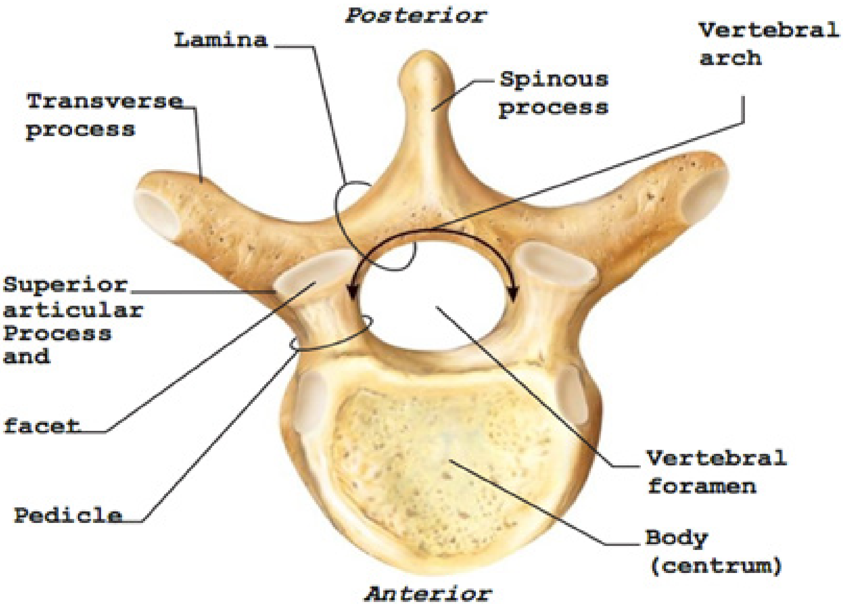
The Vertebral Column

7 Cervical
12 Thoracic
5 Lumbar
5 Sacral (fused)
4 Coccygeal (fused)

Curvatures: Cervical, Thoracic, Lumbar, Sacral.



A "Typical" Vertebra



Body and intervertebral disks

Spinous Process

Intervertebral Foramina

Articular processes/facets

Superior

Inferior

Vertebral (neural) Arch

Pedicles and Laminae

Vertebral Canal/foramen

Cervical Vertebrae (C1 – C 7)

C1 = Atlas (no body)

C1-C2 – site of rotation

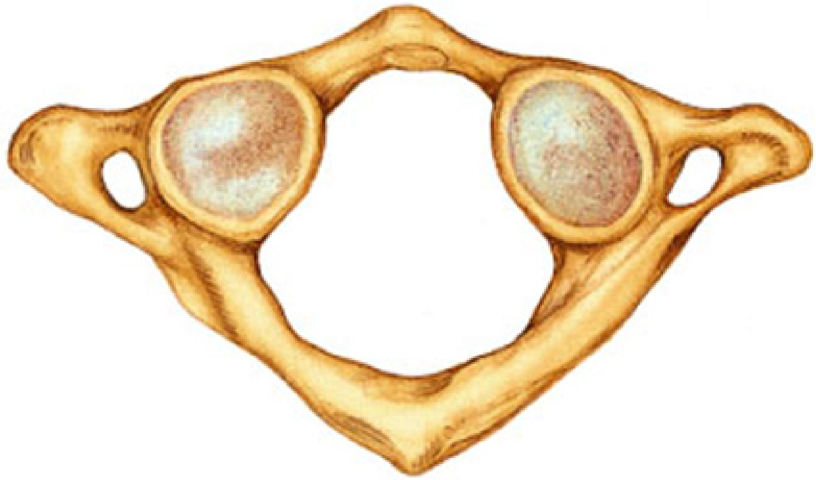
C2 = Axis

C3 - C6 are similar

Note the transverse foramina in each cervical vertebra

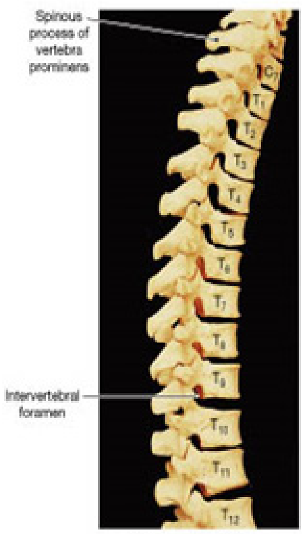
Vertebral Artery/Vein

C7 has the vertebra prominens– It has long spinous process which is palpable.

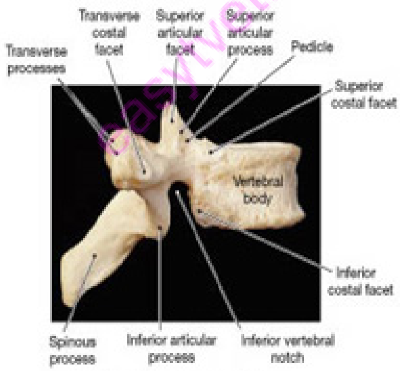


Thoracic Vertebrae (T1 - T12)

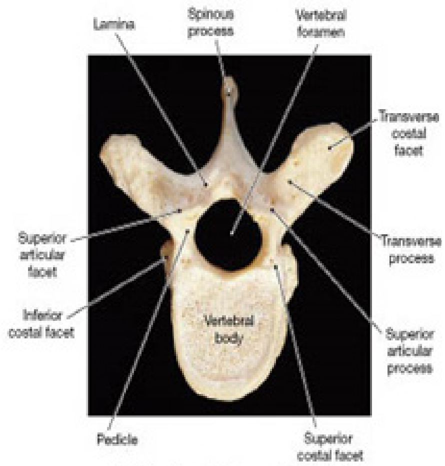
- Large Spinous Processes
- Articulations for ribs, both superior and inferior



(a) Thoracic vertebrae, lateral view



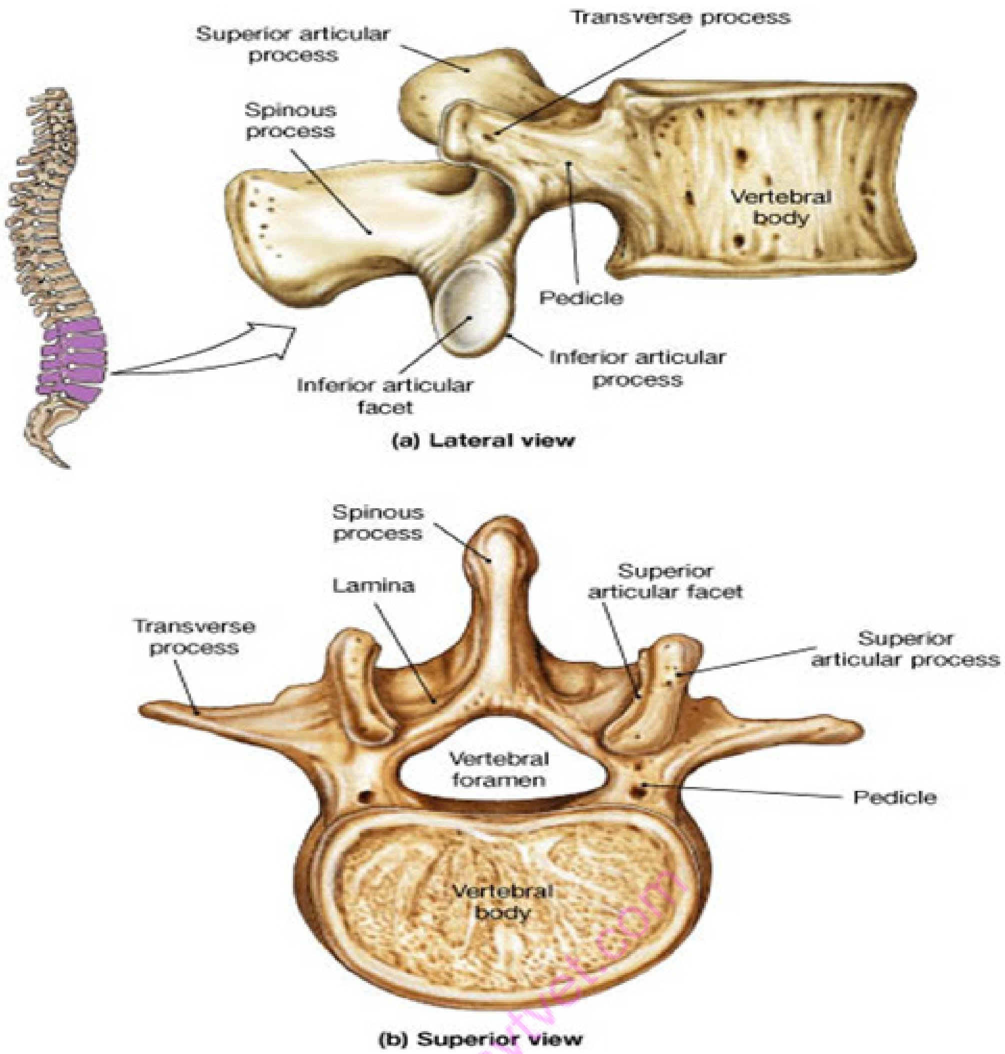
(b) Thoracic vertebra, lateral view



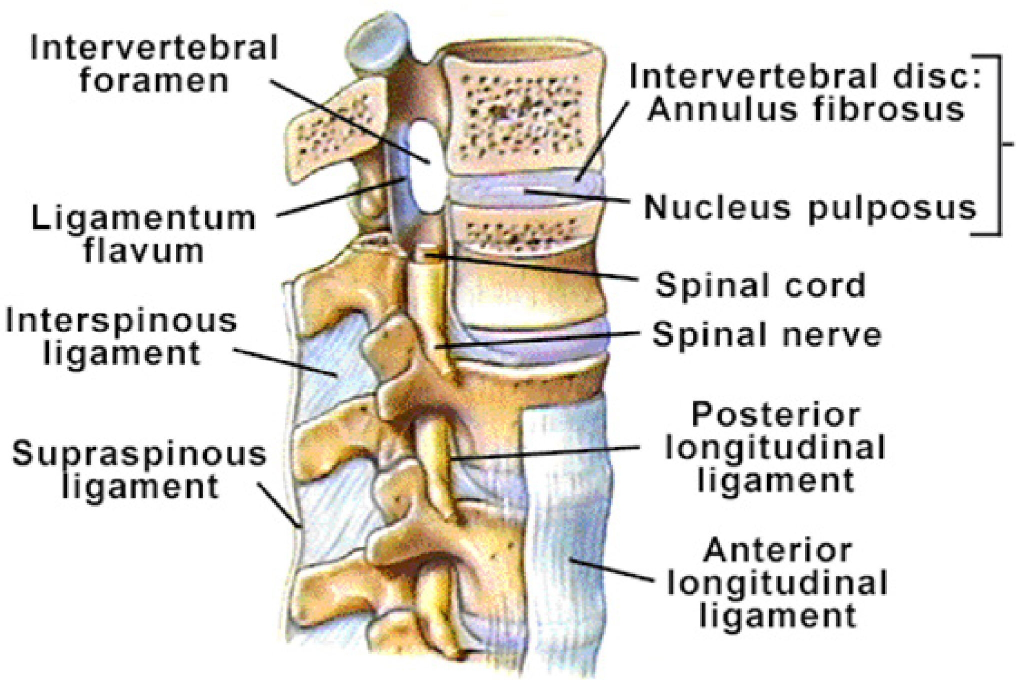
(c) Thoracic vertebra, superior view

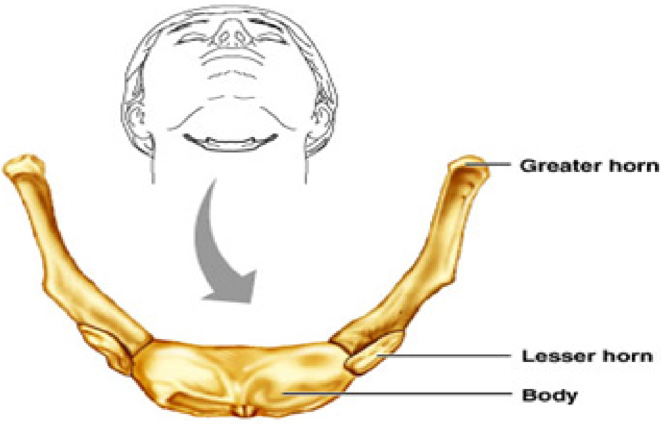
Lumbar Vertebrae (L1 - L5)

- Body	- Spinous Process
- Lamina	- Articular Facets
- Transverse Process	- Pedicle



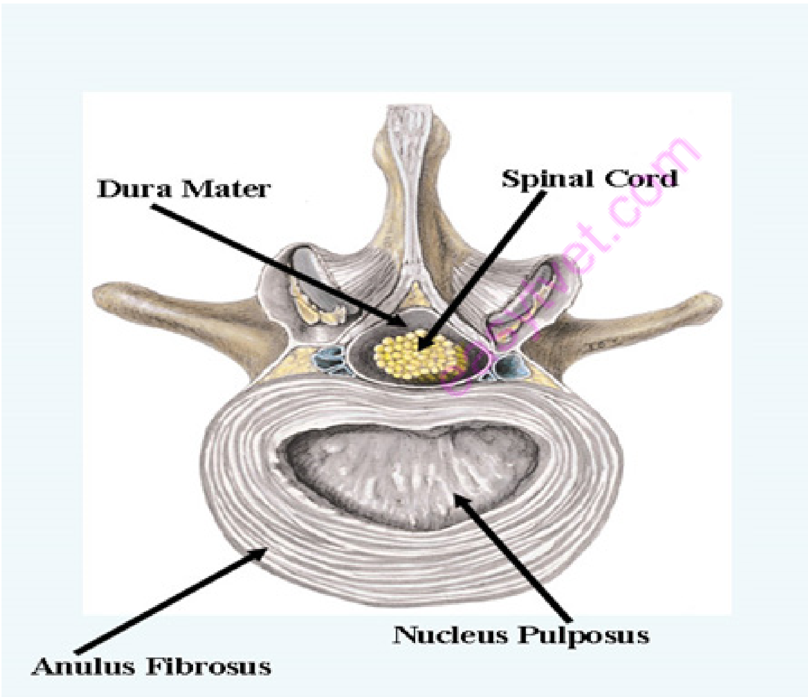
Intervertebral Articulation





Intervertebral Disk

Nucleus Pulposus | Annulus Fibrosus | Fibrocartilage



Disc Problems

Most common sites for disc problems:

C5 - C6

L4 - L5

L5 - S1

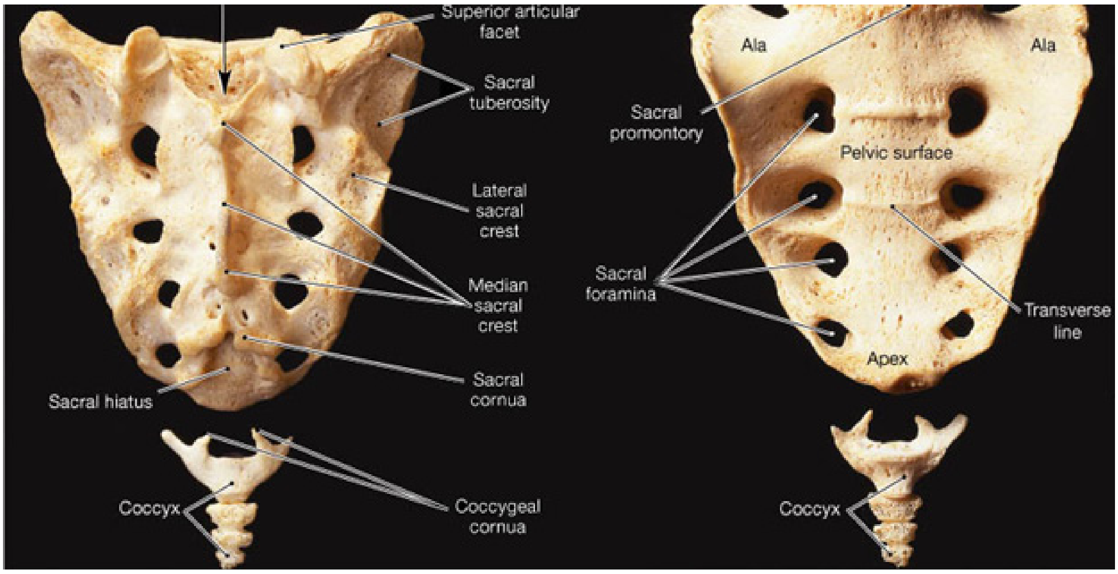
Laminectomy--(surgical removal of vertebral arch by shaving laminae to access disc)

Sacrum (5 fused)

Coccyx (3-5 fused)

Sacroiliac joint

Sacral Foramina



Thoracic (Rib) Cage

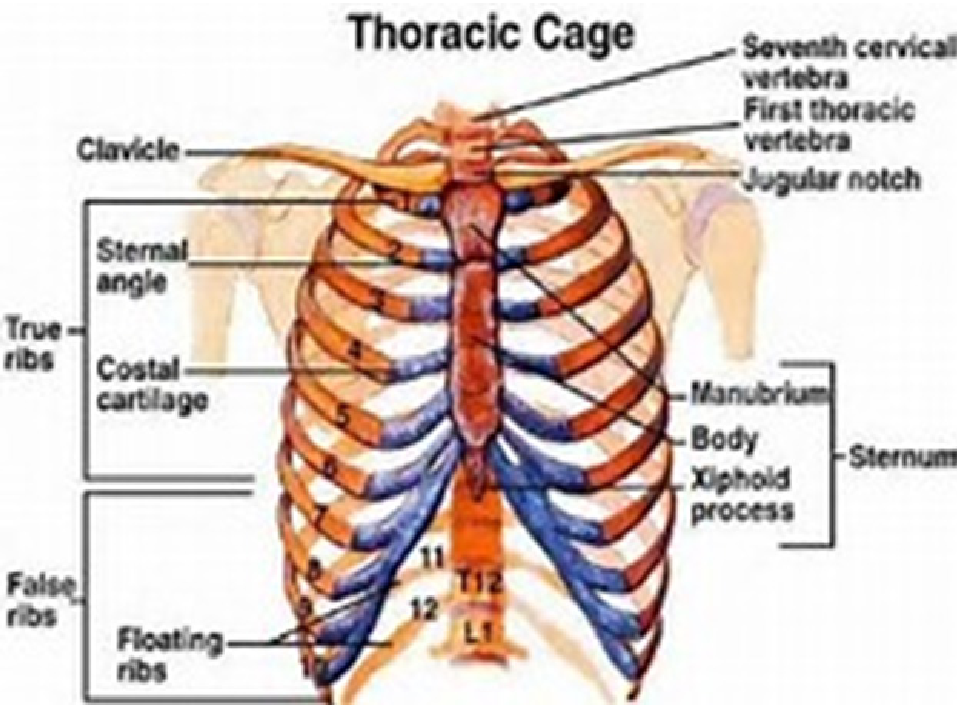
Protection and muscle attachments

Ribs – 12 pairs

1 - 7 are “true” ribs, with attachment to the sternum

8 - 12 attach indirectly to the sternum, or not at all

Costal Cartilages

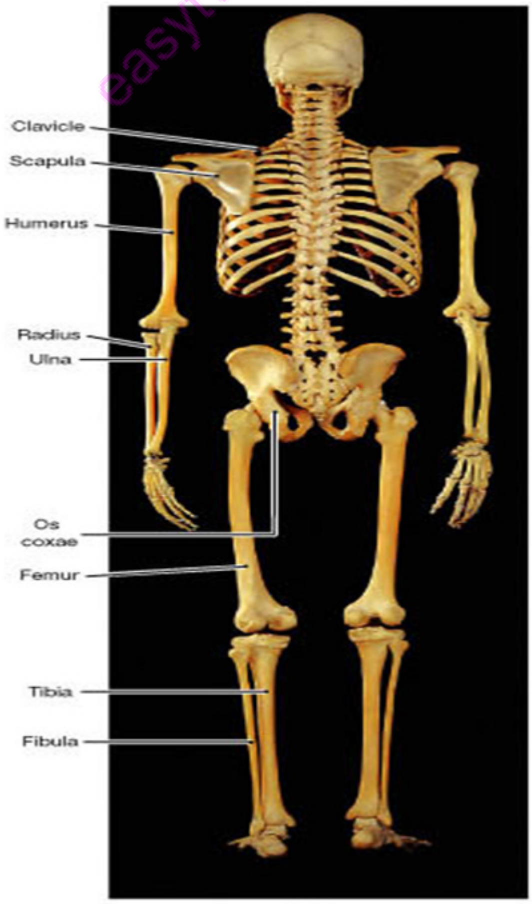


Sternum

Manubrium | Clavicular Notch | Body | Xiphoid

The Appendicular Skeleton

Appendicular Skeleton =Everything that is not in the Axial Skeleton, i.e., pelvis and limbs



(a)

The Girdles

Girdle mean--that which girds, encircles, or encloses.

Pectoral Girdle

Supports the Arms

Clavicle and Scapula

Pelvic Girdle

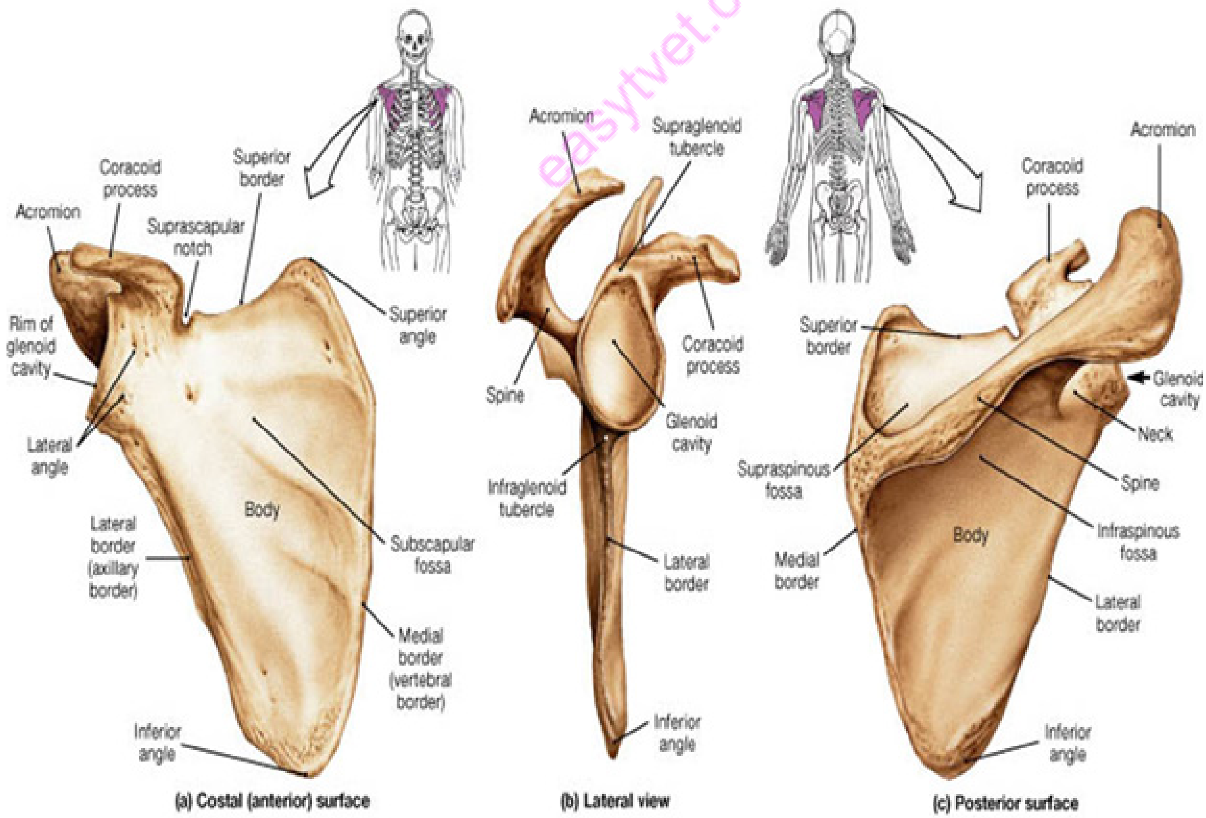
Supports the Legs

Pelvis

Ilium, ischium, pubic bone	Clavicle (collarbone)
Manubrium to Acromion	Frequently fractured

Scapula (shoulder blade)

Glenoid	Spine
Acromion	Acromioclavicular joint
Inferior and Superior Angles	Origin of biceps brachii muscle:
Coracoid Process	Supraglenoid tubercle

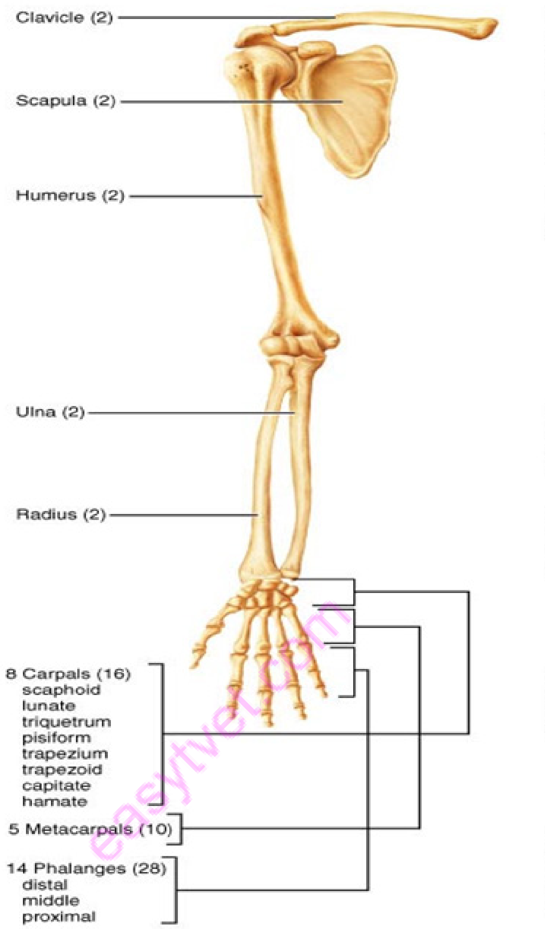


The Arm

Synonym: Upper limb

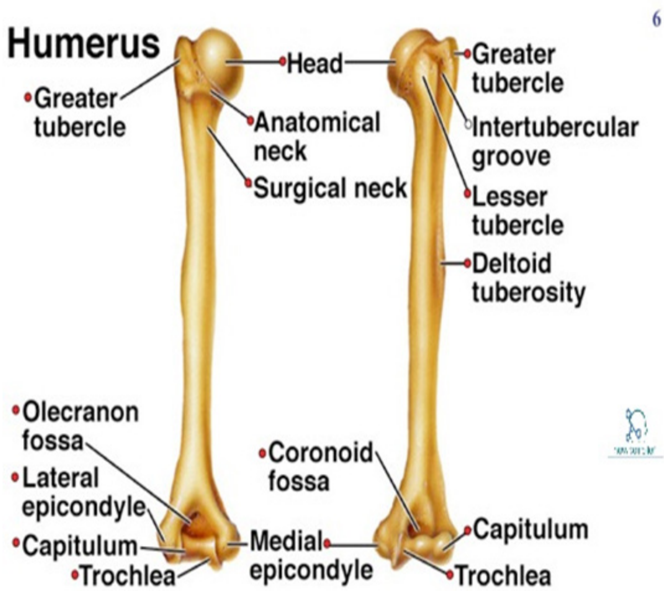
Upper Arm = Brachium | Forearm = Antebrachium

Humerus, Radius and Ulna | Carpus (wrist) | Hand (manus)



Anterior view of pectoral girdle and upper limb

Humerus



Head

Greater and Lesser Tubercles | Intertubercular Sulcus

Biceps tendon | Coronoid Fossa

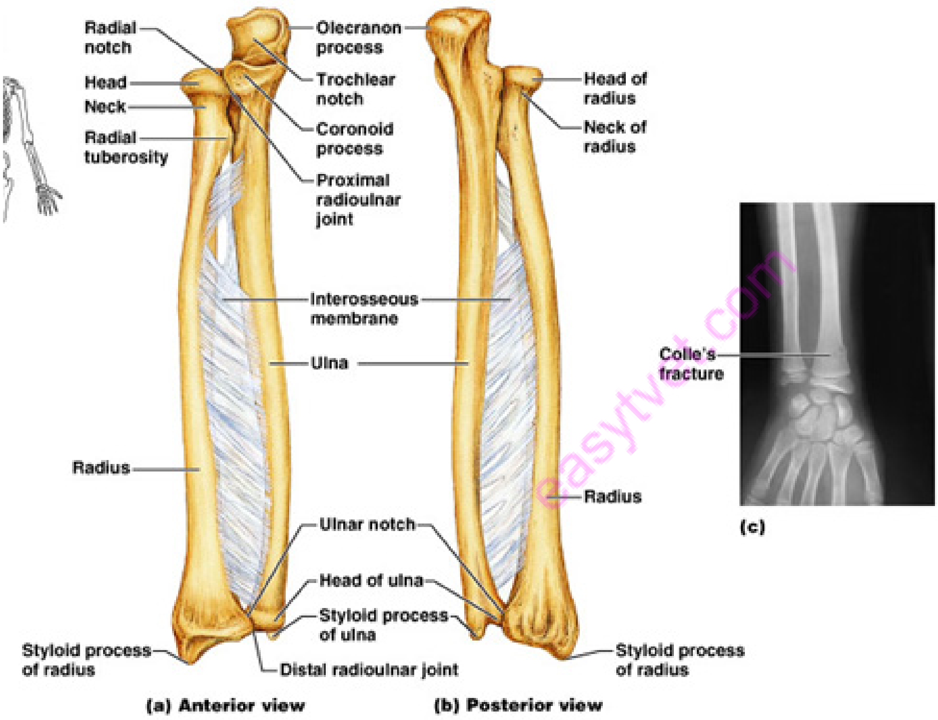
Olecranon Fossa | Trochlea

Medial and Lateral Epicondyles

Radius

Head, neck, shaft | Insertion of biceps brachii:

Radial Tuberosity | Radial Styloid Process



Ulna

Olecranon | Trochlear notch

Coronoid Process | Ulnar Styloid Process

Interosseous Membrane (between radius and ulna)

Note how the two bones can cross \ "Funny bone"

Carpus = Wrist

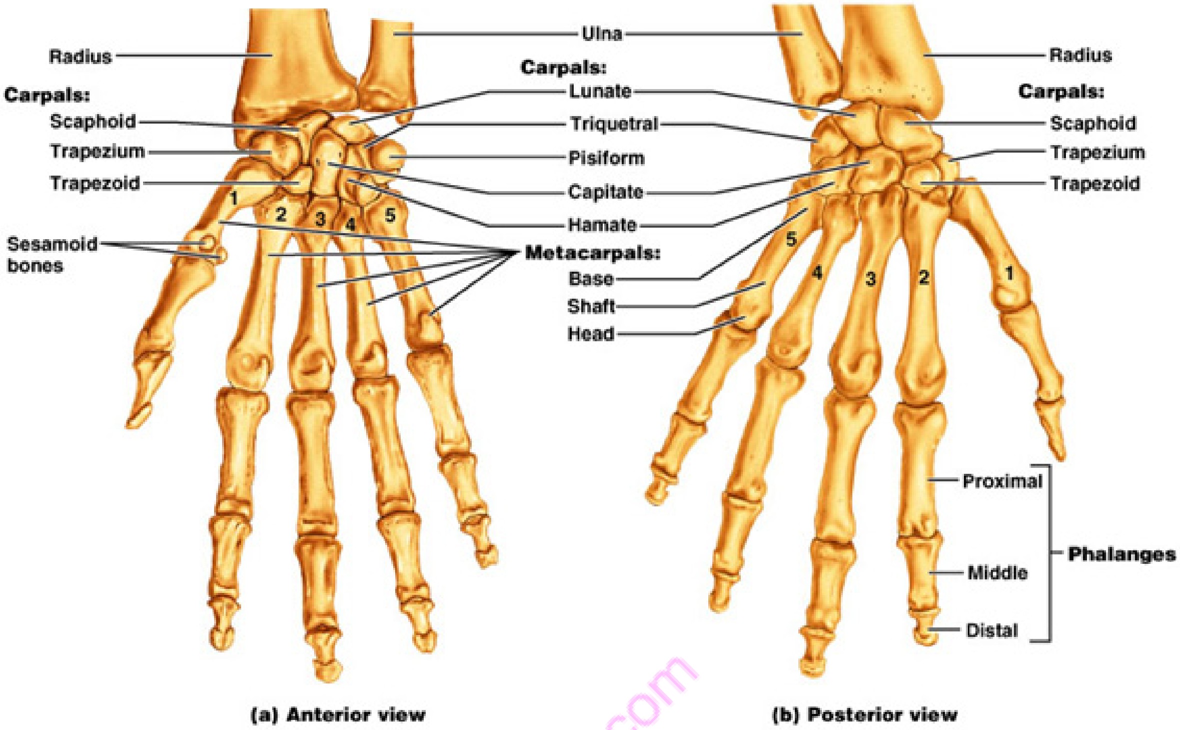
Four Proximal

Scaphoid | Lunate | Triquetrum | Pisiform

Four Distal

Trapezium | Trapezoid | Capitate | Hamate

Scaphoid is frequently fractured



Hand = Manus

Five metacarpal bones (1-5)

Five fingers

Labeled 1-5

Thumb = Pollex = digit 1

Two phalangeal bones

Fingers = phalanges = digits 2-5

Three phalangeal bones

Proximal, middle, distal

The Girdles

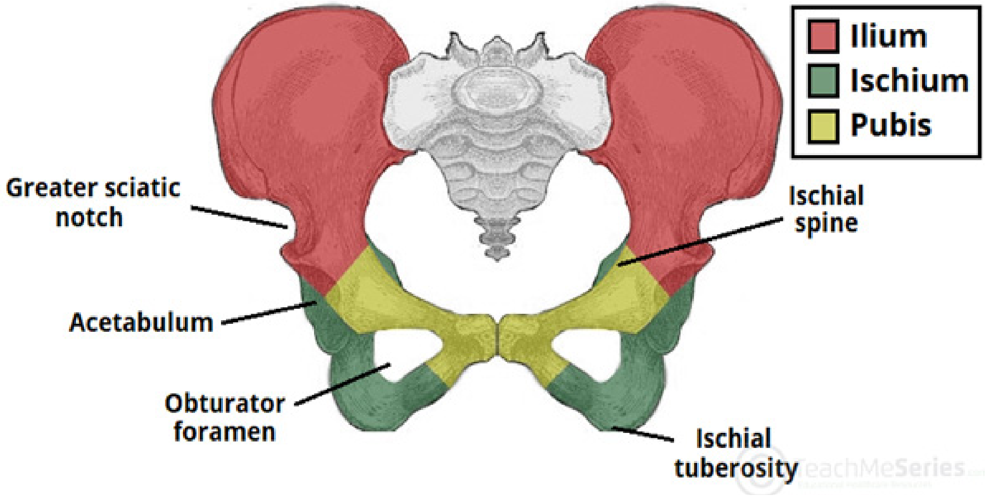
Pectoral Girdle

Supports the Arms | Clavicle and Scapula

Pelvic Girdle

Supports the Legs | Pelvis

Pelvis = hip bone = (innominate bone)



Three bones: Ilium, Ischium, Pubis

- Anterior and posterior iliac spines meet to form the iliac crest
- Greater and Lesser Sciatic Notches
- Ischial Tuberosity

Acetabulum

Acetabular fossa—head of the femur enters.

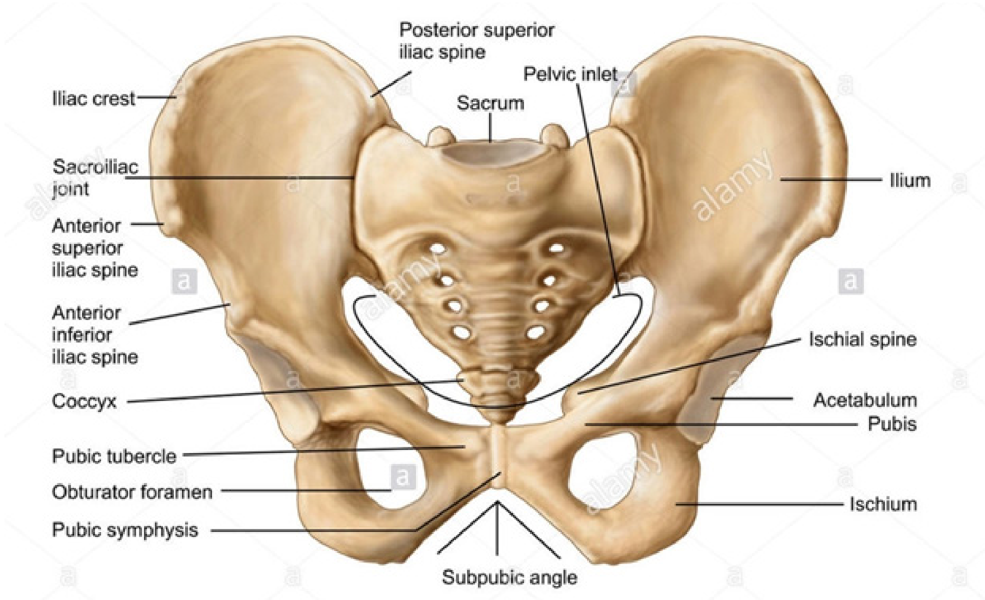
Obturator Foramen– nerves & muscles pass thru'

- Articular Surface for Articulation with Sacrum

Different between male and female

Pubic symphysis | Fibrocartilage

- Stretches at childbirth (Relaxin)

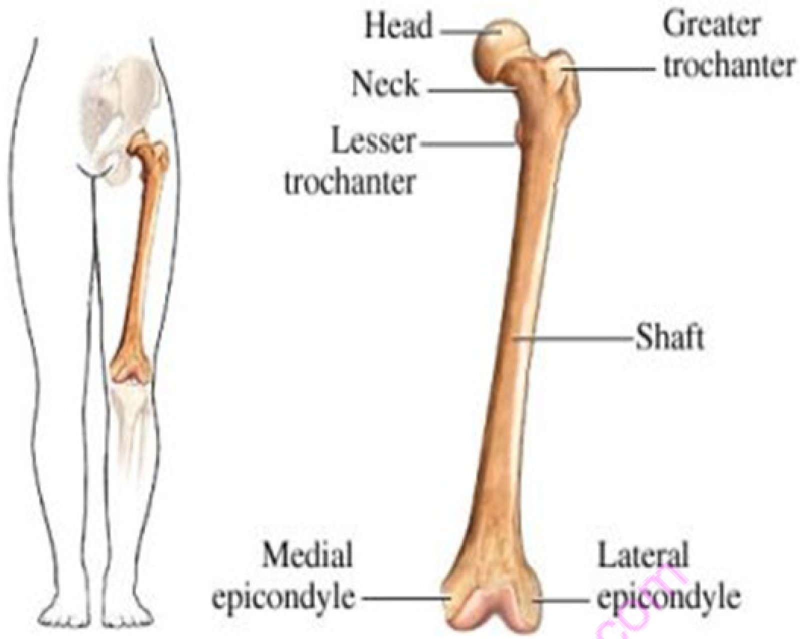


The leg

AKA Lower Limb

Femur | Patella | Tibia/fibula | Tarsus | Foot

Femur



Head and fovea capitus

Articulate with pelvis

Neck

Greater and Lesser Trochanters

Shaft

Lateral and medial condyles and epicondyles

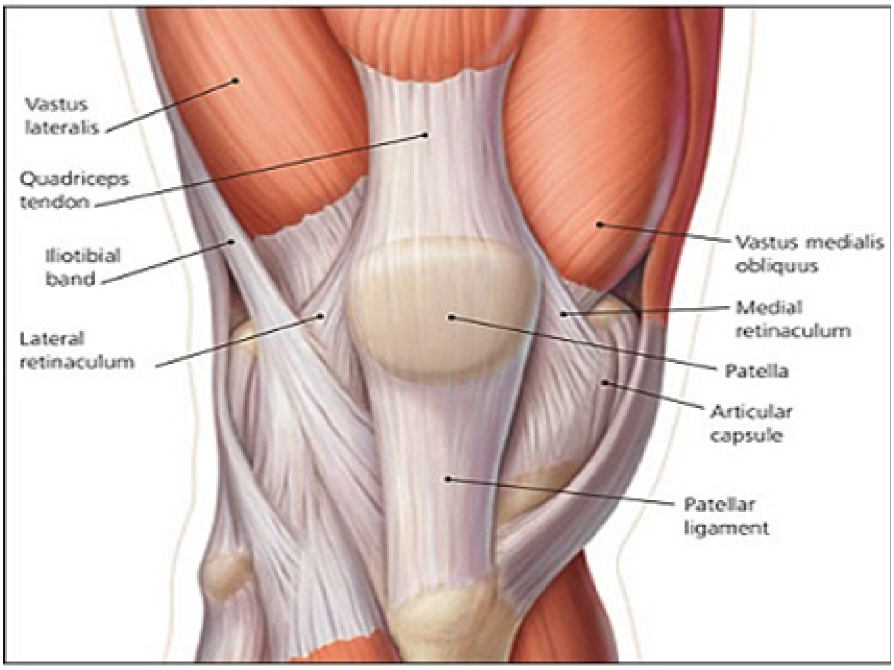
Intercondylar fossa

Patellar Surface

Patella = knee cap

Sesamoid Bone

Enclosed in the tendon of the quadriceps group of muscles



Tibia = shin bone

Lateral and medial condyles

Intercondylar eminence

Tibial tuberosity

Inferior articular surface

Medial malleolus

(= ankle bone)

Interosseous Membrane—attaches it to fibula

Fibula

Head | Shaft

Lateral malleolus (= ankle bone)

Not weight bearing

Stabilizes the ankle and offer attachment to muscles in the lower leg.

Tarsus (7 bones)

Cute Tillie Never Could Cooperate

Foot

Metatarsals (1-5)

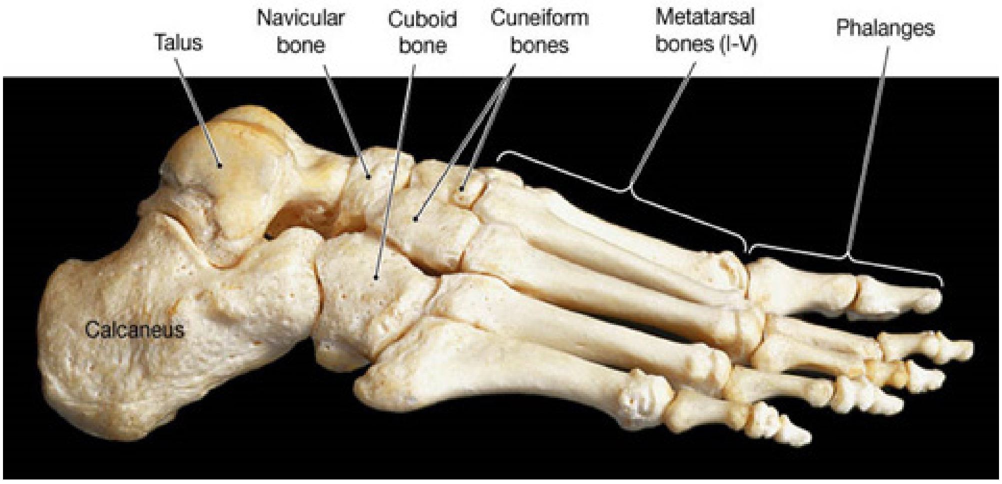
Phalanges (3 per toe except big toe)

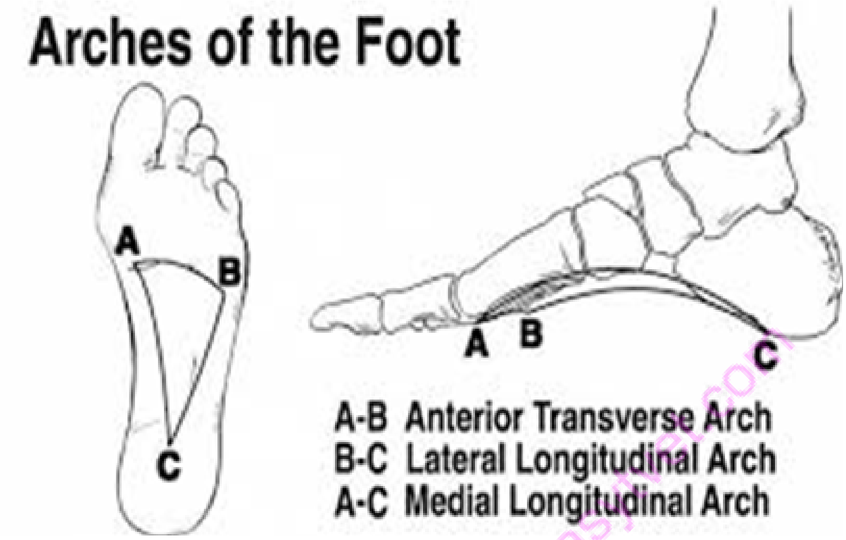
Longitudinal Arches

Medial and lateral

Transverse Arch

Cute Tillie Never Could Cooperate





Fractures (a review)

Bleeding, then clot

Periosteal reaction

Fibroblasts | Osteoblasts

Callus

New bone "collar"

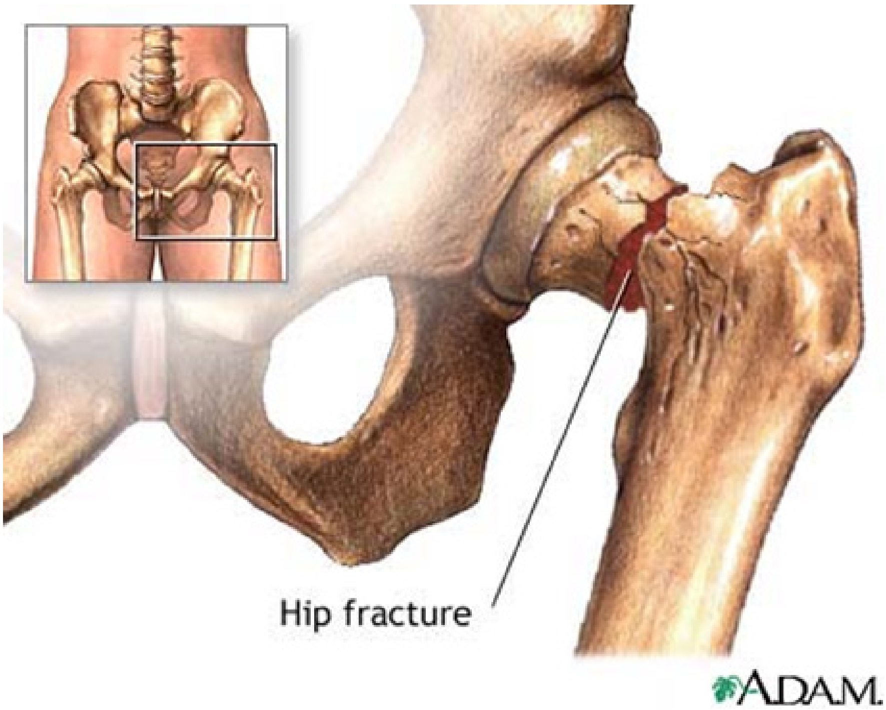
Remodeling

"Hip" fracture

"Grandma fell and broke her hip."

More accurately, "Grandma broke her femoral neck and then fell."

Sometimes the fix is at the intertrochanteric line



Diabetes, hypertension, osteoporosis

25% die from complications in first year mostly related to immobility:

Anesthesia | Muscle Atrophy | Pneumonia | Decubitus ulcers | Depression and disorientation

CAVITIES OF THE BODY

4 cavities:

1. Cranial | 2. Thoracic | 3. Abdominal | 4. Pelvic.

1) Cranial Cavity

Contains the brain

Boundaries formed by the bones of the skull:

Anteriorly — 1 frontal bone

Laterally — 2 temporal bones

Posteriorly — I occipital bone

Superiorly — 2 parietal bones

Inferiorly — 1 sphenoid and 1 ethmoid bone and parts of the frontal, temporal and occipital bones.

2) Thoracic Cavity

Situated in the upper part of the trunk.

Boundaries formed by a bony framework and supporting muscles :

Anteriorly — the sternum and costal cartilages of the ribs

Laterally — 12 pairs of ribs and the intercostal muscles

Posteriorly — the thoracic vertebrae and the intervertebral discs between the bodies of the vertebrae

Superiorly — the structures forming the root of the neck

Inferiorly — the diaphragm, a dome-shaped muscle.

Contents of thoracic cavity

The trachea, 2 bronchi, 2 lungs, the heart, aorta, superior and inferior vena cava, numerous other blood vessels, the oesophagus, lymph vessels and lymph nodes, and nerves.

The mediastinum: refers to the space between the lungs including the structures found there, such as the heart, oesophagus and blood vessels.

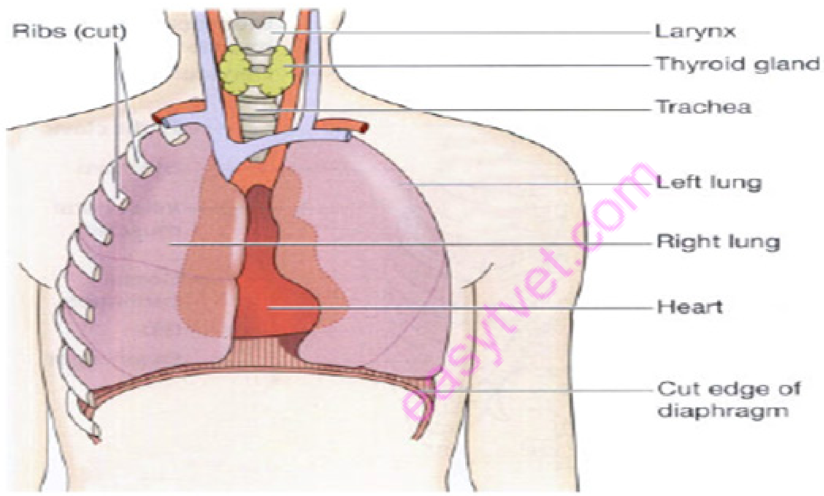


Figure 3.34 Some of the main structures in the thoracic cavity and the root of the neck.

3) Abdominal Cavity

Largest cavity in the body. It's oval in shape

Situated in the main part of the trunk and its boundaries are:

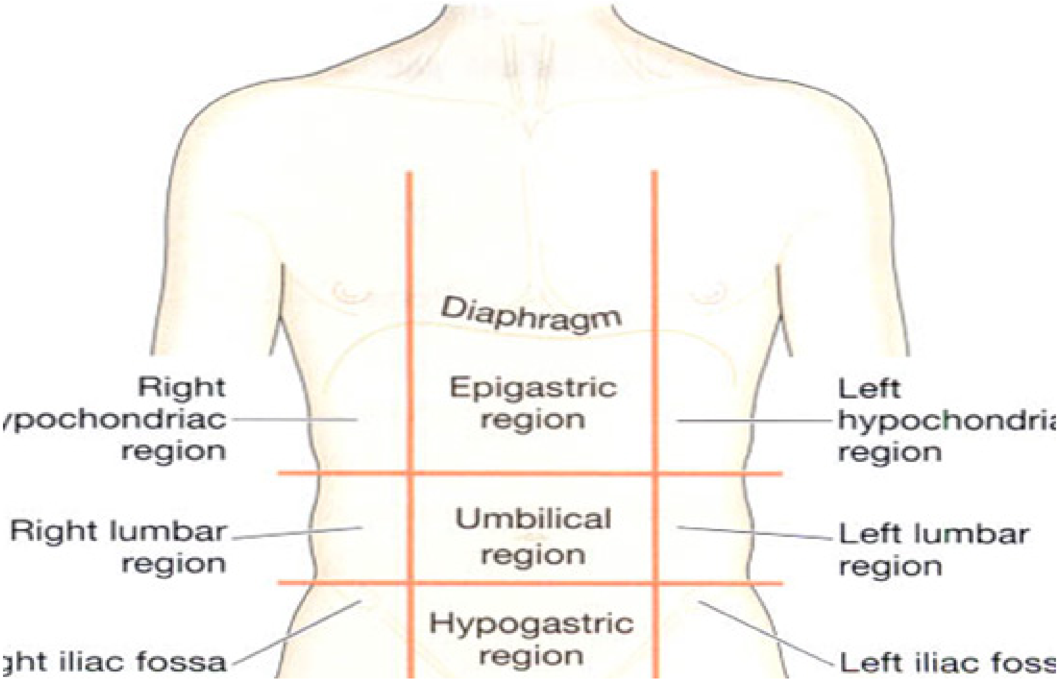
Superiorly — the diaphragm, which separates it from the thoracic cavity

Anteriorly — the muscles forming the anterior abdominal wall

Posteriorly —the lumbar vertebrae and muscles forming the posterior abdominal wall

Laterally — the lower ribs and parts of the muscles of the abdominal wall

Inferiorly — the pelvic cavity with which it is continuous.



Contents of abdominal cavity

Organs and glands involved in the digestion and absorption of food. These are:

the stomach, small intestine and most of the large intestine

the liver, gall bladder, bile ducts and pancreas.

Other structures include:

1. the spleen
2. 2 kidneys and the upper part of the ureters
3. 2 adrenal (suprarenal) glands
4. numerous blood vessels, lymph vessels, nerves
5. lymph nodes.

4) Pelvic Cavity

Roughly funnel shaped and extends from the lower end of the abdominal cavity.

Boundaries are:

Superiorly — continuous with the abdominal cavity

Anteriorly — the pubic bones

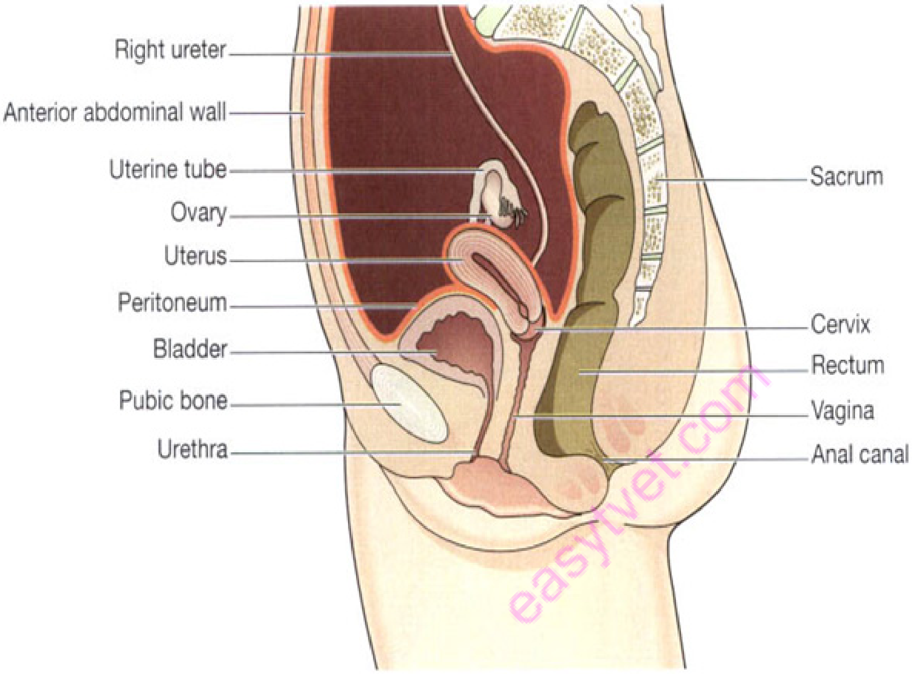
Posteriorly — the sacrum and coccyx

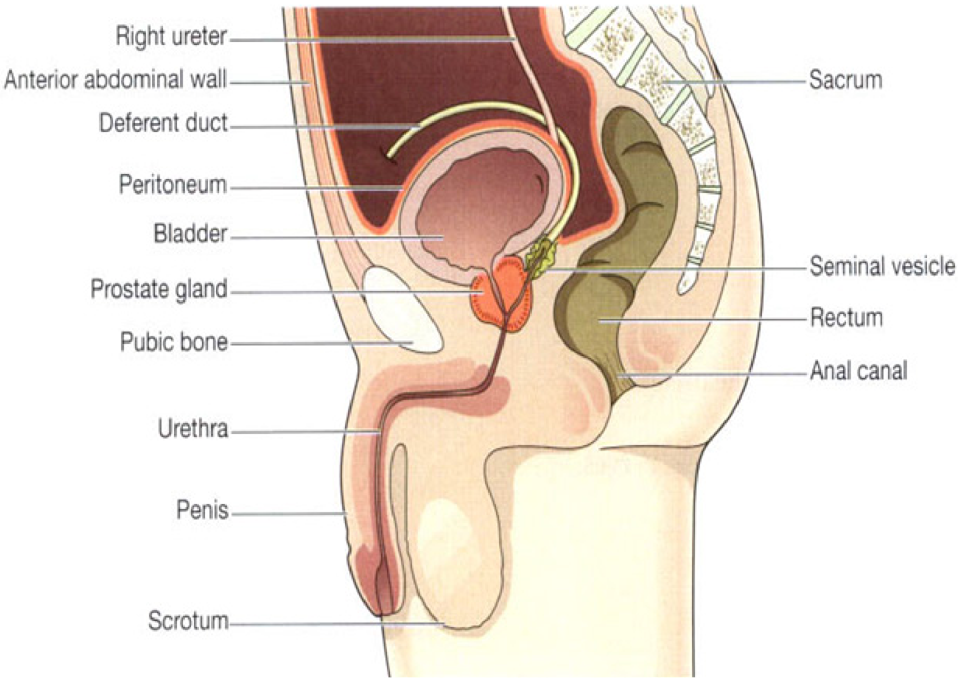
Laterally — the innominate bones

Inferiorly — the muscles of the pelvic floor.

Contents of pelvic cavity

- Sigmoid colon, rectum and anus
- Some loops of the small intestine
- Urinary bladder, lower parts of the ureters and the urethra
- In the female, the organs of the reproductive system: the uterus, uterine tubes, ovaries and vagina.
- In the male, some of the organs of the reproductive system: the prostate gland, seminal vesicles, spermatic cords, deferent ducts (vas deferens), ejaculatory ducts and the urethra (common to the reproductive and urinary systems)





Joints (Joint Classification)

The structural classification of joints

- Fibrous joints (bones held together by dense collagen fibers)
- Cartilaginous joints (bones held together by cartilage)
- Synovial joints (bones held together by ligaments)

The functional classification of joints

- Synarthrosis (an immovable joint)
- Amphiarthrosis (a slightly movable joint)
- Diarthrosis (a freely movable joint)

1. Joints (Fibrous Joints)

Lack a synovial cavity

The articulating bones are held very closely together by dense irregular connective tissue

Fibrous joints permit little or no movement

Three types of fibrous joints

- Sutures
- Syndesmoses
- Gomphoses

Sutures

Occur only between bones of the skull

Syndesmoses

- Permits slight movement
- Interosseous membrane
- Between the tibia and fibula in the leg

Gomphoses

- Immovable joint
- Joint in which a cone-shaped peg fits into a socket
- Articulations of the teeth with the sockets of the maxillae and mandible

2. Joints (Cartilaginous Joints)

Lacks a synovial cavity

- Allows little or no movement
- Joint is tightly connected by either cartilage

Two types of cartilaginous joints

1. Synchondroses
2. Symphyses

Synchondroses

- Connecting tissue is hyaline cartilage
- Epiphyseal (growth) plate

Symphyses

Slightly movable joint

Ends of the articulating bones are covered with hyaline cartilage, but a disc of fibrocartilage connects the bones

Pubic symphysis

Between the anterior surfaces of the hip bones

Intervertebral joints between the vertebrae

3. Joints (Synovial Joints)

Synovial cavity allows a joint to be freely movable

Ligaments hold bones together in a synovial joint

Articular Capsule

A sleeve-like capsule of fibrous tissue encloses the synovial cavity

The articular capsule allows movement and protects the joint from injury

Synovial Fluid

Thick sticky fluid with egg white consistency

The synovial membrane secretes synovial fluid

Functions to reduce friction by:

- lubricating the joint
- absorbing shocks
- supplying oxygen and nutrients to the cartilage

– removing carbon dioxide and metabolic wastes from the cartilage

– Creates surface tension and prevents bones from separating.

Synovial membrane

Composed of epithelial cells

It lines the capsule, covers part of the bone within the joint not covered by articular cartilage, & covers intracapsular structures that do not bear weight,

Articular (Hyaline cartilage)

Covers parts of the bone in contact

Provides smooth articular surface, adsorbs and bears the body weight. Has no blood supply, nourished by the synovial fluid.

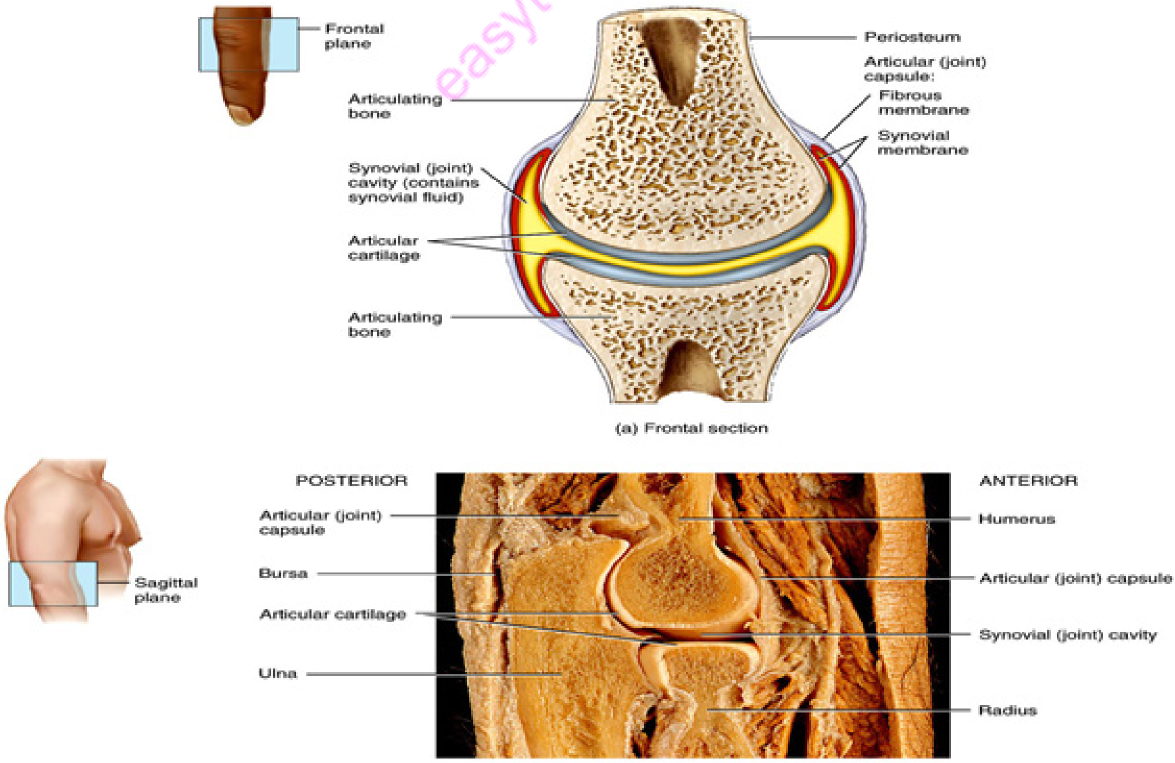
Bursae (sacs of synovial fluid) are present in some joints, e,g knee joint that acts as a cushion to prevent friction between a bone and a ligament or tendon or skin.

Other intracapsular structures

– Are found within the capsule e.g menisci and fat pads at the knee joint –maintains stability of the joint

– Extracapsular structures: ligaments, muscles and tendons. Provides the joint with stability.

– Nerve and blood supply.



(a) Frontal section

(b) Sagittal section of right elbow joint

Figure 09.03 Tortora - PAP 12/e

Accessory Ligaments and Articular Discs

- Collateral ligaments of the knee joint
- Anterior and posterior cruciate ligaments of the knee joint
- Menisci
- Pads of cartilage lie between the articular surfaces of the bones
- Allow bones of different shapes to fit together more tightly

Nerves and Blood Supply

Nerve endings convey information about pain from the joint to the spinal cord and brain

Nerve endings respond to the degree of movement and stretch at a joint

Arterial branches from several different arteries merge around a joint before penetrating the articular capsule

Bursae and Tendon Sheaths

Bursae

Sac-like structures containing fluid similar to synovial fluid

Located between tendons, ligaments and bones

Cushion the movement of these body parts

***Tendon* sheaths**

Wrap around tendons | Reduce friction at joints

Joints (Types of Movements at Synovial Joints)

- Movements are grouped into four main categories:
  - 1) Gliding
  - 2) Angular movements
  - 3) Rotation
  - 4) Special movements

Intercarpal joints

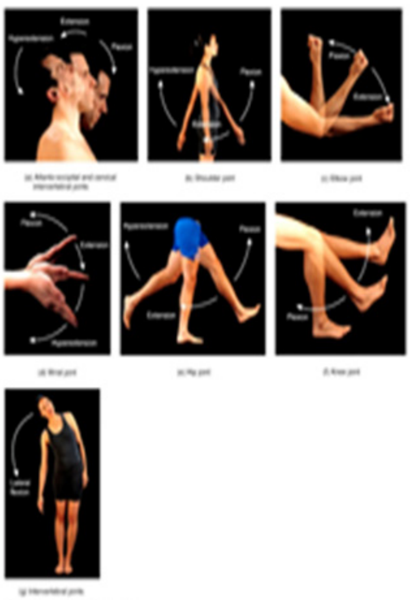


Figure 09.06 Tortora - PAP 12/e
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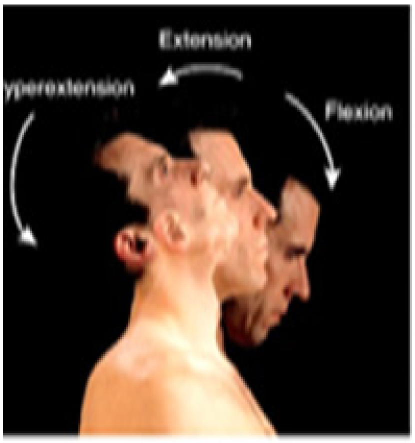
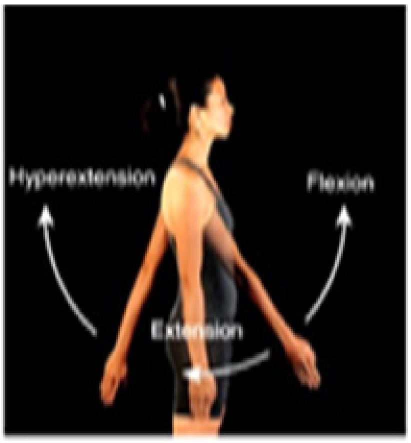
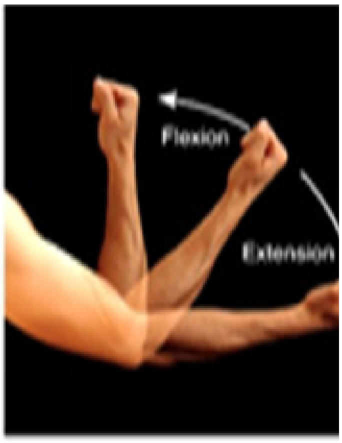


(a) Atlanto-occipital and cervical intervertebral joints



(b) Shoulder joint



(c) Elbow joint

(d) Wrist joint

(e) Hip joint

(f) Knee joint

(g) Intervertebral joints

Gliding

Simple movement back-and-forth and from side-to-side

There is no significant alteration of the angle between the bones

Limited in range

Intercarpal joints

Angular Movements

Increase or a decrease in the angle between articulating bones

Angular movements include

- Flexion
- Extension
- Lateral flexion
- Hyperextension
- Abduction
- Adduction
- Circumduction

Flexion

Decrease in the angle between articulating bones

Bending the trunk forward

Extension

Increase in the angle between articulating bones

Flexion and extension are opposite movements

Lateral flexion

Movement of the trunk sideways to the right or left at the waist

Hyperextension

Continuation of extension beyond the normal extension

Bending the trunk backward

Abduction

Movement of a bone away from the midline

Moving the humerus laterally at the shoulder joint

Adduction

Movement of a bone toward the midline

Movement that returns body parts to normal position from abduction

(a) Atlanto-axial joint (b) Shoulder joint (c) Hip joint

Figure 09.08 Tortora - PAP 12/e

Circumduction

Movement of a body part in a circle

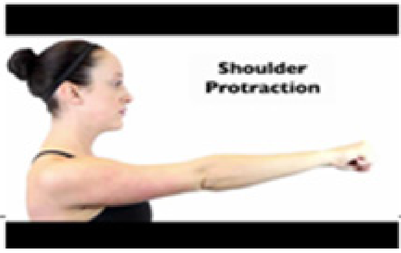
Moving the humerus in a circle at the shoulder joint

Rotation

A bone revolves around its own longitudinal axis

Turning the head from side to side as when you shake your head “no”

- **Special Movements**
  - Elevation
  - Depression
  - Protraction
  - Retraction
  - Inversion
  - Eversion
  - Dorsiflexion
  - Plantar flexion
  - Supination
  - Pronation
  - Opposition



Elevation

Upward movement of a part of the body

Closing the mouth

Its opposing movement is depression

Depression

Downward movement of a part of the body

Opening the mouth

Protraction

Movement of a part of the body anteriorly

Thrusting the mandible outward

Its opposing movement is retraction

Retraction

Movement of a protracted part of the body back to normal

Inversion

Movement of the foot medially

Its opposing movement is eversion

Eversion

Movement of the sole laterally

Dorsiflexion

Bending of the foot at the ankle in an upward direction

Its opposing movement is plantar flexion

Plantar flexion

Bending of the foot at the ankle in a downward direction

Supination

Movement of the forearm so that the palm is turned upward

Its opposing movement is pronation

Pronation

Movement of the forearm so that the palm is turned downward

Opposition

Movement of the thumb in which the thumb moves across the palm to touch the tips of the fingers on the same hand

Joints (Types of Synovial Joints)

Synovial joints are classified based on type of movement

- Planar
- Hinge
- Pivot
- Condyloid
- Saddle
- Ball-and-socket

Planar Joints

Primarily permit back-and-forth and side-to-side movements

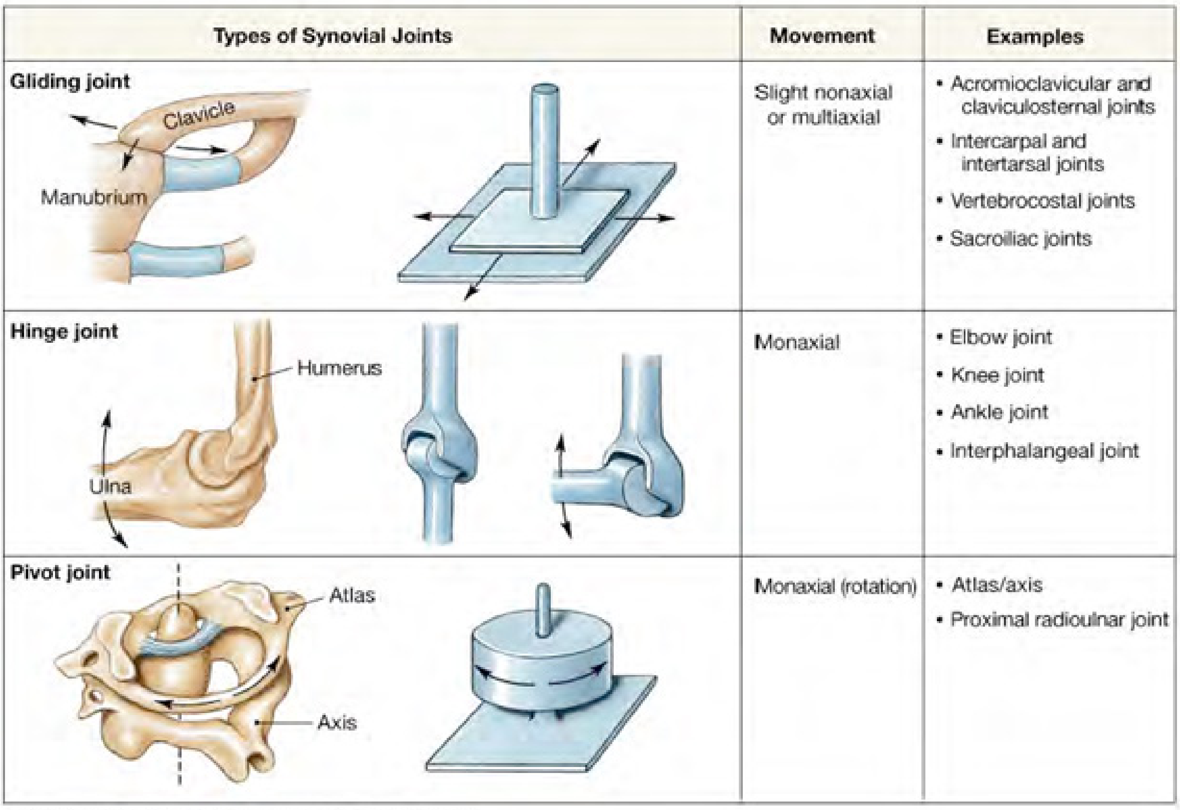
Intercarpal joints

Hinge Joints

Produce an opening and closing motion like that of a hinged door

Permit only flexion and extension

Knee and elbow, phalanges of the fingers and toes



Types of Synovial Joints	Movement	Examples
Gliding joint	Slight nonaxial or multiaxial	• Acromioclavicular and claviculosternal joints • Intercarpal and intertarsal joints • Vertebrocostal joints • Sacroiliac joints
Hinge joint	Monaxial	• Elbow joint • Knee joint • Ankle joint • Interphalangeal joint
Pivot joint	Monaxial (rotation)	• Atlas/axis • Proximal radioulnar joint

Pivot Joints

Surface of one bone articulates with a ring formed partly by another bone, together with a hoop shaped ligament that holds the bone to form the ring e.g head on the axis, odontoid process of the atlas & transverse ligament.

Joints that enable the palms to turn anteriorly and posteriorly

Allows rotation of a bone or limb.

Condyloid Joints

A condyle is a smooth rounded projection on a bone.

The projection of one bone fits into the oval-shaped depression of another bone. Permits flexion, extension adduction, abduction & circumduction

Wrist

Saddle Joints

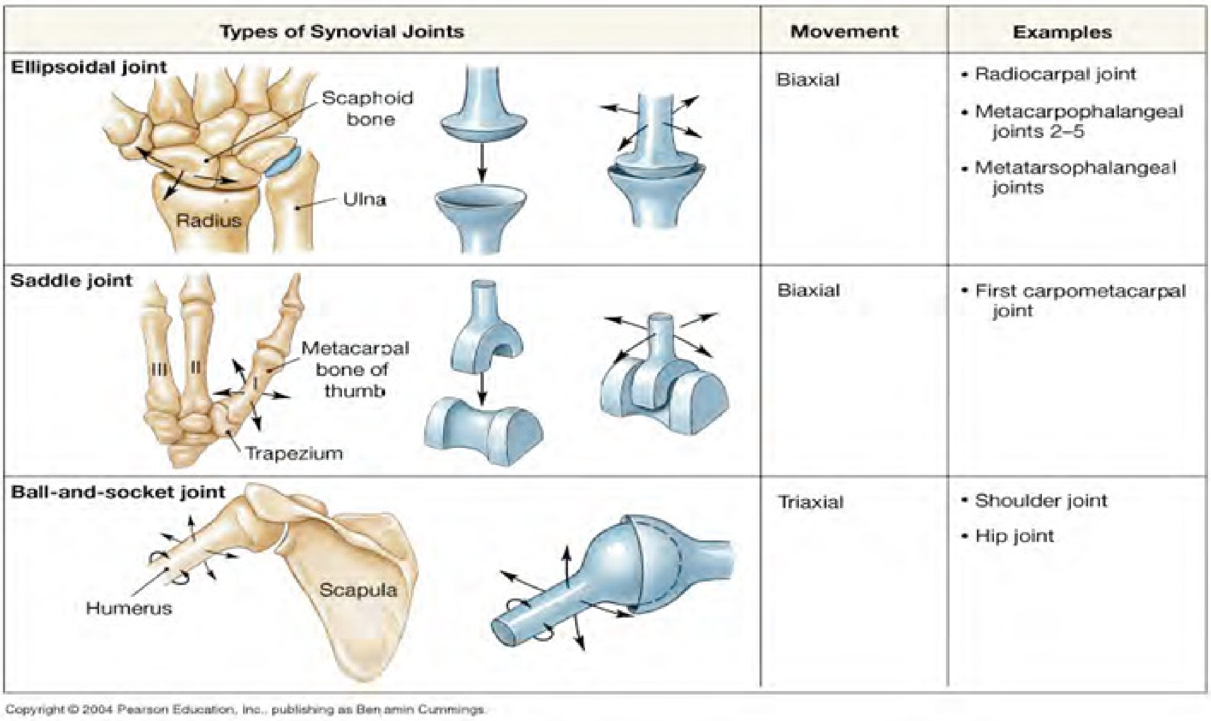
Articular surface of one bone is saddle-shaped, and the articular surface of the other bone fits into the "saddle"

Thumb (trapezium and 1st metarcarpal). Movts similar to condyloid joint with addition to opposition.

Ball-and-Socket Joints

Ball-like surface of one bone fitting into a cuplike depression of another bone. Has wide range of movements.

Shoulder and hip



Types of Synovial Joints	Movement	Examples
Ellipsoidal joint	Biaxial	• Radiocarpal joint • Metacarpophalangeal joints 2–5 • Metatarsophalangeal joints
Saddle joint	Biaxial	• First carpometacarpal joint
Ball-and-socket joint	Triaxial	• Shoulder joint • Hip joint

Joints (Factors Affecting Contact and Range for Motion at Synovial Joints)

– Range of motion (ROM)

Refers to the range, measured in degrees of a circle, through which the bones of a joint can be moved

Factors contribute to keeping the articular surfaces in contact and affect range of motion:

– Structure or shape of the articulating bones

Shape of bones determines how closely they fit together

– Strength and tension of the joint ligaments

Ligaments are tense when the joint is in certain positions

Tense ligaments restrict the range of motion

Arrangement and tension of the muscles

Muscle tension reinforces the restraint placed on a joint by its ligaments , and thus restricts movement

Contact of soft parts

The point at which one body surface contacts another may limit mobility

Movement be restricted by the presence of adipose tissue

Hormones

Flexibility may also be affected by hormones

Relaxin increases the flexibility of the pubic symphysis and loosens the ligaments between the sacrum and hip bone toward the end of pregnancy

Disuse

Movement may be restricted if a joint has not been used for an extended period

Joints (Selected Joints of the Body)

The selected joints described are:

- Temporomandibular joint
- Shoulder joint
- Elbow joint
- Hip joint
- Knee joint

Temporomandibular Joint

Combined hinge and planar joint formed by the mandible and the temporal bone

Only movable joint between skull bones

Only the mandible moves

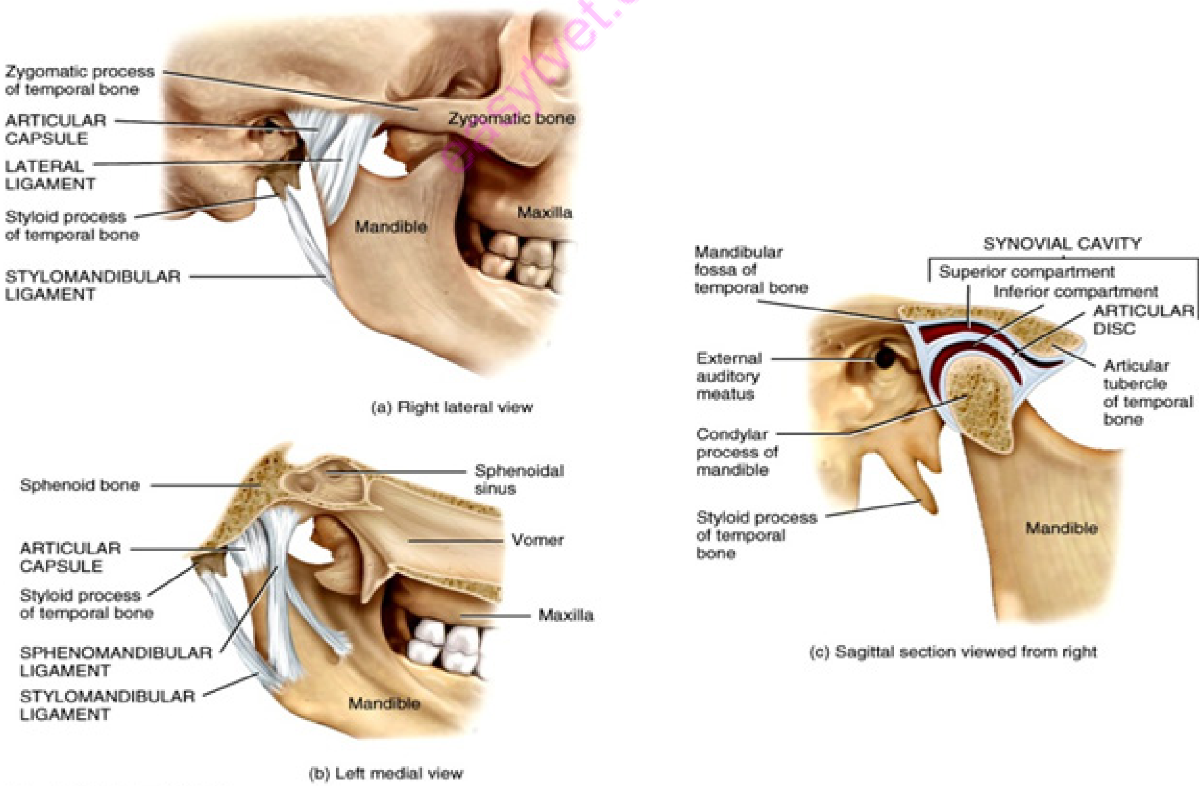


Figure 09.11 Tortora - PAP 12/e

Shoulder Joint

Ball-and-socket joint formed by the head of the humerus and the glenoid cavity of the scapula

More freedom of movement than any other joint of the body

Numerous protective bursae,

Capsular ligament is loose inferiorly to allow free movement.

Glenoid cavity is deepened by a rim of fibrocartilage,glenoid labrum which provides additional stability.

Biceps tendon is held at the intertubercular groove of the humerus by tranverse humeral ligament extends through the joint cavity to attach at the rim of glenoid cavity.

Synovial membrane covers the glenoid labrum with a sleeve round the biceps tendon.

The joint is stabilised by glenohumeral, coracohumeral, and transverse humeral ligaments. Muscles and there tendons in the shoulder. (rotator cuff)

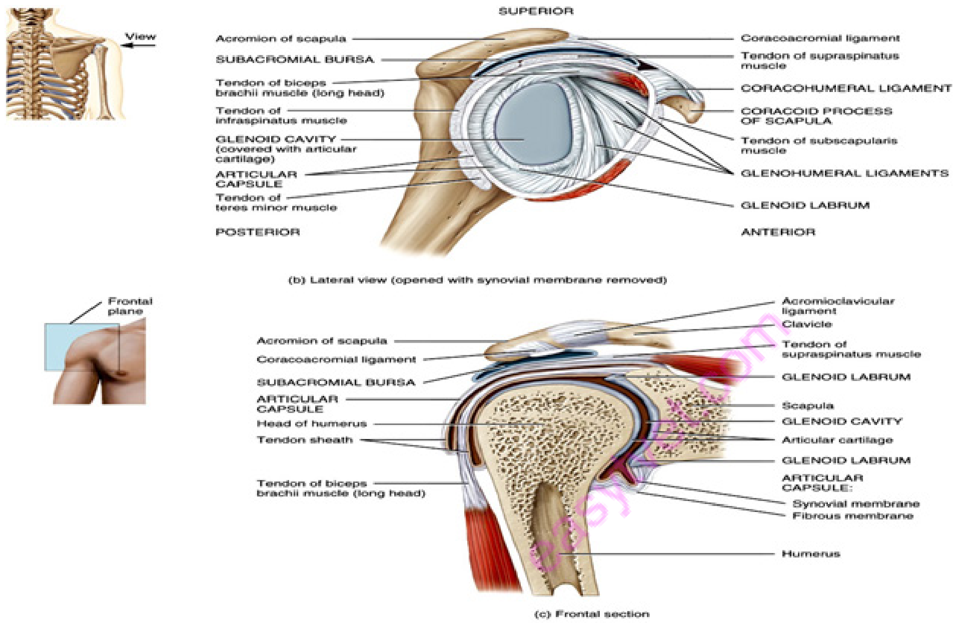
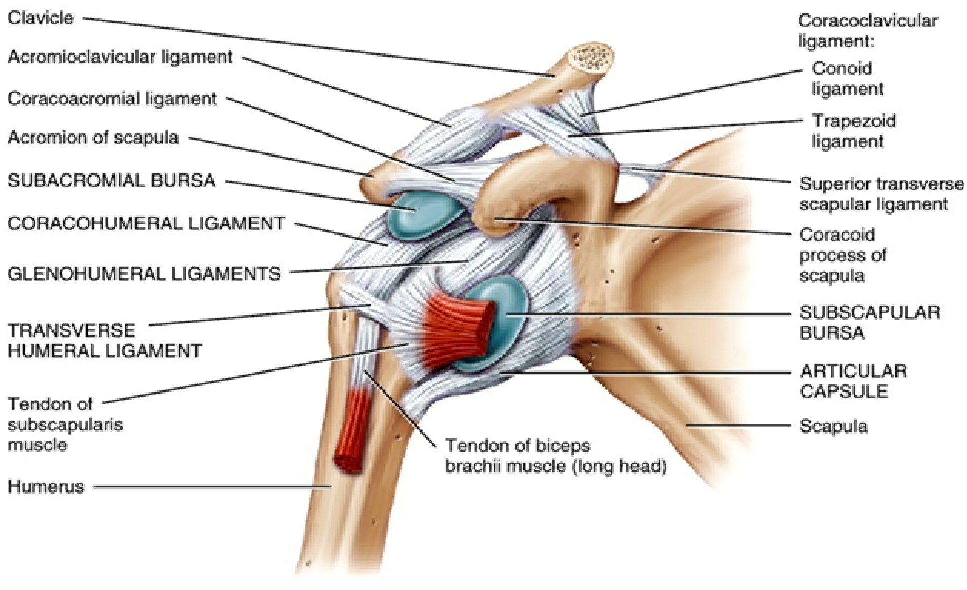


Figure 09.12bc Tortora - PAP 12/e



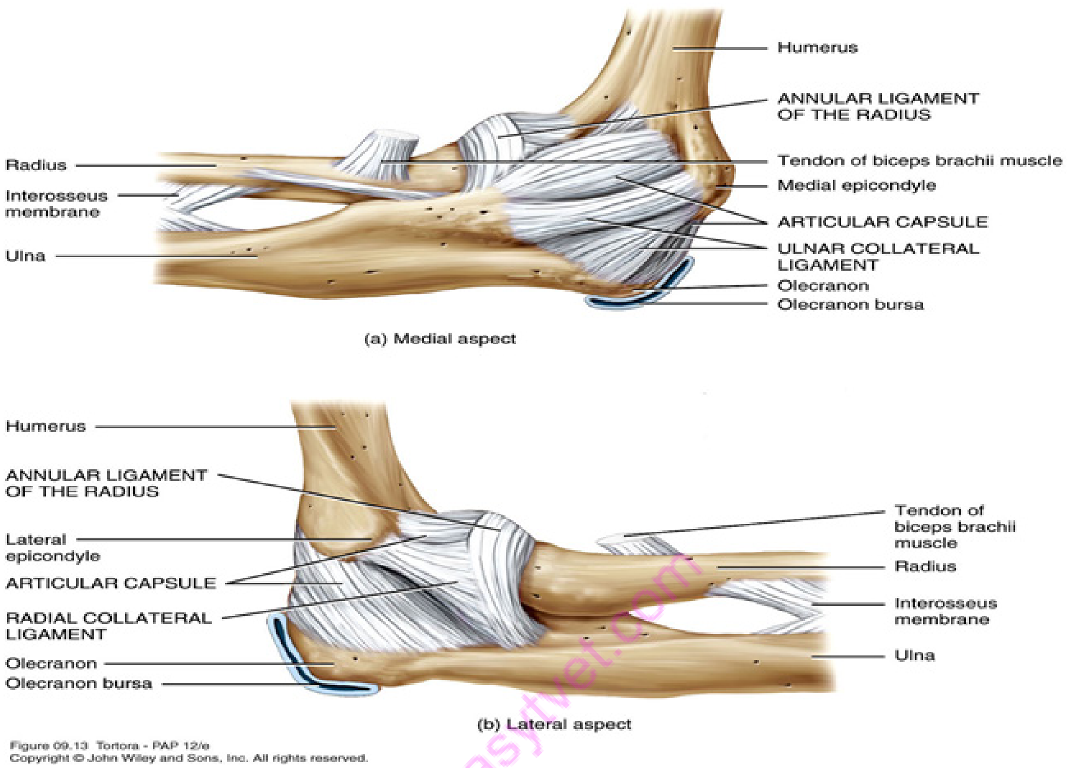
(a) Anterior view

Figure 09.12a Tortora - PAP 12/e

Elbow Joint

Hinge joint formed by the trochlea and the capitulum of the humerus, the trochlear notch of the ulna, and the head of the radius

The humeral and ulna surfaces interlock making it a stable joint. It is supported by the annullar ligament of the radius, radial collateral ligamentt, tendon of the biceps brachii and the ulna collateral ligament.



Hip Joint

Ball-and-socket joint formed by the head of the femur and the acetabulum of the hip bone

The head and neck off the femur is enclosed by the capsular ligament.

The cavity is deepened by the acetabular labrum for stability.

It is a sturdy joint stabilized by muscles and ligaments.

Ligaments: iliofemoral, ischiofemoral, pubofemoral.

A ligament of the head of the femur; ligamentum teres attaches the femoral head to the acetabulum.

Movts: flexion, extension, abduction, adduction, rotation, circumduction.

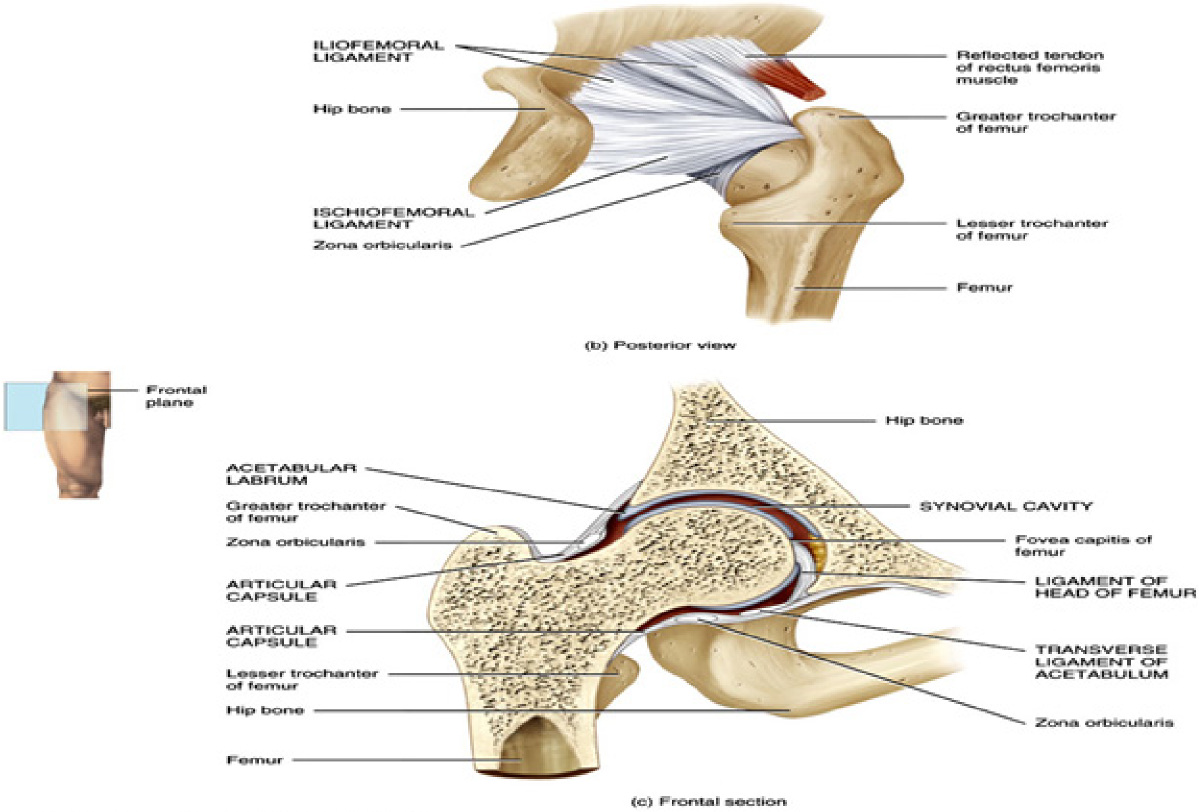


Figure 09.14bc Tortora - PAP 12/e

Knee Joint

Largest and most complex joint of the body

Modified hinge joint formed by condyles of the femur, condyles of the tibia and the posterior surface of the patella. anteriorly is the tendon of the quadriceps femoris muscle. (supports the patella)

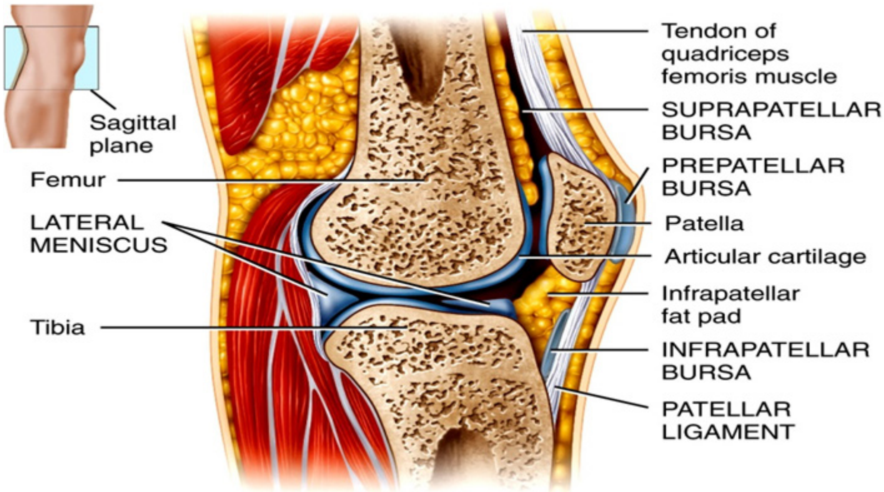
Two cruciate ligaments found intracapsularly extends from the intercondylar notch of the femur to the intercondylar eminence of the tibia crossing each other. It is covered by synovial membrane. It stabilises the joint.

The wedge shaped Semilunar cartilages/menisci lies on top of the articular condyles of the tibia provides stability, prevents lateral displacement of the bones and cushions the moving joint by shifting within the joint space in accordance with the relative positions of the articulating bones.

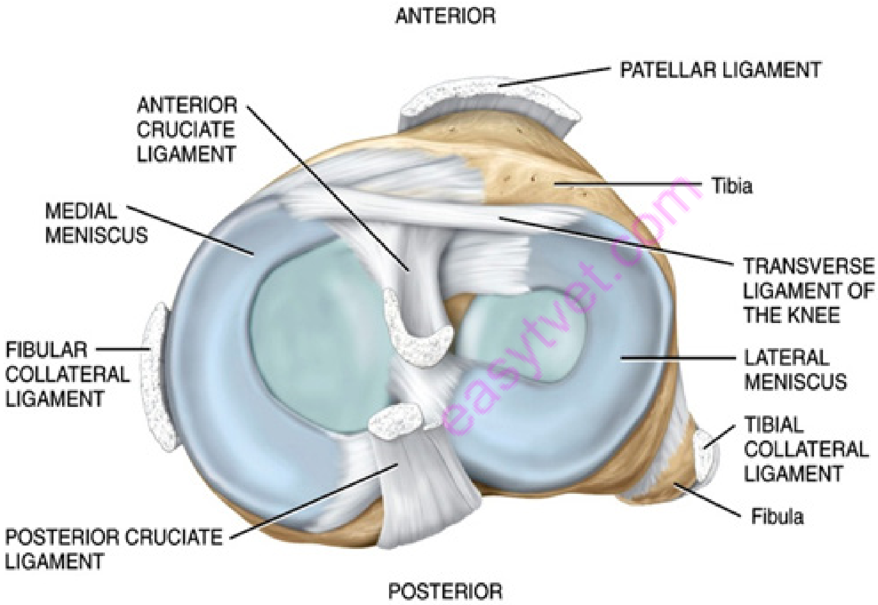
Bursae and fat pads covered by synovial membrane prevent friction between a bone and a ligament or tendon and between the skin and the patella.

Support ligaments include: patellar ligament, popliteal ligaments, and collateral ligaments.

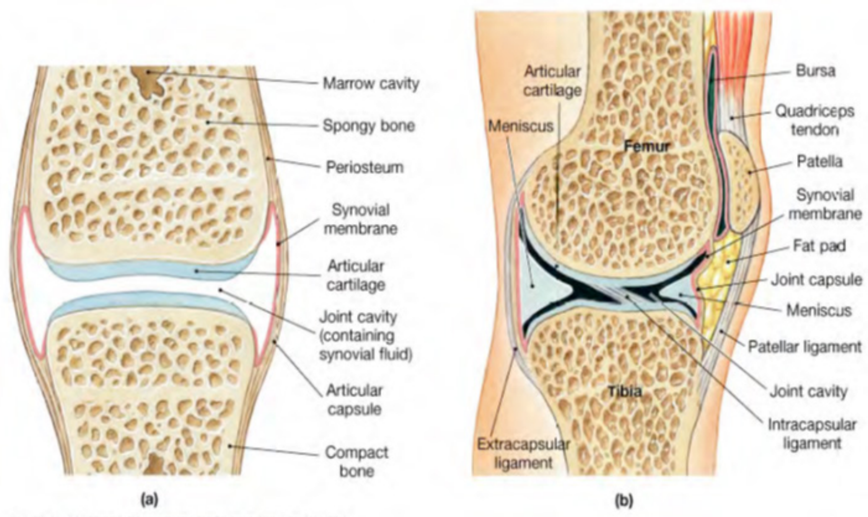
Movts: flexion, rotation, extension.



(c) Sagittal section



(e) Superior view of menisci



Joints (Aging and Joints)

Aging

May result in decreased production of synovial fluid

The articular cartilage becomes thinner

Ligaments shorten and lose some of their flexibility

Osteoarthritis is partially age-related

Stretching and aerobic exercises are helpful in minimizing the effects of aging

Help to maintain the effective functioning of ligaments, tendons, muscles, synovial fluid, and articular cartilage

Joints (Arthroplasty)

Arthroplasty

Joints may be replaced surgically with artificial joints

Most commonly replaced are the hips, knees, and shoulders

Hip Replacements

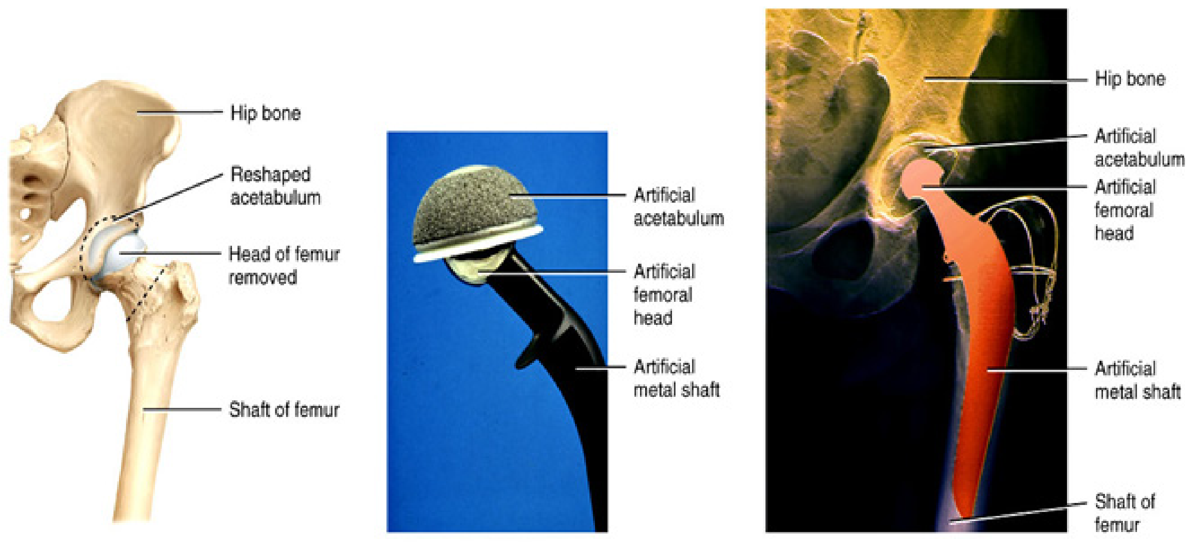
Partial hip replacements involve only the femur

Total hip replacements involve both the acetabulum and head of the femur

Knee Replacements

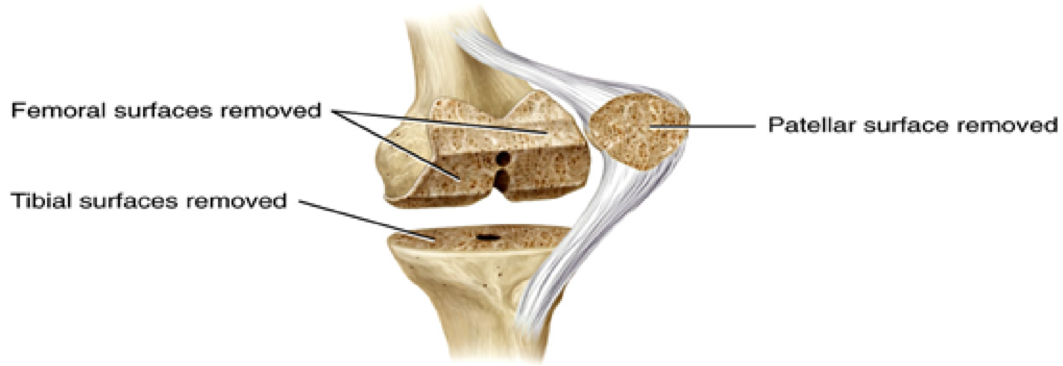
Actually a resurfacing of cartilage and may be partial or total

Potential complications of arthroplasty include infection, blood clots, loosening or dislocation of the replacement components, and nerve injury

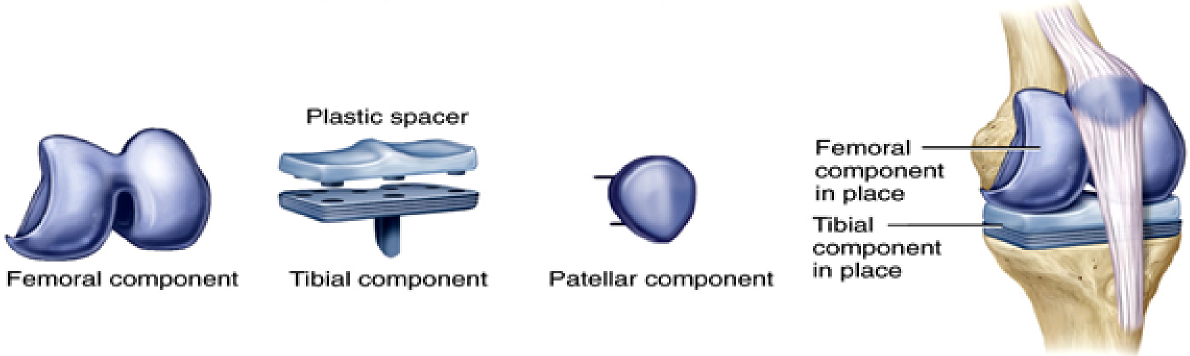


(a) Preparation for total hip replacement (b) Components of an artificial hip joint (c) Radiograph of an artificial hip joint

Figure 09.16abc Tortora - PAP 12/e



(d) Preparation for total knee replacement



(e) Components of artificial knee joint (isolated and in place)

Figure 09.16de Tortora - PAP 12/e

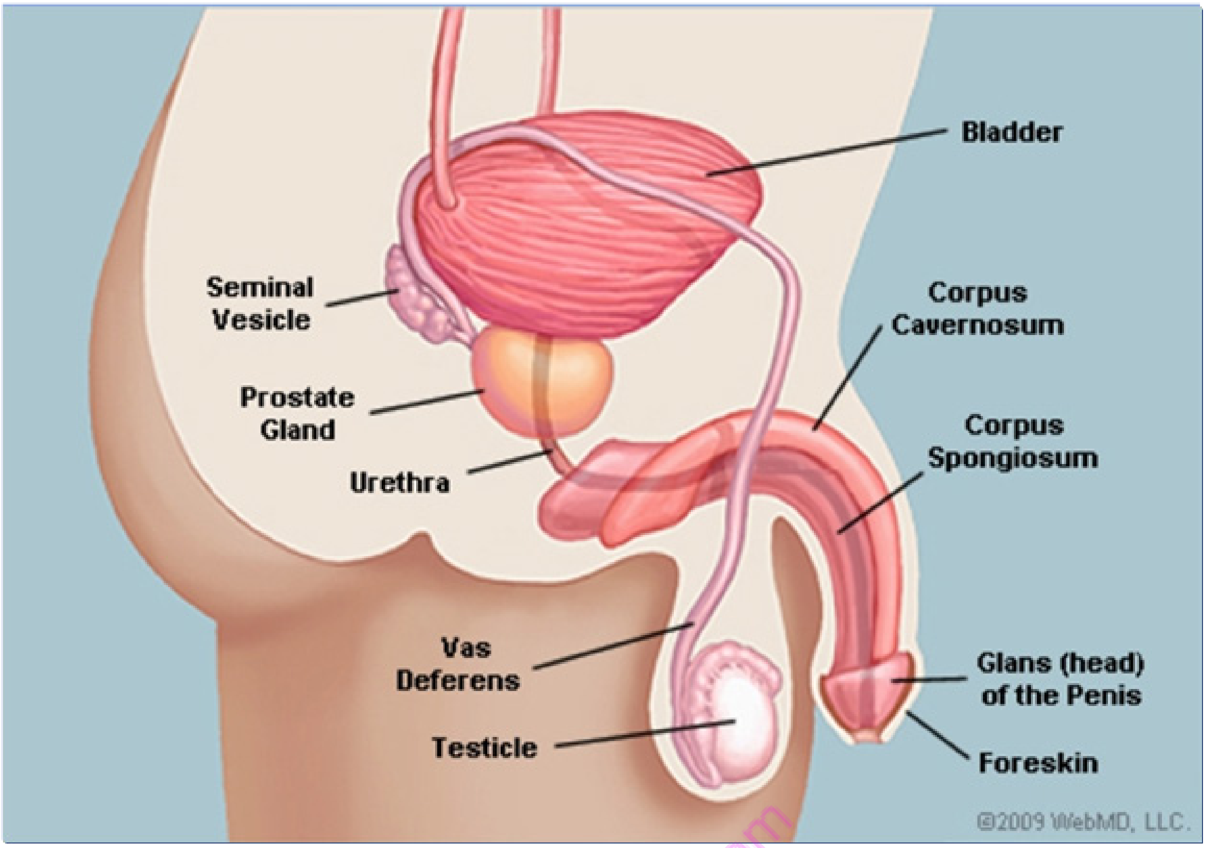
REPRODUCTIVE SYSTEM

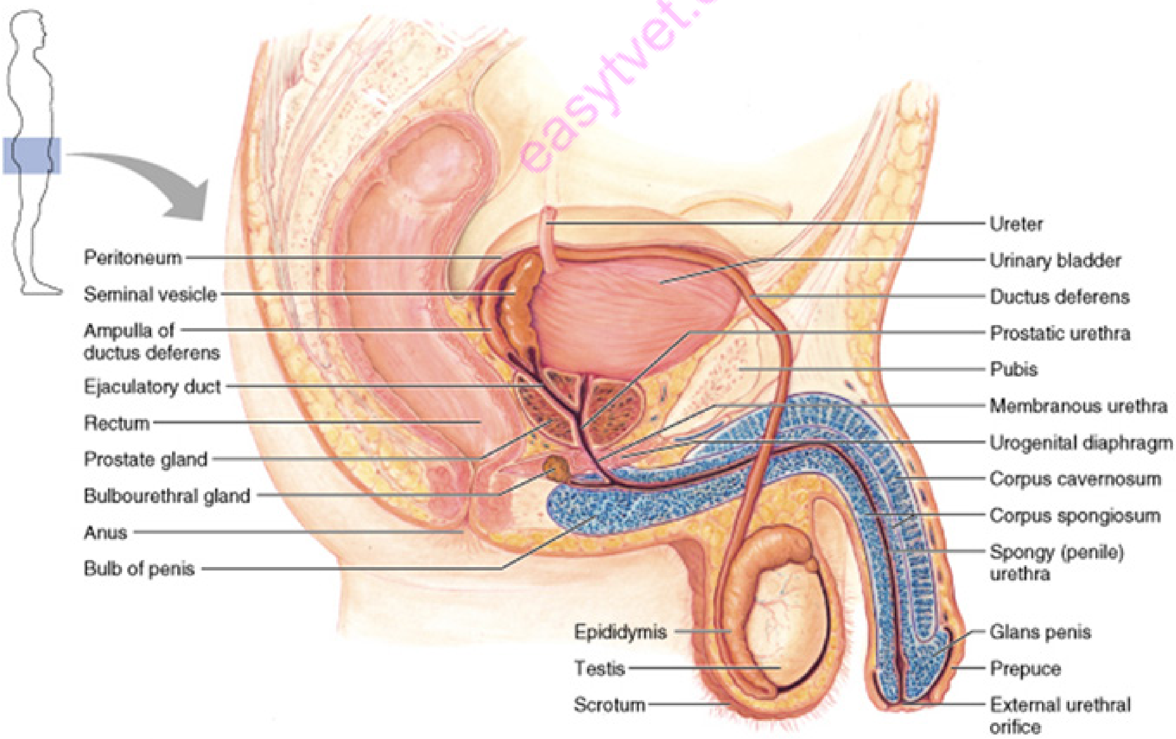
Introduction

Male and female reproductive systems function together to produce offspring

Female reproductive system nurtures developing offspring, and produce important hormones

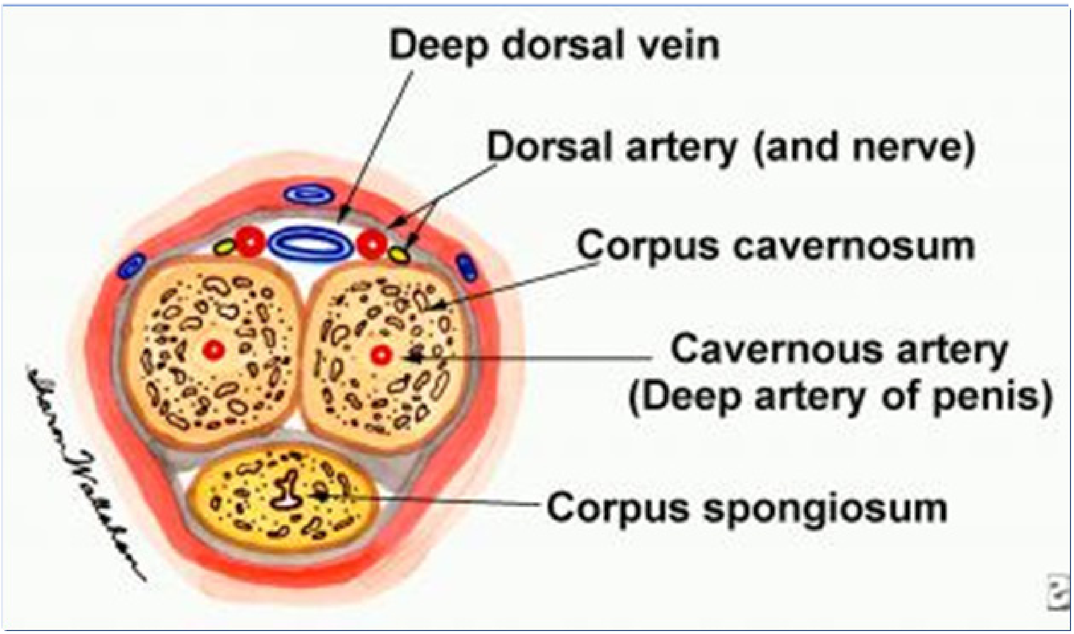
The Male Reproductive System

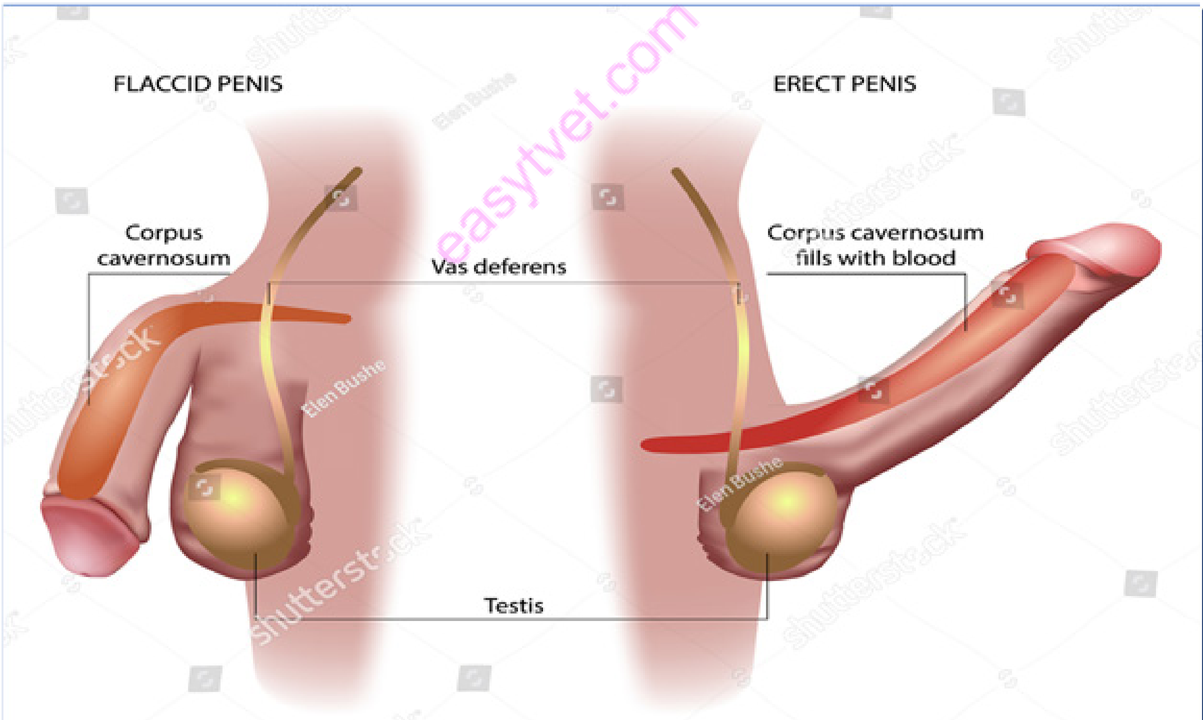




The Two Erectile Tissue of the Penis

1. Corpus cavernosum
2. Corpus spongiosum





Testes

Primary organs

Develop in the abdominal pelvic cavity of fetus

Descend into scrotal sac shortly before or after birth

Produce the male sex cells (sperm)

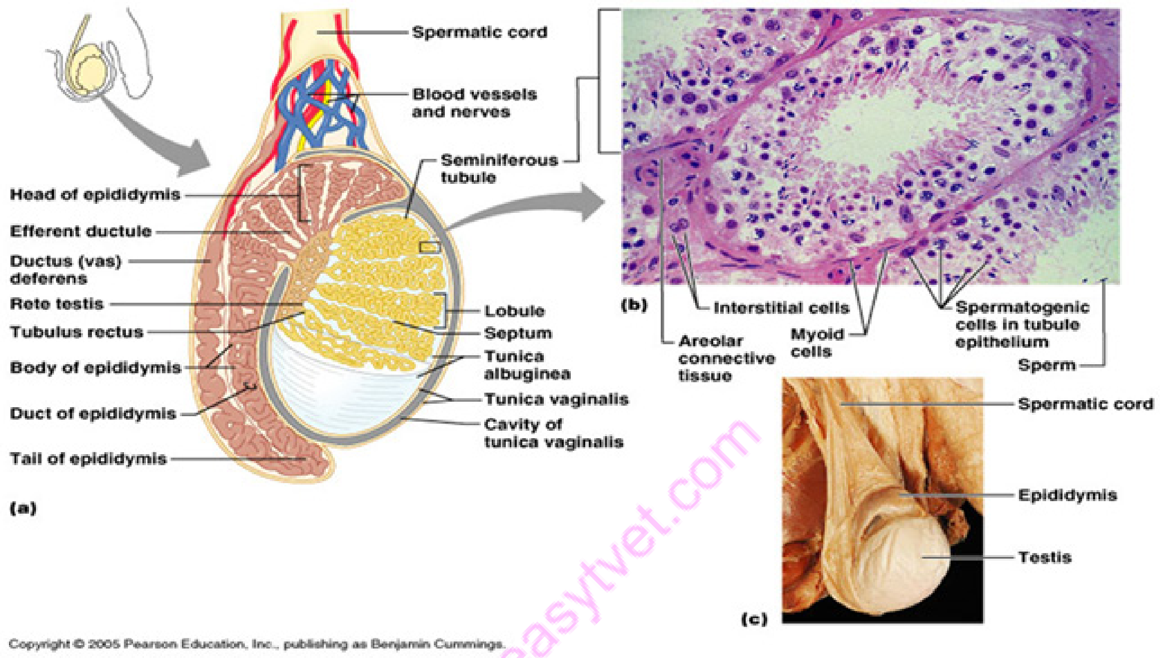
Produce the male hormone testosterone

Scrotum – sac that holds the testes

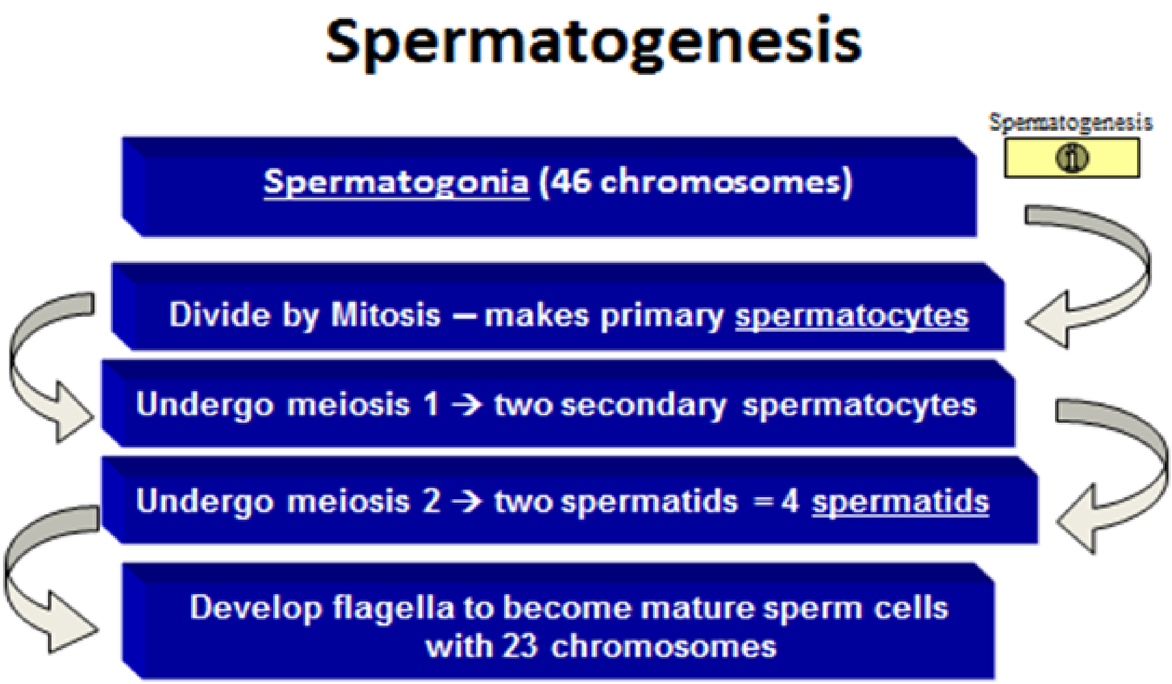
Seminiferous tubules

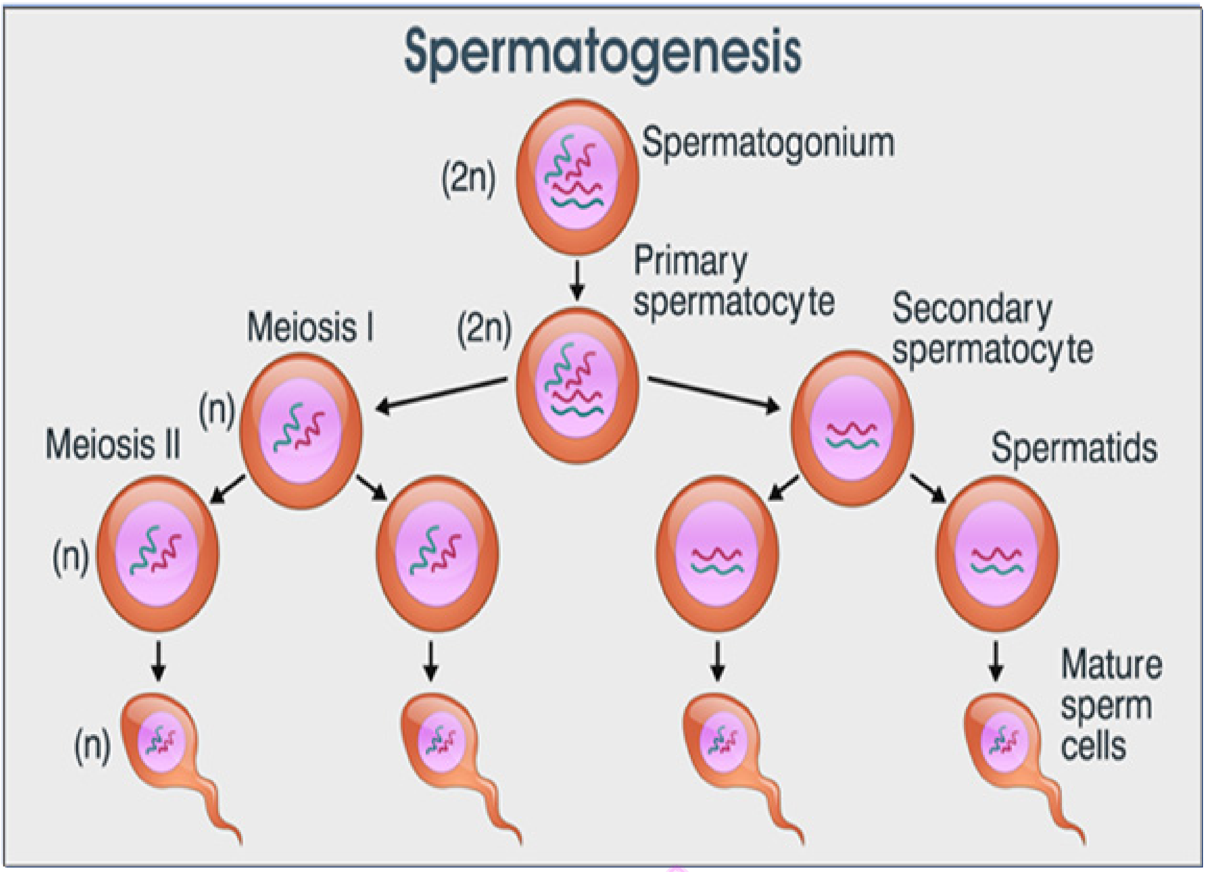
Located within the testes

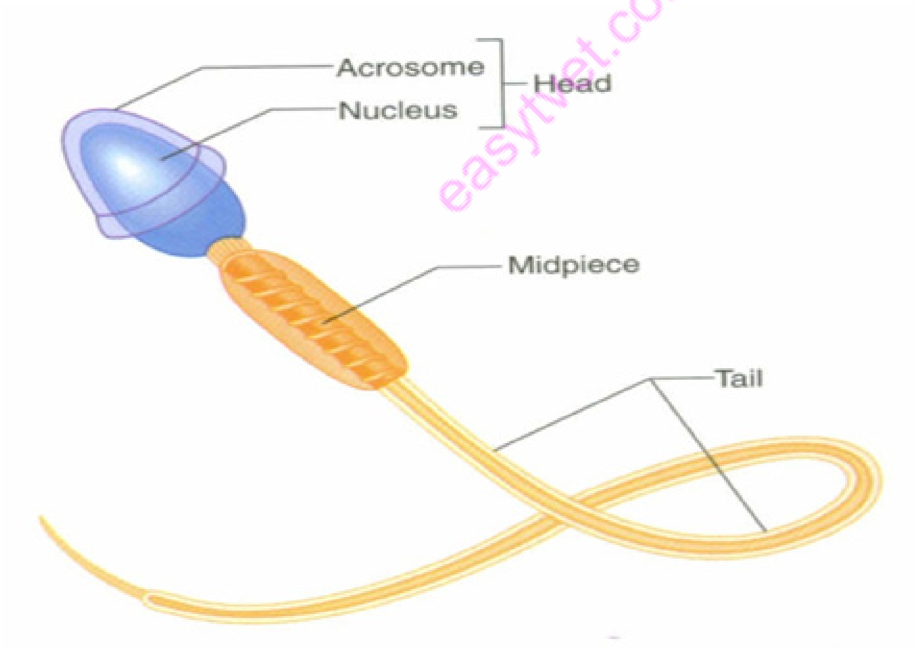
Filled with spermatogenic cells that produce sperm cells



Sperm Cells







Head

Nucleus with 23 chromosomes

Acrosome – enzyme-filled sac

Helps sperm penetrate ovum

Mid-piece

Mitochondria that generate cell's energy

Tail

Flagellum that propels sperm forward

Male Internal Accessory Organs

Epididymis

Sits on top of each testis

Receives spermatids from seminiferous tubules

Spermatids become sperm cells

Vas deferens

Tube connected to epididymis

Carries sperm cells to urethra

Seminal Vesicle

Secrete

Fluid rich in sugar used to make energy

Prostaglandins – stimulate muscular contractions in female to propel sperm forward

Seminal fluid

Released into vas deferens just before ejaculation

60% of semen volume

Prostate gland

Surrounds urethra

Produces and secretes a milky, alkaline fluid into urethra just before ejaculation

Fluid protects sperm in the acidic environment of the vagina

40% of semen

Bulbourethral (Cowper's) glands

Produce a mucus-like fluid

Secreted just before ejaculation

Lubricates end of penis

Semen

Alkaline mixture

Nutrients

Prostoglandins

to 5.0 ml per ejaculate

Sperm count of 40 to 250 million/mL

Male External Accessory Organs

Scrotum

Holds testes away from body

Temperature 1° below body temperature

Lined with serous membrane that secrets fluid

Testes move freely

Penis

Shaft

Erectile tissues surround urethra. That is

Corpus Cavernosum

Corpus spongiosum

Glans penis

Cone-shaped structure on end of penis

Contain sensory nerve endings which causes an orgasm--ejaculation

Prepuce

Skin covering glans penis in uncircumcised males

Functions

Deliver sperm

Urination

Sexual Response Cycle

It has four phases.

Phase 1: Excitement

General characteristics of the excitement phase, which can last from a few minutes to several hours, include the following:

Muscle tension increases.

Heart rate quickens and breathing is accelerated.

Skin may become flushed (blotches of redness appear on the chest and back).

Nipples become hardened or erect.

Blood flow to the genitals increases, resulting in swelling of the woman's clitoris and labia minora (inner lips), and erection of the man's penis.

Vaginal lubrication begins.

The woman's breasts become fuller and the vaginal walls begin to swell.

The man's testicles swell, his scrotum tightens, and he begins secreting a lubricating liquid.

Phase 2: Plateau

General characteristics of the plateau phase, which extends to the brink of orgasm, include the following:

The changes begun in phase 1 are intensified.

The vagina continues to swell from increased blood flow, and the vaginal walls turn a dark purple.

The woman's clitoris becomes highly sensitive (may even be painful to touch) and retracts under the clitoral hood to avoid direct stimulation from the penis.

The man's testicles are withdrawn up into the scrotum.

Breathing, heart rate, and blood pressure continue to increase.

Muscle spasms may begin in the feet, face, and hands.

Muscle tension increases.

Phase 3: Orgasm

The orgasm is the climax of the sexual response cycle. It is the shortest of the phases and generally lasts only a few seconds.

General characteristics of this phase include the following:

Involuntary muscle contractions begin.

Blood pressure, heart rate, and breathing are at their highest rates, with a rapid intake of oxygen.

Muscles in the feet spasm.

There is a sudden, forceful release of sexual tension.

In women, the muscles of the vagina contract. The uterus also undergoes rhythmic contractions.

In men, rhythmic contractions of the muscles at the base of the penis result in the ejaculation of semen.

A rash, or "sex flush" may appear over the entire body

Phase 4: Resolution

During resolution, the body slowly returns to its normal level of functioning, and swelled and erect body parts return to their previous size and color.

This phase is marked by a general sense of well-being, enhanced intimacy and, often, fatigue.

Some women are capable of a rapid return to the orgasm phase with further sexual stimulation and may experience multiple orgasms.

Men need recovery time after orgasm, called a refractory period, during which they cannot reach orgasm again.

Erection, Orgasm & Ejaculation

Erection

Parasympathetic nervous system stimulates erectile tissue i.e. corpus cavernosum and corpus spongiosum

Becomes engorged with blood

Orgasm

Rhythmic peristaltic contractions of the smooth muscles of the urethra and accessory glands.

Sperm cells propelled out of testes into urethra

Secretions from accessory organs also released into urethra

Emission and Ejaculation

Emission --Semen is forced into the urethra

Ejaculation– forceful expulsion of semen from the urethra out of the penis

Emission and ejaculation are stimulated by sympathetic nervous system , which cause peristaltic contractions of the tubular system, contractions of the seminal vesicle and prostate and contractions of the muscles at the base of the penis.

Sympathetic nerves then stimulate erectile tissue to release blood

Penis returns to flaccid state

Male Reproductive Hormones

- Hypothalamus
- Gonadotropin-releasing hormone (GnRH)
- Stimulates anterior pituitary to release
- Follicle-stimulating hormone (FSH) – initiates spermatogenesis
- Luteinizing hormone (LH) – stimulates interstitial cells in the testes to produce testosterone
- Testosterone

Secondary sex characteristics

Maturation of male reproductive organs

Regulated by negative feedback

Diseases and Disorders of the Male Reproductive System

- Prostate cancer—most common form of cancer for men over 40 years. Risk factor of getting it increases with age.
- Prostatitis—inflammation of the prostate gland. It may be acute or chronic
- Testicular cancer—malignant growth in one or both testis. More common in men between 15-30 years; more aggressive malignancy
- Benign prostatic hypertrophy (BPH)—non-malignant enlargement of the prostate gland. Common among older men
- Epididymitis—inflammation of the epididymitis. Common cause is lower urinary tract inflammation.
- Impotence or erectile dysfunction—disorder in which erection cannot be achieved or maintained. About 50% of men between 50 and 70 experience some degree of erectile dysfunction

Female Reproductive System

Two Ovaries

Primary sex organs produce sex cells called ova, Hormones estrogen and progesterone

Located in the pelvic cavity

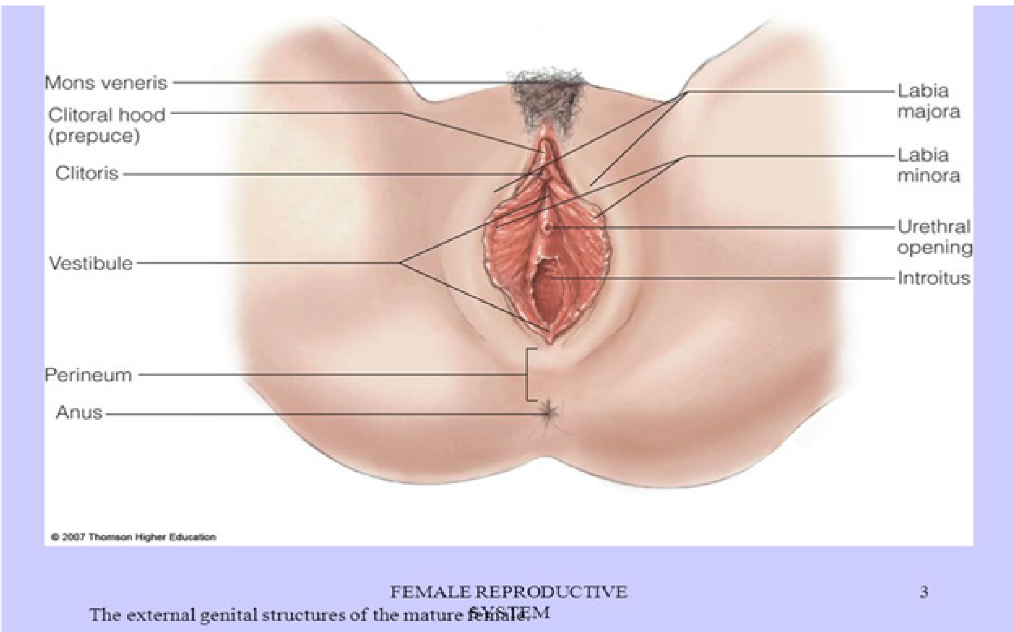
Medulla

Inner area; contains nerves, lymphatic vessels, and blood vessels

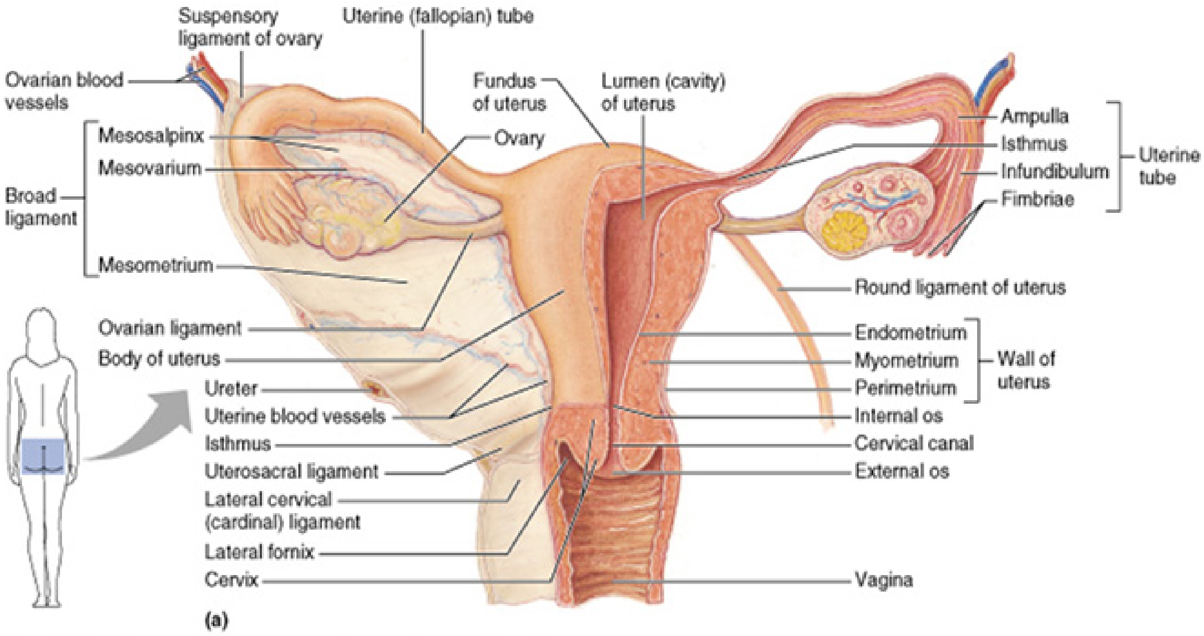
Cortex

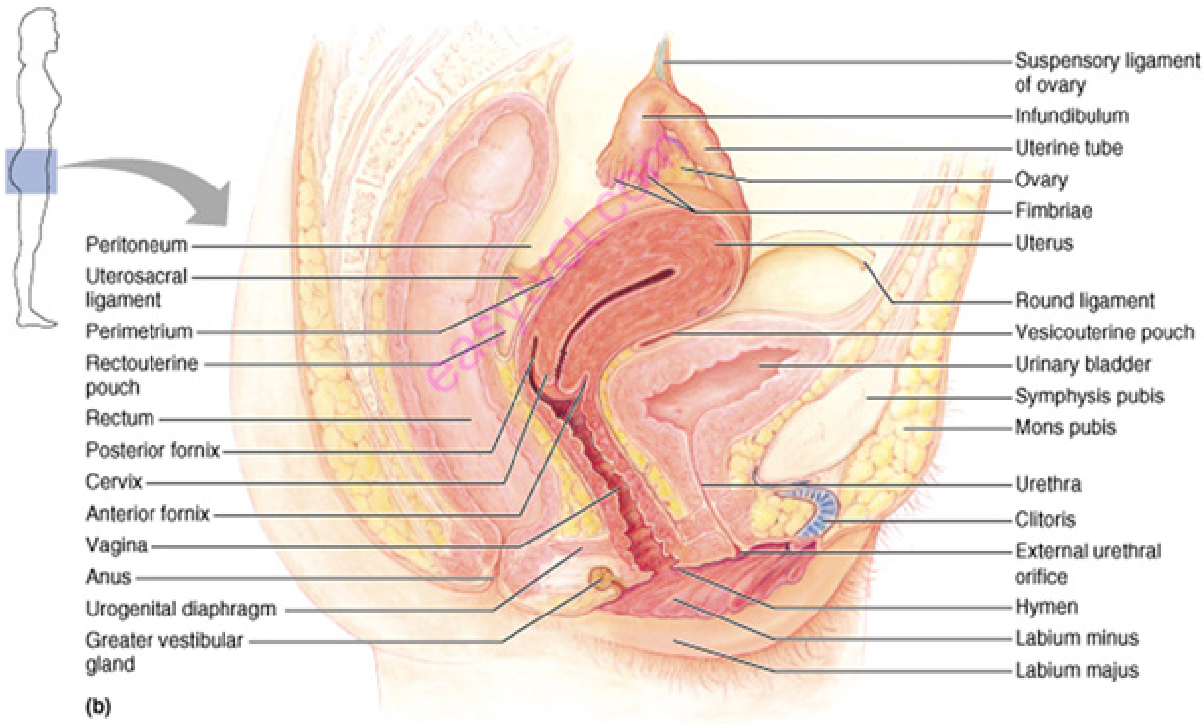
Outer area; contains ovarian follicles

Covered by epithelial and dense connective tissues



The external genital structures of the mature female.





Ovum Formation (cont.)

Primordial follicles develop before birth and contain a primary oocyte or immature ovum (born with maximum number) *Follicular cells*

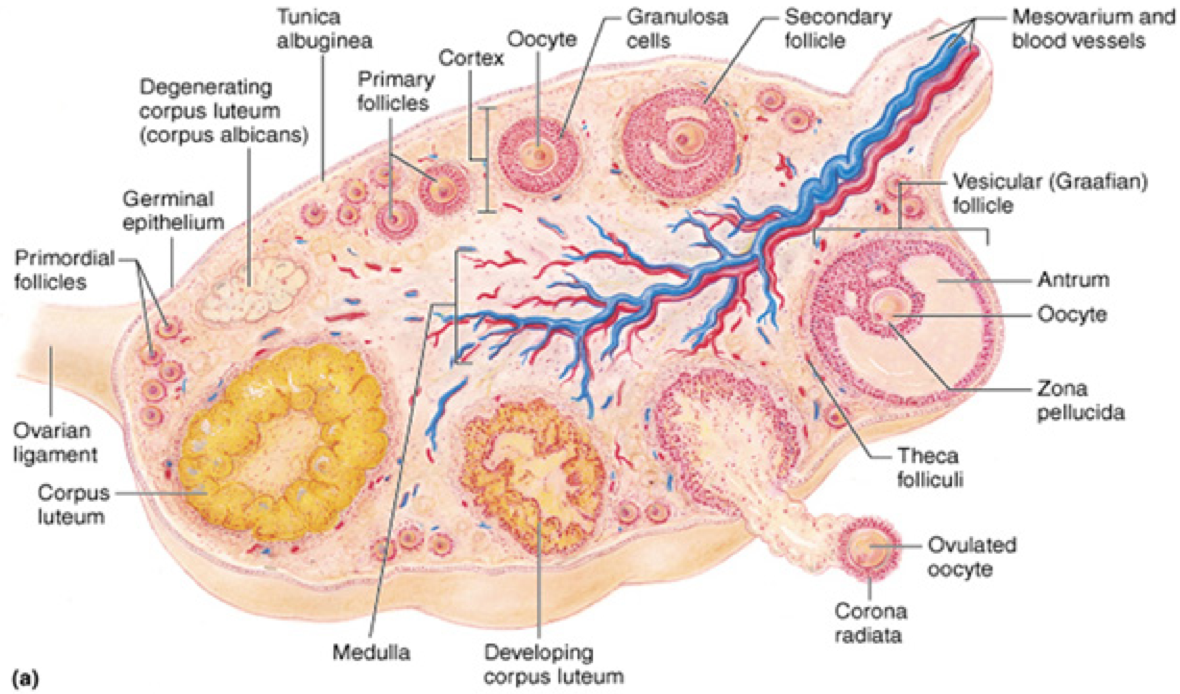
Oogenesis is the process of ovum formation

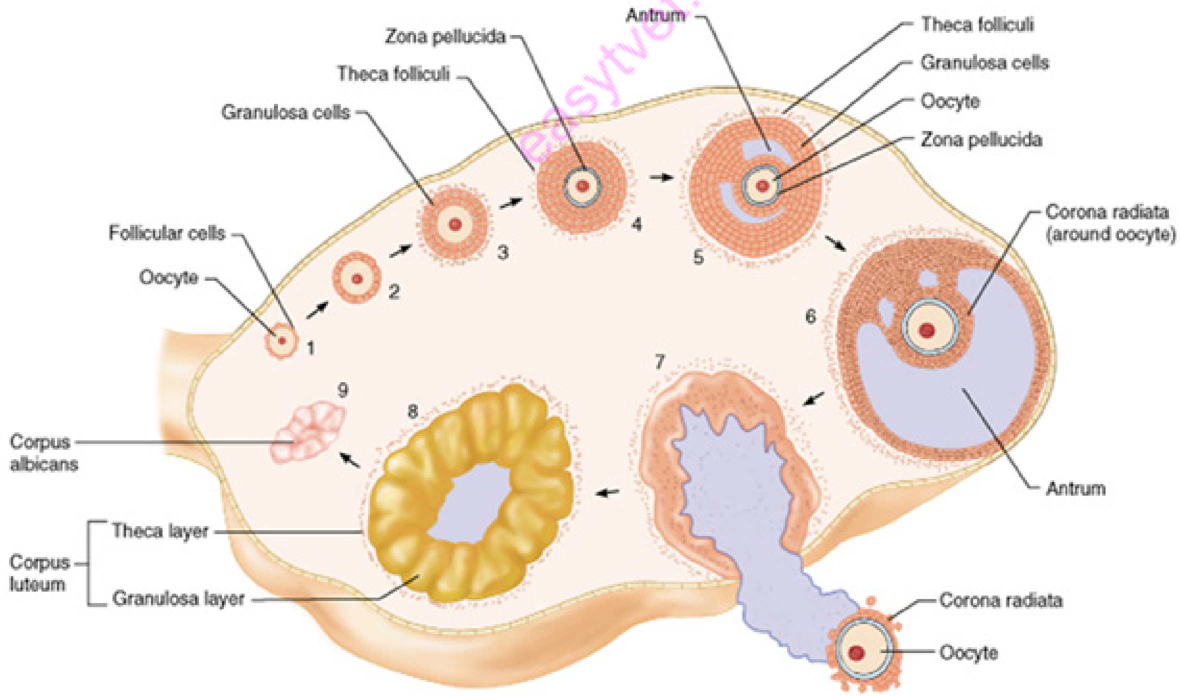
At puberty, primary oocytes are stimulated to continue meiosis

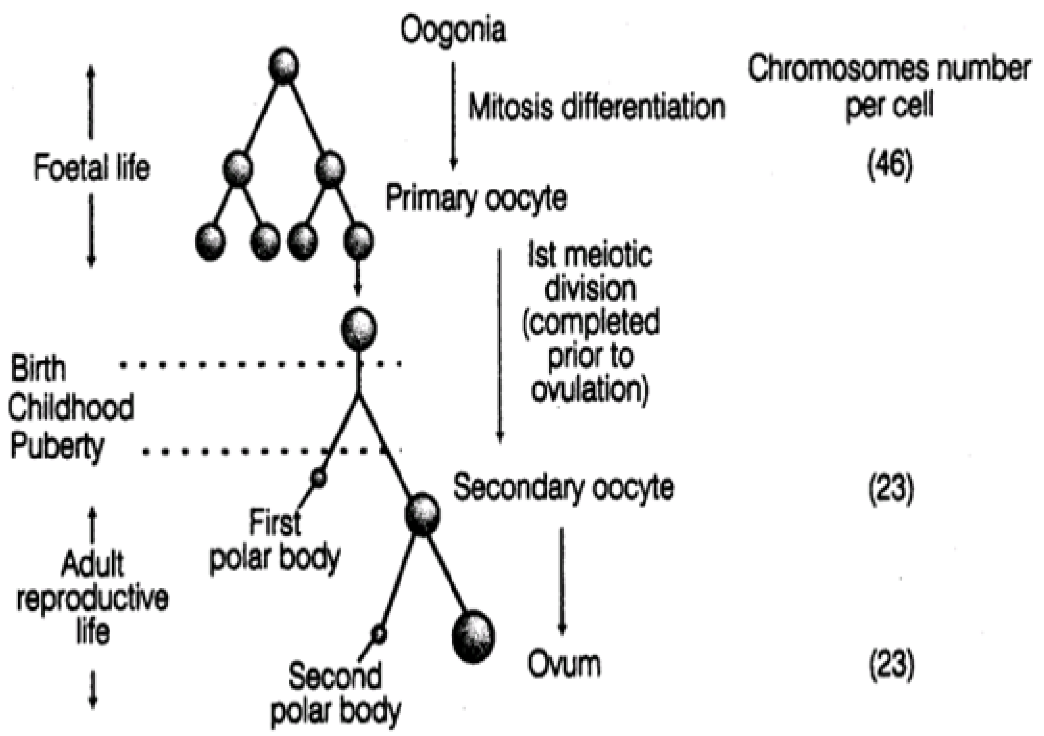
Becomes 1 polar body (a nonfunctional cell) and a secondary oocyte

Secondary oocyte released during ovulation

If fertilized, the oocyte divides to form a mature, fertilized ovum







Oogenesis in human female showing formation of ovum

Female Internal Accessory Organs

Fallopian tube – oviduct

***Infundibulum and fimbri*ae**

Fringed, expanded end of fallopian tube near ovary

Function to "catch" an ovum

Muscular tube

Lined with mucous membrane and cilia

Propels ovum toward uterus

Uterus

Hollow, muscular organ, and receives embryo and sustains its development

Divisions

- Fundus – domed upper portion
- Body – main portion
- Cervix – narrow, lower section extending into vagina (cervical orifice)

Wall of uterus

Endometrium

Innermost lining

Vascular

Tubular glands – mucus

Myometrium

Middle, thick, muscular layer

Perimetrium

Thin layer covering the myometrium

Secretes serous fluid to coat and protect uterus

Vagina

Tubular, muscular organ which extends from uterus to outside body (vaginal introitus)

Muscular folds – rugae – enable expansion

Receive erect penis

Passage for delivery of offspring and uterine secretions

Wall

Innermost mucosal layer

Middle muscular layer

Outer fibrous layer

External Accessory Organs

Mammary glands

Secretion of milk

Structures

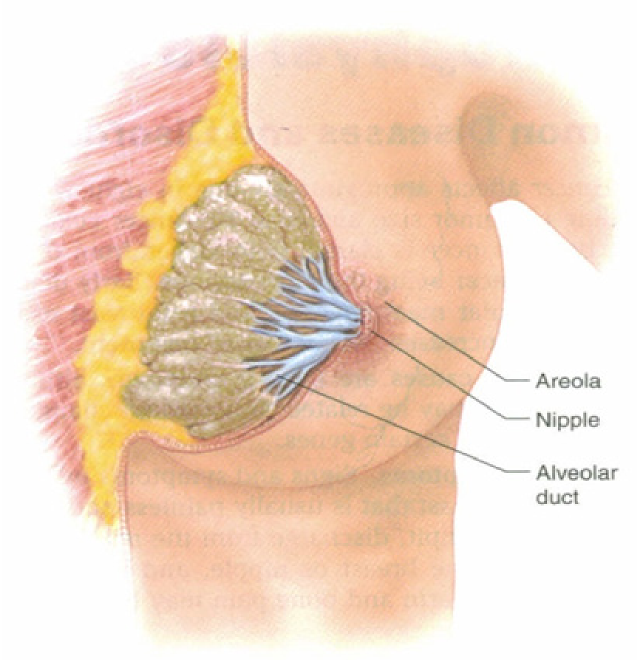
Nipple

Oxytocin induces lactiferous ducts to deliver milk through openings

Areola – pigmented area around nipple

Alveolar glands – within mammary glands

Make milk when stimulated by prolactin



External Genitalia

Collectively known as the vulva

Labia majora

Rounded folds of adipose tissue and skin

Protect other external reproductive organs

Labia minora

Folds of skin between labia majora

Very vascular

Merge to form hood over clitoris

Vestibule – space enclosed by labia minora

Bartholin's glands secrete mucus during sexual arousal

Clitoris

Anterior to urethral meatus

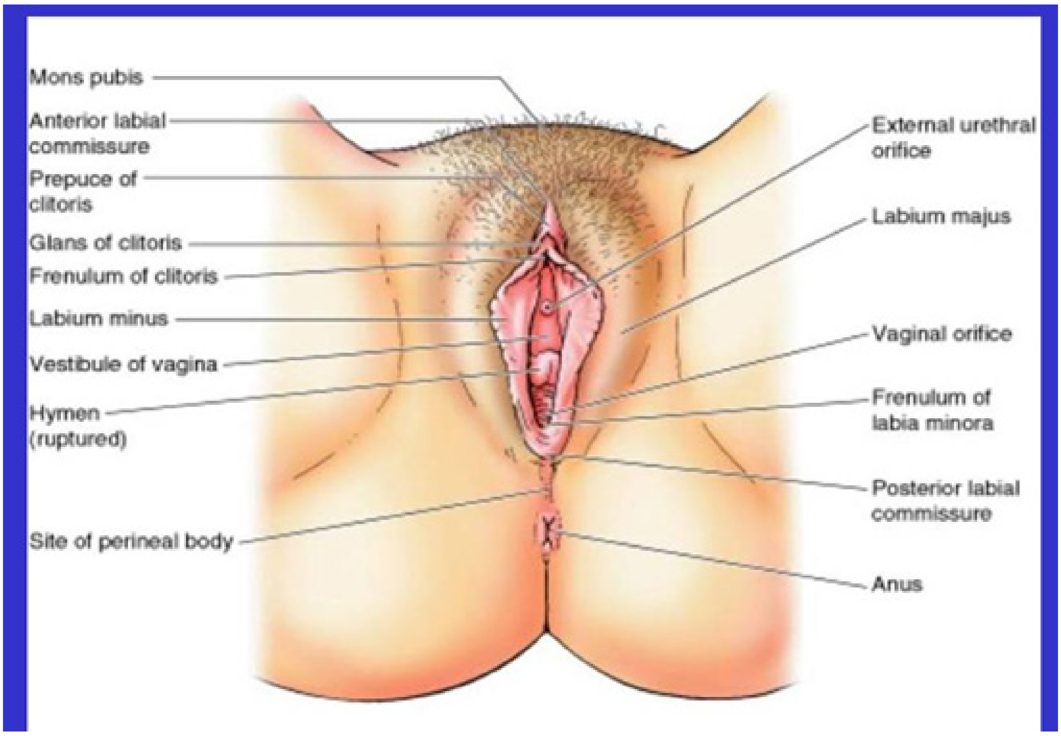
Contains female erectile tissue

Rich in sensory nerves

Perineum

Between vagina and anus

Area for episiotomy, if needed, during birth process



Erection, Lubrication, and Orgasm

Nervous stimulation

Clitoris becomes erect

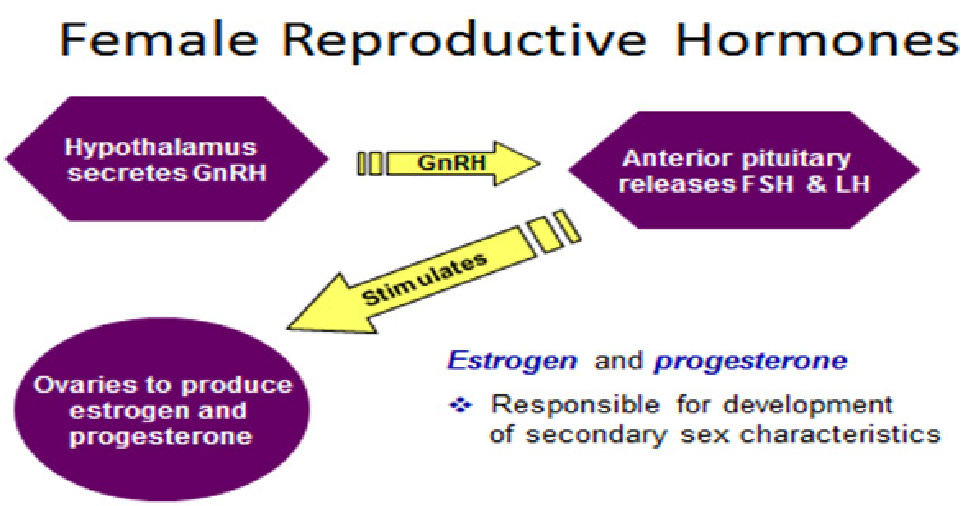
Bartholin's glands activated – lubrication

Vagina elongates

Orgasm

Sufficient stimulation of clitoris

Walls of uterus and fallopian tubes contract to propel sperm up tubes



Reproductive Cycle

Menstrual cycle

Regular changes in uterine lining, resulting in monthly bleeding

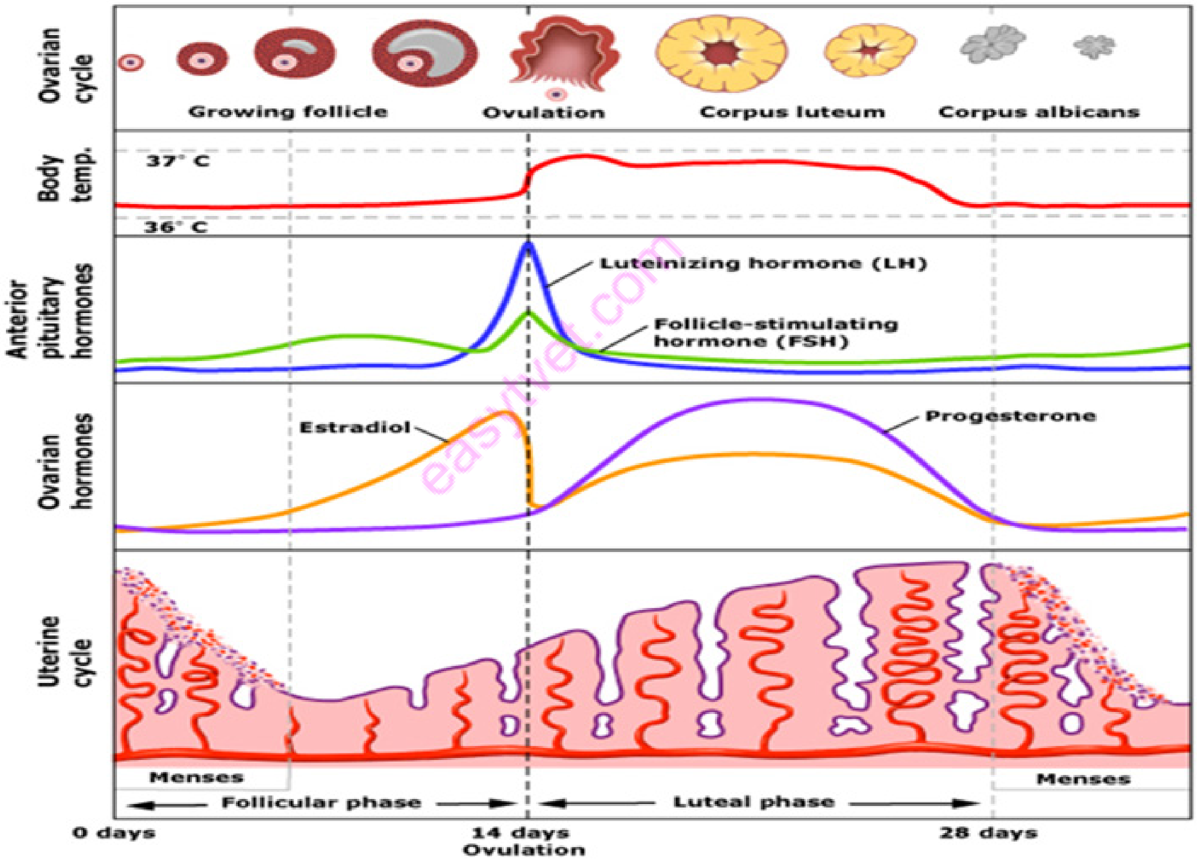
Ovarian Cycle

Menarche – first menstrual period

Menopause – termination of cycle due to normal aging of ovaries

Phases of the Menstrual Cycle

1. The Menstrual Phase: Day (1-5) – During this phase the endometrium is shed. There is bleeding.

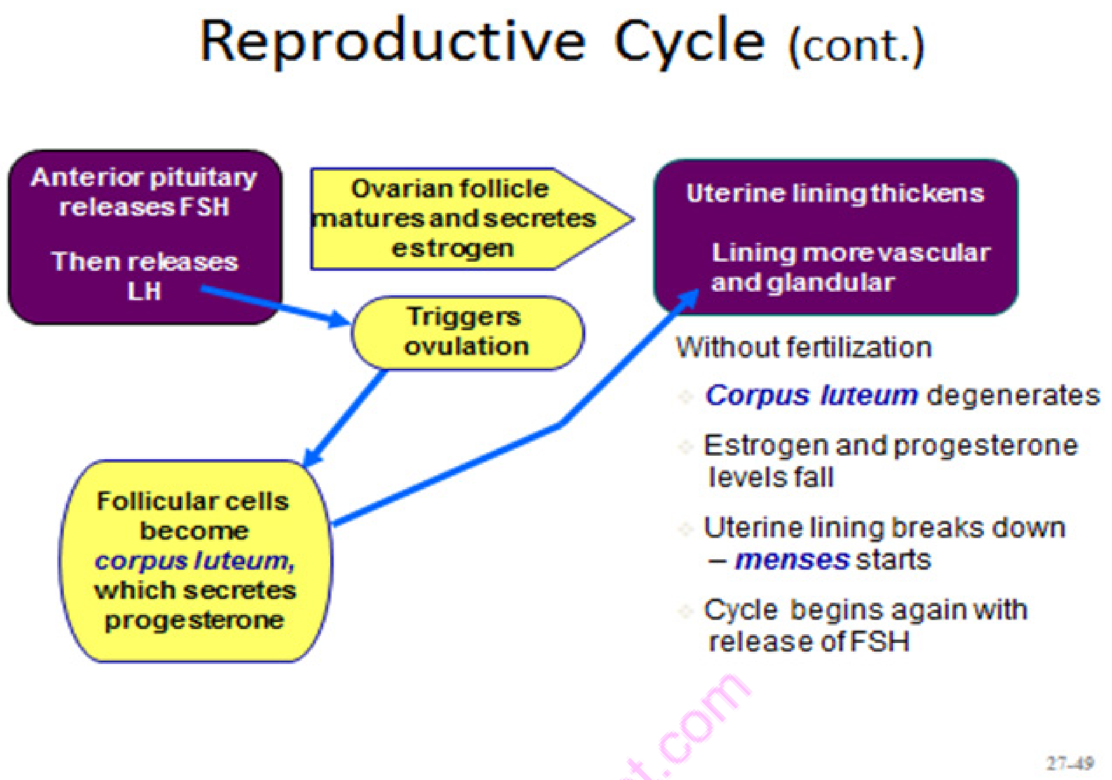


2. Proliferative Phase: Day (6-14)

During this phase the endometrium builds a new stratum functionalis as it responds to rising estrogen levels. As the layer thickens glands secrete a clear sticky mucus that help the sperm to find the egg.

3. Secretory phase: Day (15-28)

During this phase the stratum functionalis is highly vascularised and there is secretion of glycoproteins to support a developing embryo incase the fertilization occurs. These changes are response to progesterone released by the corpus luteum in the ovary. If there is no fertilization, the progesterone level drops signaling changes that cause death of the stratum functionalis. The arteries constrict cutting out blood supply and suddenly opens again but the weak capillaries fragment and the menstrual phase begins again.



Diseases and Disorders of the Female Reproductive System

- Breast cancer—second leading cause of cancer deaths in women; classified as stage 0 to 4
- Cervical cancer—slow to develop; pap smear detects abnormal cervical cells
- Cervicitis—inflammation of the cervix often due to infection
- Dysmenorrhea—a condition with severe menstrual cramps that limit daily activities
- Endometriosis—tissues of the uterine lining growing outside the uterus
- Fibrocystic breast disease—abnormal cystic tissue in the breast; size varies according to the menstrual cycle; common in 60% of women between 30 and 50 years.
- Fibroids—benign growth in the uterine wall; affects 25% of women in their 30s and 40s
- Ovarian cancer—considered more deadly than other types; detection difficult and only detected when it has spread to other areas
- Premenstrual syndrome (PMS)—collection of symptoms occurring just before a menstrual period
- Vaginitis/vulvo-vaginitis—inflammation of the vagina/inflammation of the vagina and vulva; both associated with abnormal vaginal discharge

- Uterine/endometrial cancer—most common in post-menopausal women; causes about 6% of cancer deaths among women

Pregnancy

Pregnancy – condition of having a developing offspring in the uterus

Fertilization – process in which a sperm cell unites with an ovum; results in pregnancy

Only one sperm cell penetrates the follicular cells and the zona pellucida that surround the ovum's cell membrane

After fertilization, ovum releases enzymes that cause the zona pellucida to become impenetrable to other sperm

Zygote forms from union of ovum and sperm, it contains 46 chromosomes.

The Prenatal Period

Time before birth

Zygote – undergoes rapid mitosis

First week after fertilization

Cleavage – rapid cell division

Morula – ball of cells resulting from cleavage

Travels down fallopian tube to uterus

Becomes blastocyst, which implants in endometrial wall

Blastocyst

Some cells (inner cell mass) become embryo

Others, along with cells from uterus, form placenta

Embryonic period

Week 2 through 8

Inner cell mass organizes into three primary germ layers

Ectoderm | Mesoderm | Endoderm

Formation of

Placenta | Amnion | Umbilical cord | Yolk sack

Most internal organs and external structures of embryo

Last 3 months – fetal brain cells rapidly divide

GI and respiratory systems last to develop.

Fetal period

Week 8 through birth

Rapid growth

5th month – skeletal muscles active

6th month – gains weight

Fetal Circulation

Placenta and umbilical blood vessels carry out the exchange of nutrients, oxygen, and waste products.

Unique differences from normal circulation

Foramen ovale – hole between right and left atria enables most of fetal blood to bypass lungs

- Ductus arteriosus – connection between pulmonary artery and aorta.
- Ductus venosus – vessel that bypasses liver

Hormonal Changes During Pregnancy

Embryonic cells secrete human chorionic gonadotropin (HCG)

Maintains the corpus luteum

Estrogen and progesterone

Secreted by corpus luteum and placenta

Functions

Stimulate uterine lining to thicken, development of mammary glands, enlargement of female reproductive organs

Inhibit release of FSH and LH from anterior pituitary gland (preventing ovulation) and uterine contractions

Relaxin

From corpus luteum

Inhibits uterine contractions and relaxes ligaments of pelvis

Lactogen

From placenta

Stimulates enlargements of mammary glands

Aldosterone

From adrenal gland

Increases sodium and water retention

Parathyroid hormone (PTH)

Helps maintain high calcium levels in the blood

The Birth Process

Begins when progesterone levels fall

Prostaglandins secreted by uterus stimulate uterine contractions

Uterine contractions stimulate posterior pituitary gland to release oxytocin

Oxytocin stimulates strong uterine contractions

Three stages

Dilation

Cervix thins and softens (effacement)

Lasts 8 – 24 hours

Expulsion or parturition

Actual birth

May take 30 minutes or less

Placental stage – 10 to 15 minutes after the birth, the placenta separates from uterine wall and is expelled.

The postnatal period

Six-week period following birth

Neonatal period – first four weeks

Neonate is adjusting to life outside uterus

Milk production and secretion

Prolactin – production of milk

Oxytocin – ejection of milk from mammary gland ducts

Production continues as long as breast-feeding continues

GASTRO INTESTINAL SYSTEM

Digestive System

Responsible for providing raw materials to support life:

Food molecules catabolized for energy and building blocks to supply anabolic reactions (cell division, repair, secretions, etc.)

Digestive System Organization

1. Gastrointestinal (Gl) tract (Alimentary canal)

Tube within a tube

Direct link/path between organs

Structures

- Mouth
- Oral Cavity
- Pharynx
- Esophagus
- Stomach
- Duodenum
- Jejunum
- Ileum
- Caecum
- Ascending colon
- Transverse colon
- Descending colon
- Sigmoid colon
- Rectum
- Anus

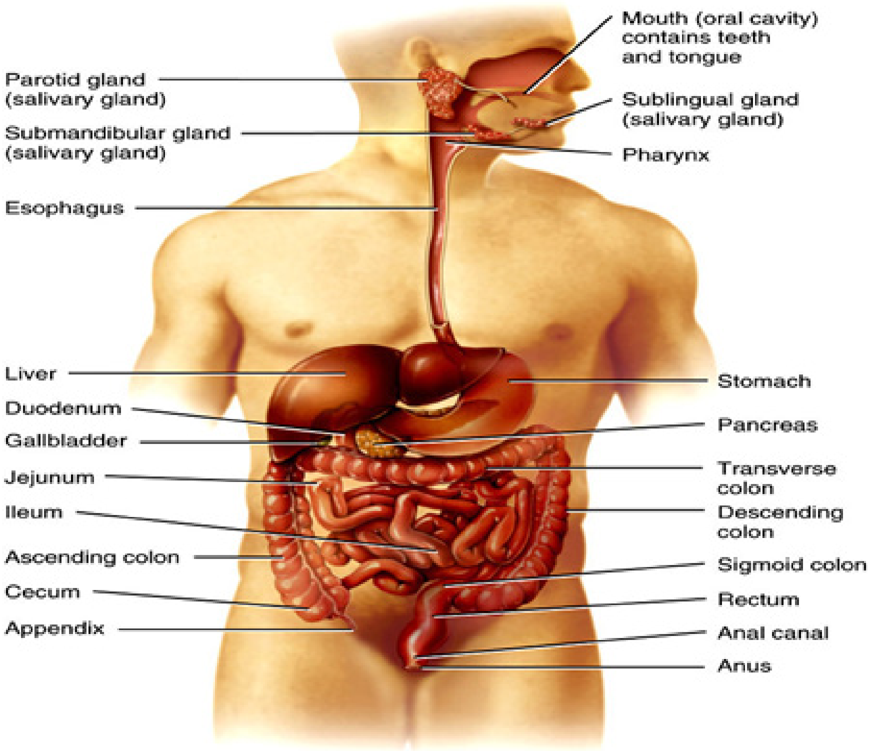
2. Accessory structures

Not in tube path

Organs

- Teeth
- Tongue
- Salivary glands
- Liver
- Gall bladder
- Pancreas

Organs of the digestive system



(a) Right lateral view of head and neck and anterior view of trunk

Figure 24.01a Tortora - PAP 12/e

The Digestive Process

Ingestion

Taking in food through the mouth

Propulsion (movement of food)

Swallowing

Peristalsis – propulsion by alternate contraction & relaxation

Mechanical digestion

Chewing

Churning in stomach

Mixing by segmentation

Chemical digestion

By secreted enzymes: see later

Absorption

Transport of digested end products into blood and lymph in wall of canal

Defecation

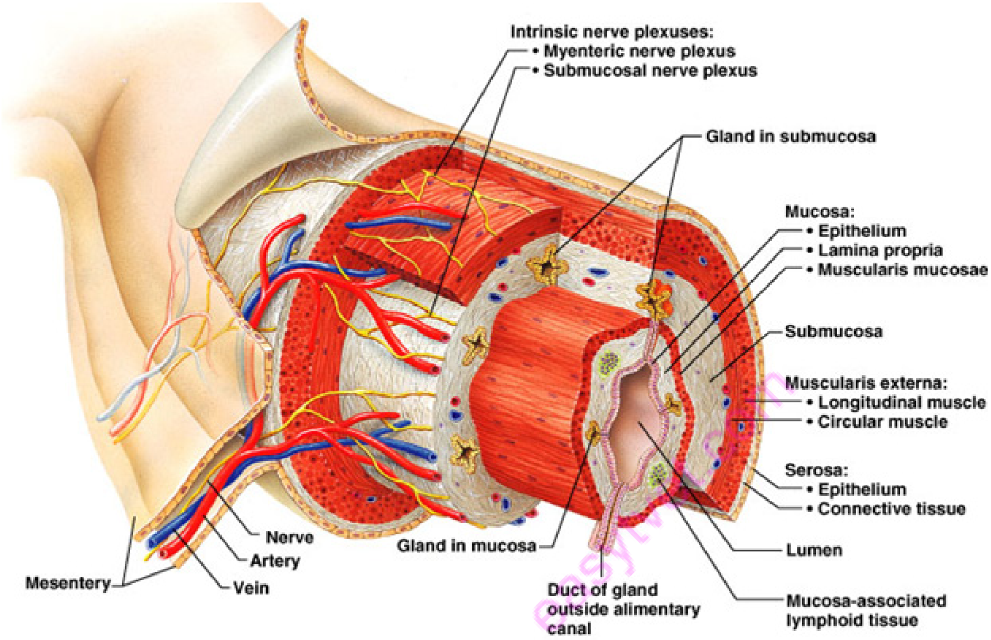
Elimination of indigestible substances from body as feces

Histology of alimentary canal wall

Same four layers from esophagus to anal canal

Mucosa | Submucosa | Muscularis externa | Serosa

from lumen (inside) out



Peritoneum

Largest serous membrane of the body

Divided into

- Parietal peritoneum – lines wall of cavity
- Visceral peritoneum – covers some organs

Also called serosa

Space between the two is peritoneal cavity

5 major peritoneal folds

1. Greater omentum 2. falciform ligament 3. lesser omentum 4. mesentery 5. mesocolon

Weave between viscera binding organs together

Neural innervation of the GIT

1. Enteric nervous system (ENS)

Intrinsic set of nerves - "brain of gut"

Neurons extending from esophagus to anus

2 plexuses

Myenteric plexus – GI tract motility

Submucosal plexus – controlling secretions

2. Autonomic nervous system

Extrinsic set of nerves

Parasympathetic stimulation increases secretion and activity by stimulating ENS

Sympathetic stimulation decreases secretions and activity by inhibiting ENS

Review of some definitions….

Peritoneum: serous membranes of the abdominopelvic cavity

Visceral peritoneum: covers external surfaces of most digestive organs

Parietal peritoneum: lines body wall

Peritoneal cavity: slit-like potential space between visceral and parietal peritoneum

Serous fluid – lubricating

Mouth/Oral cavity

The mouth is a mucosa-lined cavity. It's bounded by the lips anteriorly, hard & soft palate superiorly, and tongue inferiorly, muscles of the cheeks laterally.

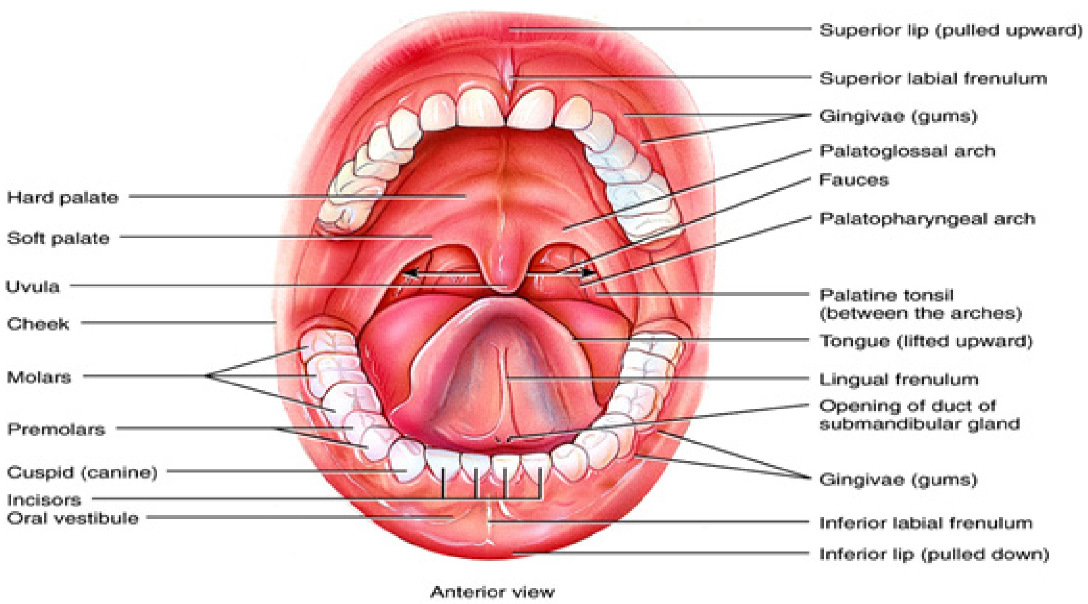


Figure 24.05 Tortora - PAP 12/e

The anterior opening is the oral orifice. It's continuous posteriorly with the oropharynx via the fauces. The space btwn the lips and the teeth and gums is the oral vestibule, while the space btwn the teeth/gums and oropharynx is the oral cavity proper.

It's lined by stratified squamous epithelium, which provides protection against heat, chemicals, abrasion, and pathogens.

Tongue

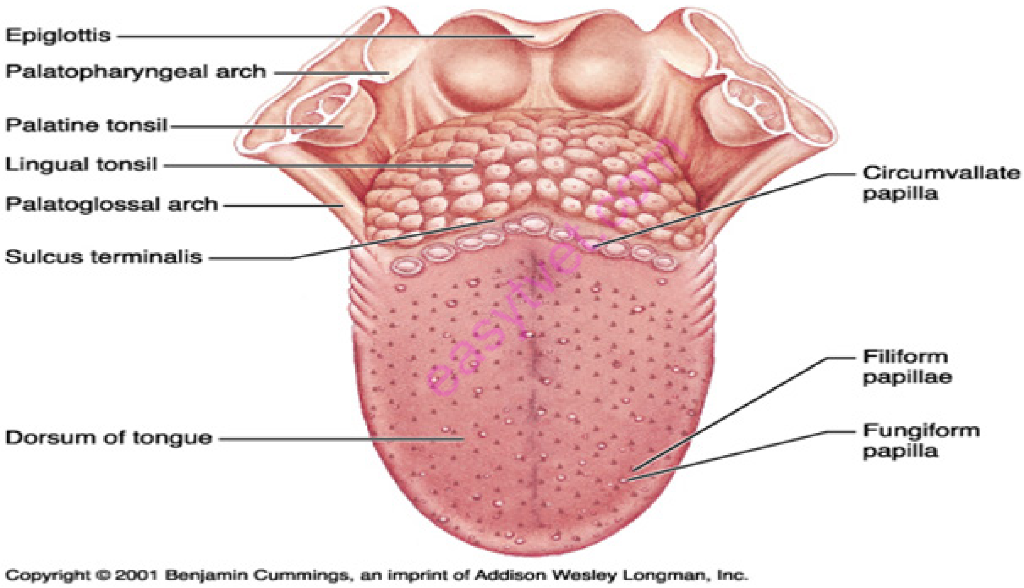
The tongue is composed of interlacing bundles of skeletal muscle.

Intrinsic muscles of the tongue are confined to the tongue and adjust its shape.

Extrinsic muscles of the tongue are anchored to skull structures and adjust the tongue's position.

The superior tongue surface bears papillae, projections of the mucosa.

Papillae increase surface area, which creates friction that can assist in eating/manipulating foods. Papillae also contain sensory receptors for taste in the taste buds.



Dorsal Surface of the Tongue

Functions of the tongue

- Speech
- Manipulate food into teeth for mastication
- Compress food into bolus for swallowing
- Analyze food for texture, taste, temp
- Produce secretions:
  i. Mucin - lubrication
  ii. Lingual lipase - start lipid digestion

Teeth

Called "dentition" (like dentist)

Teeth are classified according to shape and function

Incisors: chisel-shaped for chopping off pieces

Canines: cone shaped to tear and pierce

Premolars (bicuspids) and

Molars - broad crowns with 4-5 rounded cusps for grinding

Tooth structure

Two main regions

Crown (exposed)

Root (in socket)

Meet at neck

Enamel

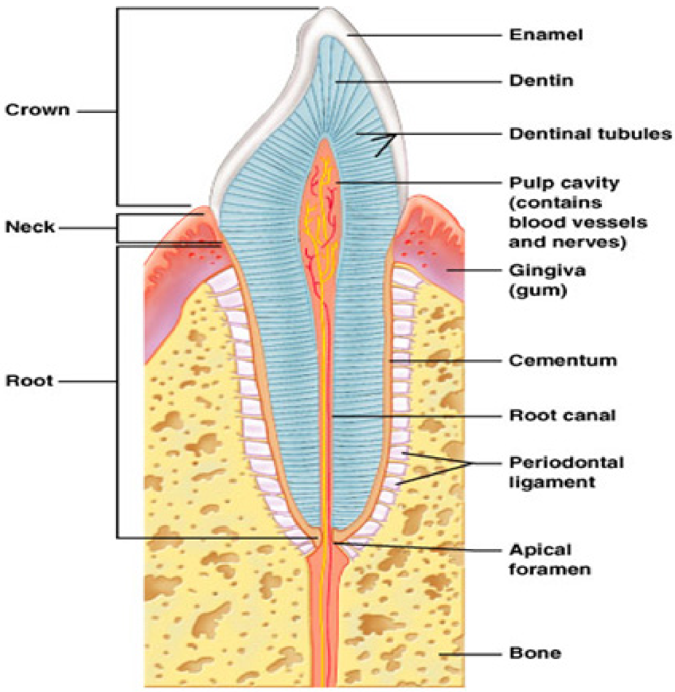
99% calcium crystals

Hardest substance in body

Dentin – bulk of the tooth (bone-like but harder than bone, with collagen and mineral)

Pulp cavity with vessels and nerves

Root canal: the part of the pulp in the root



Cementum – bone layer of tooth root

Attaches tooth to periodontal ligament

Periodontal ligament

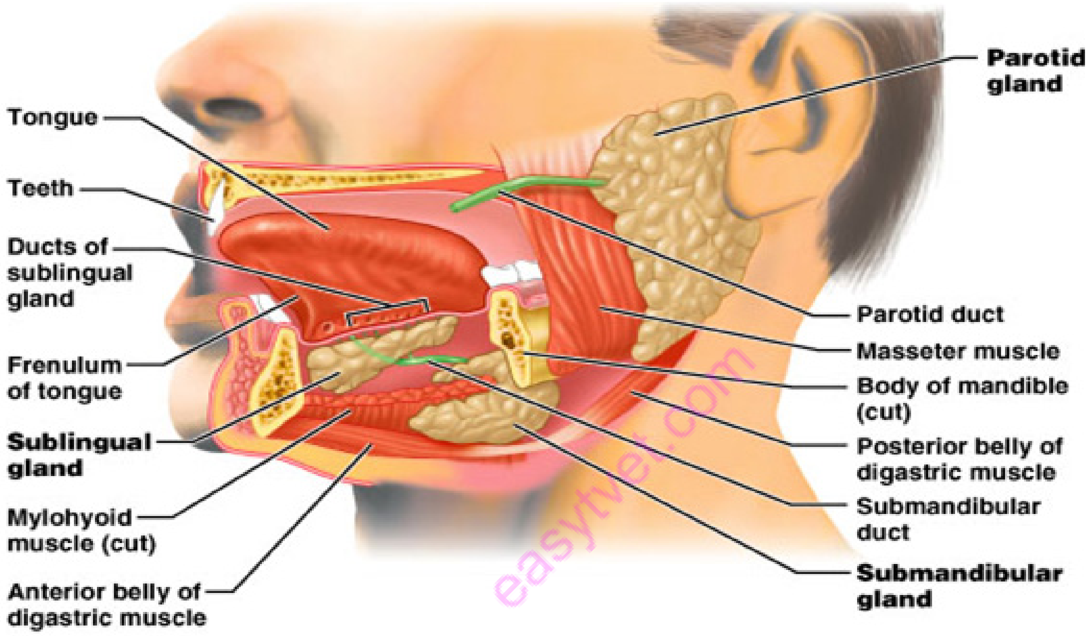
Anchors tooth in boney socket of the jaw

Continuous with gingiva (gums)

Cavities or caries - rot

Plaque – film of sugar, bacteria and debris

The Major Salivary Glands



Saliva: mixture of water, ions, mucus, enzymes

- Keep mouth moist
- Dissolves food so can be tasted
- Moistens food
- Starts enzymatic digestion
- Buffers acid
- Antibacterial and antiviral

Intrinsic salivary glands – within mucosa

Secrete saliva all the time to keep mouth moist

Extrinsic salivary glands

Paired (2 each)

Parotid | Submandibular | Sublingual | External to mouth | Ducts to mouth

Secrete saliva only right before or during eating

Parotid salivary glands: inferior to zygomatic arch, thick secretion, high salivary amylase. A duct opens into the mouth (25% of saliva)

Sublingual salivary glands: inferior to tongue, watery secretion, high in buffers (5% of saliva)

Submandibular salivary glands posterior ducts opens on the near on each side of the frenulum at the floor of mouth, buffers, mucin, amylase (70% of saliva)

Pharynx

The pharynx, or throat, is the passageway leading from the mouth and nose to the esophagus and larynx.

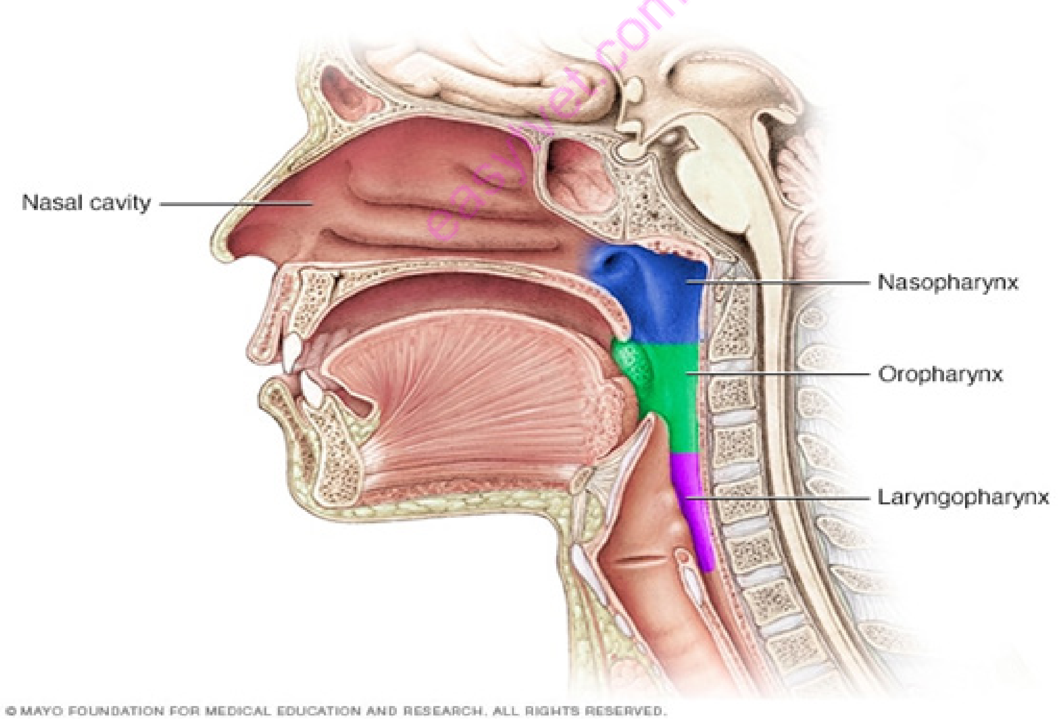
Food Passes from mouth into pharynx then into the oesophagus.

Three parts of the Pharynx

Nasopharynx--Functions only in respiration

Oropharynx--Digestive and respiratory functions

Laryngopharynx--Digestive and respiratory functions



Esophagus

Continuation of pharynx in mid neck, 25cm long & 2cm in diameter

Muscular tube collapsed when lumen empty

Descends through thorax

Abdominal part only 2 cm long

Joins stomach at cardiac orifice*

Cardiac sphincter at cardiac orifice to prevent regurgitation (food coming back up into esophagus)

Gastroesophageal junction and GERD (Gastro-esophageal Reflux Disease)

Functions of the mouth, pharynx & esophagus

Formation of a bolus

Swallowing (Deglutition)

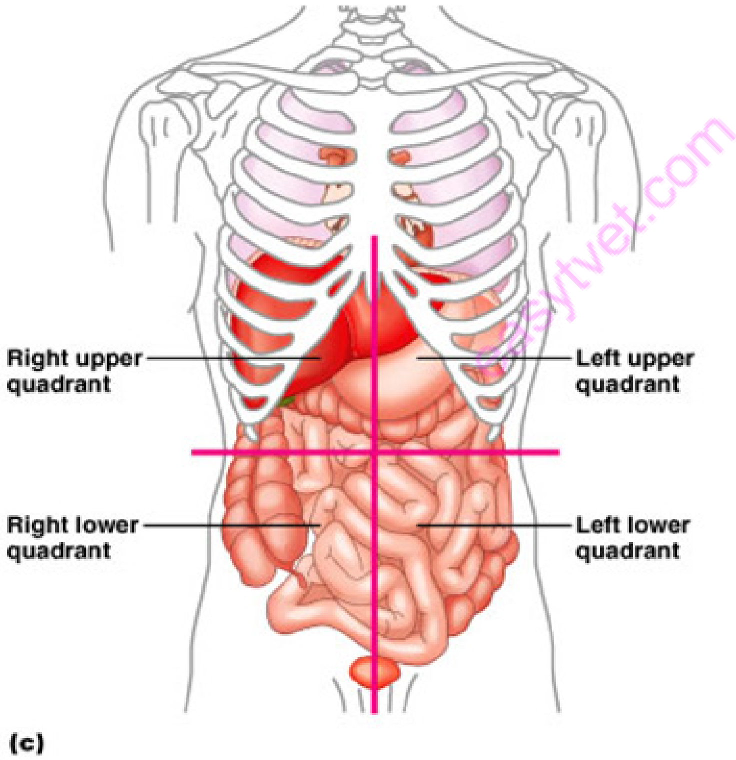
Peristalsis

Stomach

Lies mostly in LUQ

Anchored at both ends but mobile in between

Capacity: 1.5 L food; max capacity 4L (1 gallon)



Usually “J” shaped

Lies epigastric, umbilical and left hypochondriac regions of the abdomen.

Anteriorly: left lobe of the liver, anterior abdominal wall

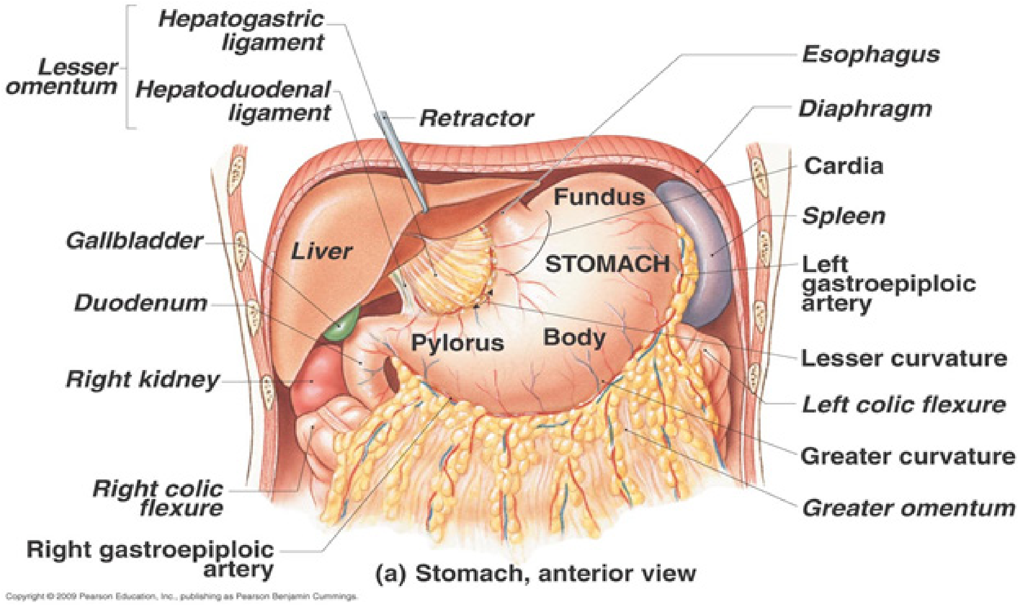
Posteriorly: abdominal aorta, spleen, pancreas, left kidney, & adrenal gland

Superiorly: diaphragm, esophagus, left lobe of the liver

Inferiorly: transverse colon, small intestine

To the left: diaphragm

To the right: liver and duodenum



Stomach Regions

Four Major Regions:

1. *Cardia*

   -where esophagus connects via gastroesophageal sphincter

   -gastric glands produce mucus to protect esophagus

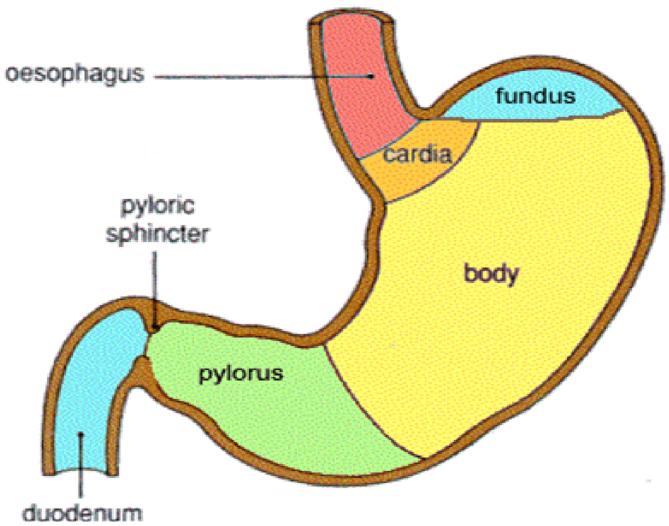
2. *Fundus* -superior region, contact with the diaphragm

3. *Body* -majority of stomach

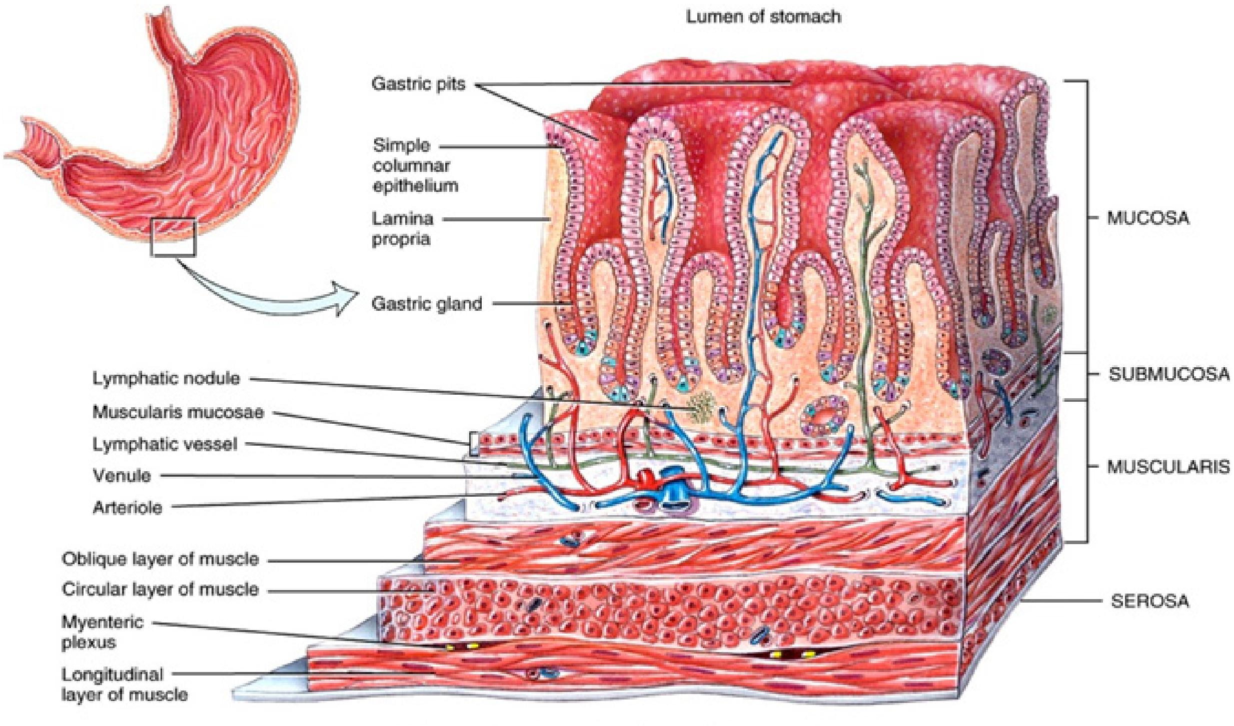
   -holds chyme

   -gastric glands secrete enzymes and acids for digestion

4. *Pylorus*



Histology of the stomach



(a) Three-dimensional view of layers of the stomach

Figure 24.12a Tortora - PAP 12/e

Mucosa

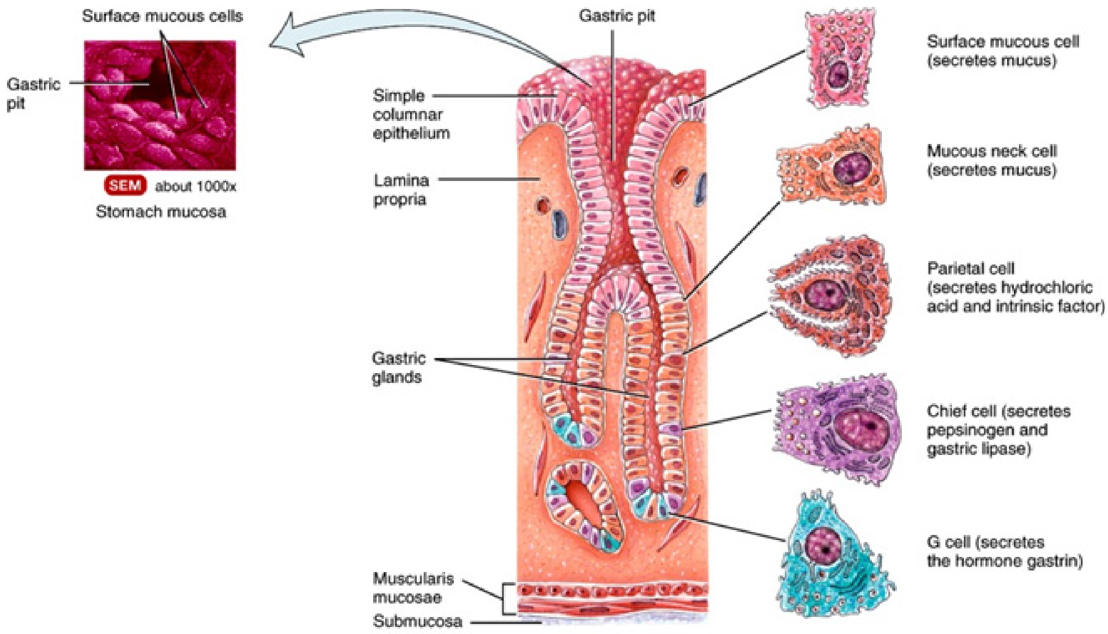
The basic cell types of Mucosa are:

Mucous neck cells – found in the upper portion of the gland. Secrete acidic mucus and function as stem cells for surface mucous cells.

Chief cells – primary function is the secretion of pepsinogen, an inactive form of the protease, pepsin. Pepsinogen is activated by HCl and by pepsin itself.

Parietal cells – found in the mid-portion of the glands. Secrete hydrochloric acid (which gives the stomach its low pH – usually 1-3) as well as intrinsic factor.

Enteroendocrine cells – secrete multiple hormones into the plasma. An example is gastrin released by G cells. Gastrin is a hormone that regulates the stomach's motility and secretory activity.



(b) Sectional view of the stomach mucosa showing gastric glands and cell types

Figure 24.12b Tortora - PAP 12/e

Functions of the Stomach

Store ingested food (~1 L)

Mechanical breakdown of food (churning)

Chemical breakdown of food (denature and digest proteins)

Produce intrinsic factor for Vitamin B12 uptake (Vit B12 necessary for erythropoiesis)

Gastric Glands: Gastric Juice

Produce 1-3 L gastric juice / day: secretions.

Gastric juice stops the action of salivary amylase.

Gastric muscles helps in breaking down the bolus, churning of food and peristaltic movement propels the food towards the pylorus.

PNS increases gastric motility & secretion of gastric juices while SNS decreases.

Gastric juice

Vary per region: water-liquifies swallowed food

Cardia gastric glands (goblet) = mucus

Fundus and Body gastric glands =digestive enzymes and acid

Two Types of Cells:

A. Parietal cell secretions:

Intrinsic factor (Vit B12 uptake)

H+ and Cl- ions - combine to make HCl in stomach

B. Chief cell secretions:

Pepsinogen -converted to pepsin by acid in stomach; hydrolyzes proteins

Renin -infants only; curdles milk protein to aid digestion

Acid production important to gastric function: (HCL)

Kill microbes

Denature proteins (digestion, destroy enzymes in food)

Break down plant cell walls and animal connective tissue

Activate pepsin

Pyloric gastric glands = mucus and hormones

Two important hormone producing cells:

G cells: Produce gastrin

Stimulates secretion by parietal and chief cells

Promotes contraction of gastric wall

Secreted in response to food or parasympathetic stimulation

D cells: Produce somatostatin

Inhibits release of gastrin (thus inhibits gastric activity)

Secreted in response to sympathetic stimulation

Regulation of Gastric Activity

Secretion and motility controlled by 3 factors:

1. Innervation from CNS (ANS)
2. Reflexes of the ENS
3. Hormones

Mechanisms rely on stimuli from three regions: head, stomach and small intestine

Three Phases of regulation: all may act simultaneously to alter gastric activity

Secretion of Gastric Juice Phases

1. Cephalic Phase:

Prepares stomach for food

Triggered by seeing, smelling, or thinking of food

Lasts a few minutes

Neural response: parasympathetic triggers increase in all gastric secretions (mucus, enzymes, acid) and triggers G cells to release Gastrin (causes secretion and motility)

2. Gastric Phase

Initiates stomach digestive activities

Triggered by food entering stomach (stimuli = distension, peptides, low acidity)

Lasts 3-4 hours (Three Responses:)

Neural Response: stretch receptors activate ENS reflexes and parasympathetic ANS innervation, both stimulate secretions from parietal cells (acid), Chief cells (pepsin) and G cells (Gastrin)

Hormonal Response: triggered by neural response, peptides and increased pH, G cells release Gastrin which trigger secretion by parietal and chief cells and also gastric mobility

Local Response: triggered by distortion, Mast cells release histamine which stimulates parietal cells

Gastrin secretion is inhibited by a pH less than 1.5

3. Intestinal phase

Controls chyme entry into duodenum. Triggered by chyme entering duodenum.

Last many hours . Involves excitatory and inhibitory control of gastric activity depending on chyme composition.

Neural Response: stretch receptors trigger Enterogastric Reflex which turns off ENS and parasympathetic stimulation of G cells and stimulates sympathetic stimulation of pyloric sphincter (contracts)

Hormonal Responses: (different hormones depending on chyme composition:

Stomach

Much digestion occurs in stomach but not much absorption (except alcohol and drugs)

Food does not usually remain in stomach for more than 4 hrs but total time depends on chemical makeup of food (how long it will take to digest in small intestine:

Carbohydrate rich: pass quickly

Fatty foods can cause chyme to remain in stomach 6+ hrs

Small Intestine

Extends from pyloric sphincter ⟶ ileocecal valve

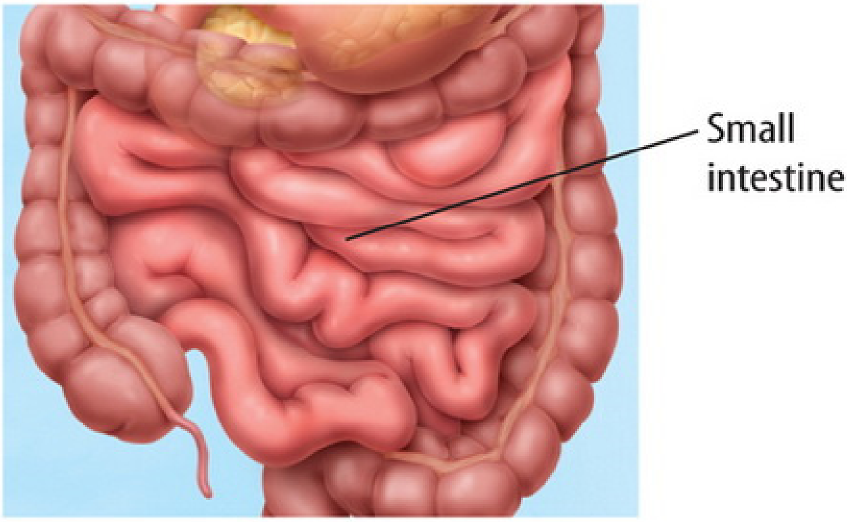
Regions

- Duodenum
- Jejenum
- Ileum

Movements

Segmentation

Peristalsis



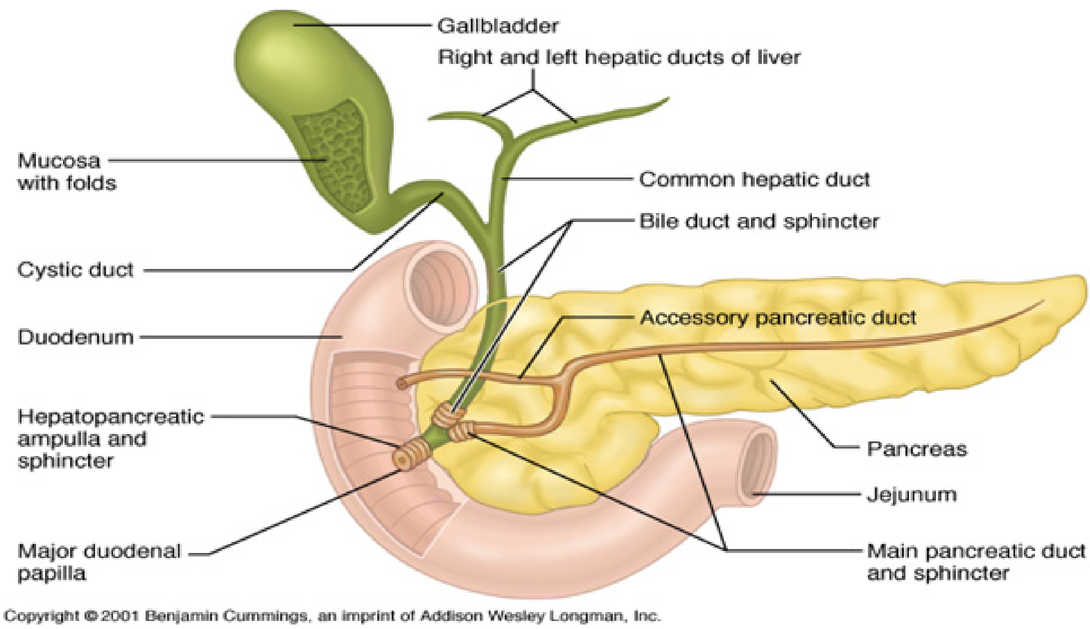
The duodenum is the shortest of the 3 divisions – about 25cm. It's mostly retroperitoneal and curves almost 180° around the head of the pancreas.

It receives the common bile duct and the main pancreatic duct. These 2 ducts unite in the duodenal wall to form the hepatopancreatic ampulla.

The ampulla opens into the duodenum via the major duodenal papilla.

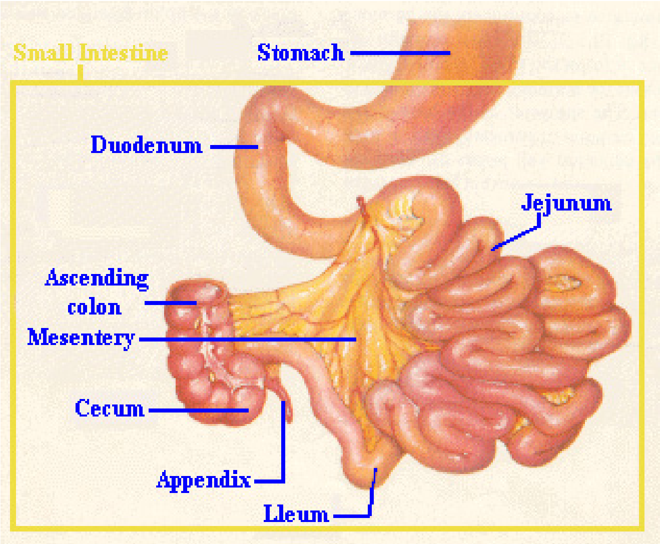
The hepatopancreatic sphincter (of oddi) controls entry of bile and pancreatic juice into the intestinal lumen.

The Duodenum and Related Organs



The *jejunum* is intraperitoneal and 2m long. It extends from duodenum to ileum and is suspended by mesentery. It's the primary site of digestion and absorption.

The *ileum* is intraperitoneal and 3m long. It's also suspended by mesentery and joins the colon at the ileocecal valve. It's primarily involved in absorption of electrolytes and vitamins.



Small intestine: Histology

Same 4 layers, but adapted for absorption:

Mucosa

Plicae: are deep, circular, permanent folds of the mucosa and submucosa. They increase surface area and slow the movement of chyme. This provides more time for absorption and digestion to occur.

Villi: plicae covered with finger-like projections of mucosa called intestinal villi.

Absorptive epithelial cells (enterocytes) line their surface. Within the core of each villus is the lamina propria, which contains blood capillaries (for absorption of amino acids and monosaccharides) and a lacteal (for absorption of fatty acids).

Microvilli: simple columnar epithelial cells (enterocytes) have microvilli on apical surfaces: membrane collectively called brush border of intestine.

The epithelium is a simple columnar with goblet cells (secretes mucus).

Epithelial invaginations known as intestinal glands (crypts of Lieberkuhn) secrete over 2 L/day of intestinal juice, which consists primarily of mucus, electrolytes, and water.

The intestinal glands also contain enteroendocrine cells (which secrete hormones like intestinal gastrin, secretin, and cholecystokinin into the plasma)

New cells created, migrate up villus, shed at tip, complete turnover 3-6 days.

Shed cells carry digestive enzymes in plasma membrane that function in lumen:

Brush border enzymes: complete digestion of carbohydrates and proteins.

Specializations/Adaptations in small intestine:

Duodenum has duodenal glands in submucosa: produce mucus to protect against acidic chyme from stomach.

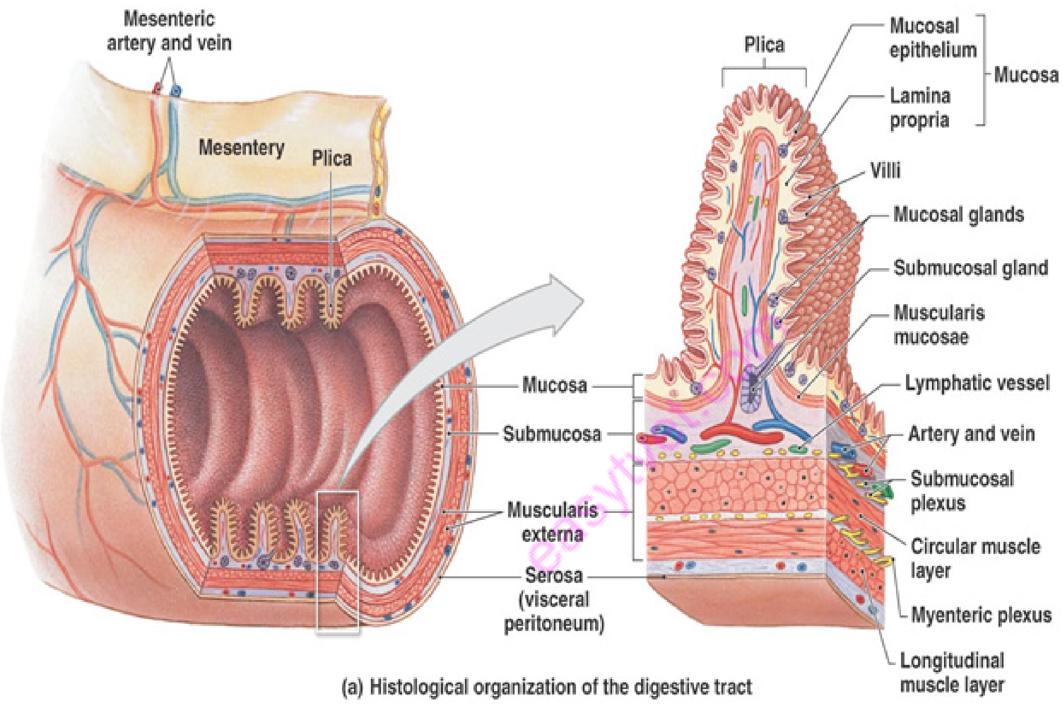
It contain the crypt of lieburkuhn which contain intestinal glands which secrete intestinal juice which help in digestion.

It has plicae which increase the surface area and slow down the movement of food in the small intestine

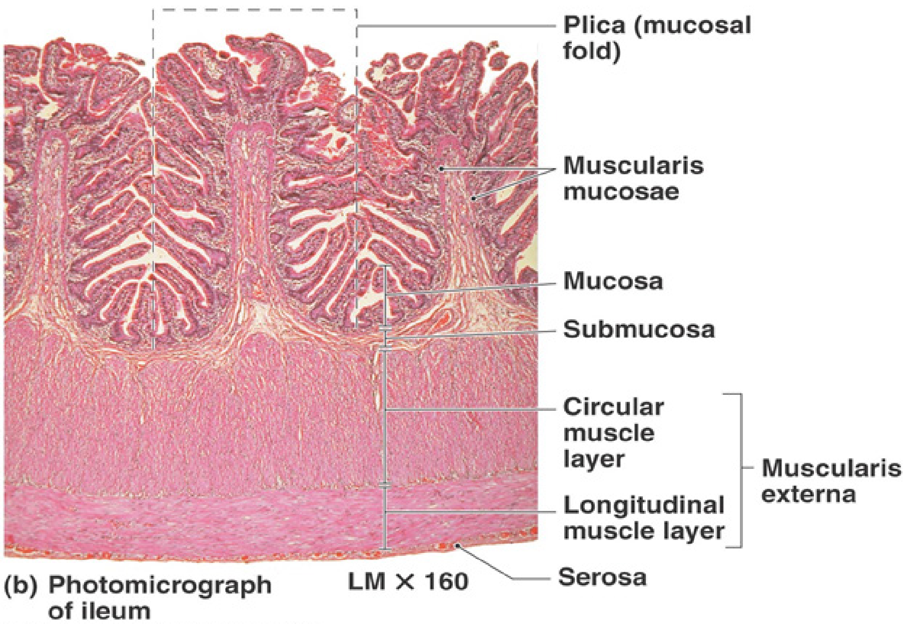
Ileum has aggregated lymphoid nodules called Peyer's Patches for immune defense

It is very long to give enough time for digestion and absorption of food.

It has villi and microvilli which increases the surface area for absorption.



(a) Histological organization of the digestive tract



(b) Photomicrograph of ileum

Histology Cont.

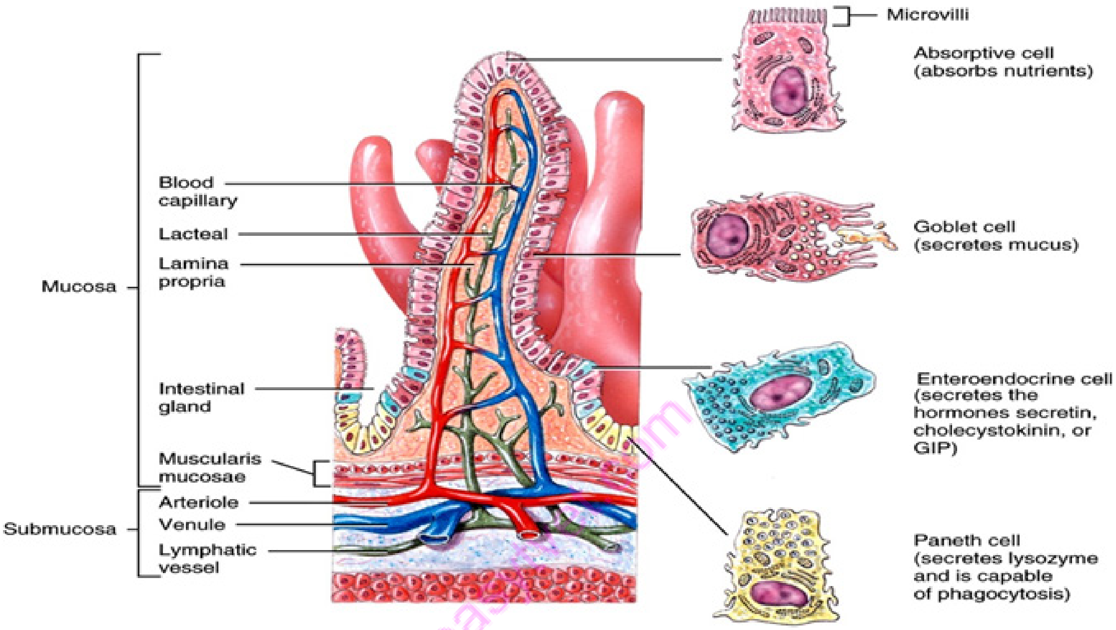
Paneth cells (which secrete antimicrobial chemicals like lysozyme),

Intraepithelial lymphocytes (which kill antigens without any need to ask permission).

The submucosa is the same except in the proximal duodenum and terminal ileum.

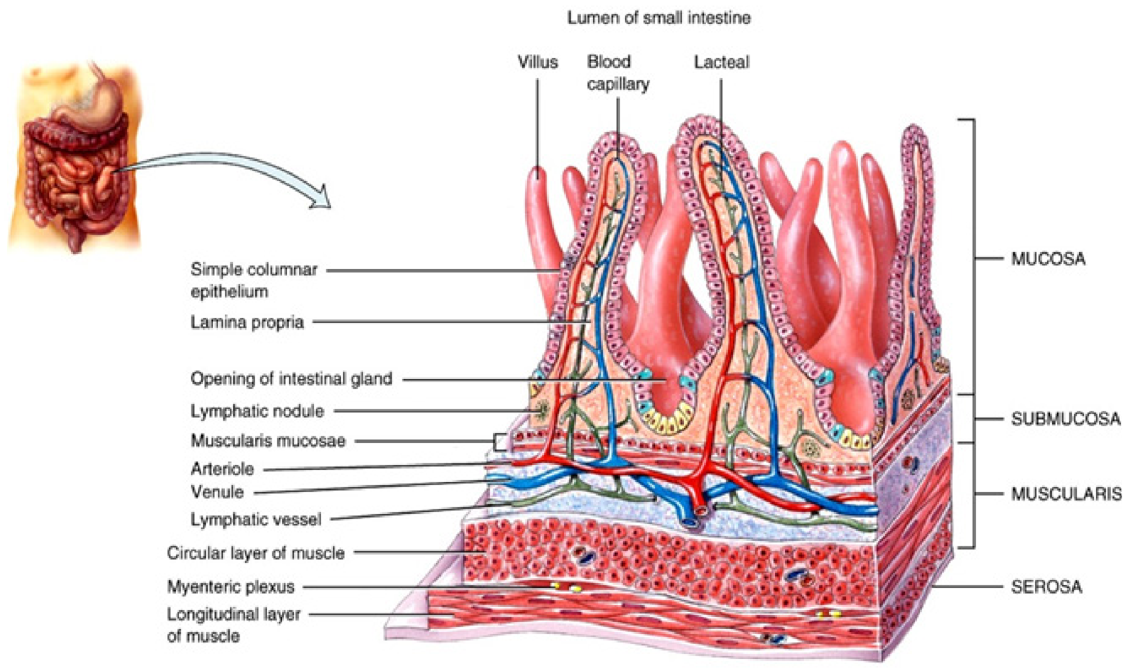
The proximal duodenal submucosa contains alkaline mucus glands that help counteract the acidic chyme.

The terminal ileal submucosa contains Peyer's patches (aggregated lymphatic follicles) which neutralises antigens or foreign bodies.



(b) Enlarged villus showing lacteal, capillaries, intestinal glands, and cell types

Figure 24.18b Tortora - PAP 12/e



(a) Three-dimensional view of layers of the small intestine showing villi

Figure 24.18a Tortora - PAP 12/e

Blood supply: superior mesenteric artery; venous drainage; superior mesenteric vein, joins the portal vein

Functions of Small intestines

- Onward movements of its contents by peristalsis
- Secretion of intestinal juice
- Completion of chemical digestion of carbohydrates, fats & proteins
- Protection against infection
- Secretion of hormone cholecytokinin and secretin
- Absorption of nutrients
- Chemical Digestion in the Small Intestine
- Chyme in the small intestine mixes with pancreatic juice, intestinal juice and bile juice to complete digestion.
- Carbohydrates to monosaccharide like glucose by amylase
- Proteins to amino acids by peptidase
- Fats to fatty acids and glycerol by lipase

Pancreatic Juice

~ 1.5 L /day in response to parasympathetic and hormonal control. pH of 8

Water + proenzymes (trypsinogen, chymotrypsinogen, procarboxypeptidase) + electrolytes (buffer)+ enzymes (amylase and lipase)

Hormonal Control from Duodenum:

Secretin: released in response to acid chyme, triggers pancreas to secrete bicarbonate and phosphate buffers

Cholecystokinin: released in response to lipids and peptides in chyme or parasympathetic stimulation, triggers pancreatic enzyme secretion and release of bile from the gall bladder.

Pancreatic Enzymes

~70% secreted as proenzymes, activated in gut

Pancreatic alpha-amylase: hydrolyzes starch

Pancreatic lipase: hydrolyzes lipids and fatty acids

Proteolytic enzymes (majority): many, each digests specific peptide bond

2 main Classes:

A. proteases: hydrolyze large proteins into peptides

B. peptidases: hydrolyze peptide chains into amino acids

All proteolytic enzymes are secreted inactive, must be activated in gut (prevent autolysis)

Enterokinase, a brush border enzyme, activates pancreatic trypsinogen to trypsin

Trypsin activates all other pancreatic proteolytic pro-enzymes via cleavage

Bile

Bile flow: bile secreted by hepatocytes cells of the liver

It is stored in the gall bladder

pH 8

500-100ml secreted daily

Composition: water, mineral salts, mucus, bile salts, bile pigments (bilirubin), cholesterol

Functions:

Emulsify fats

- Increases solubility of cholesterol and fatty acid and enhance absorption of fat soluble vitamins A,D, E & K.
- Allows excretion of bilirubin, as urobilinogen in urine and stercobilinogen which colors and deodorizes feces.

Large Intestine

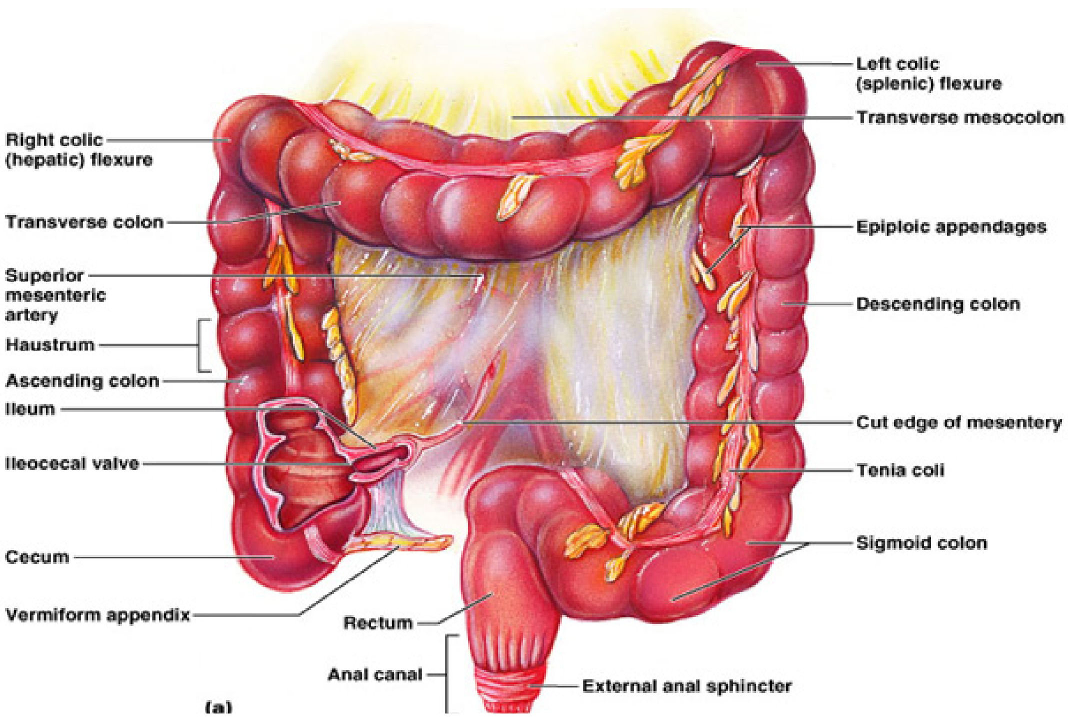
Subdivisions

Cecum | Appendix | Colon | Rectum

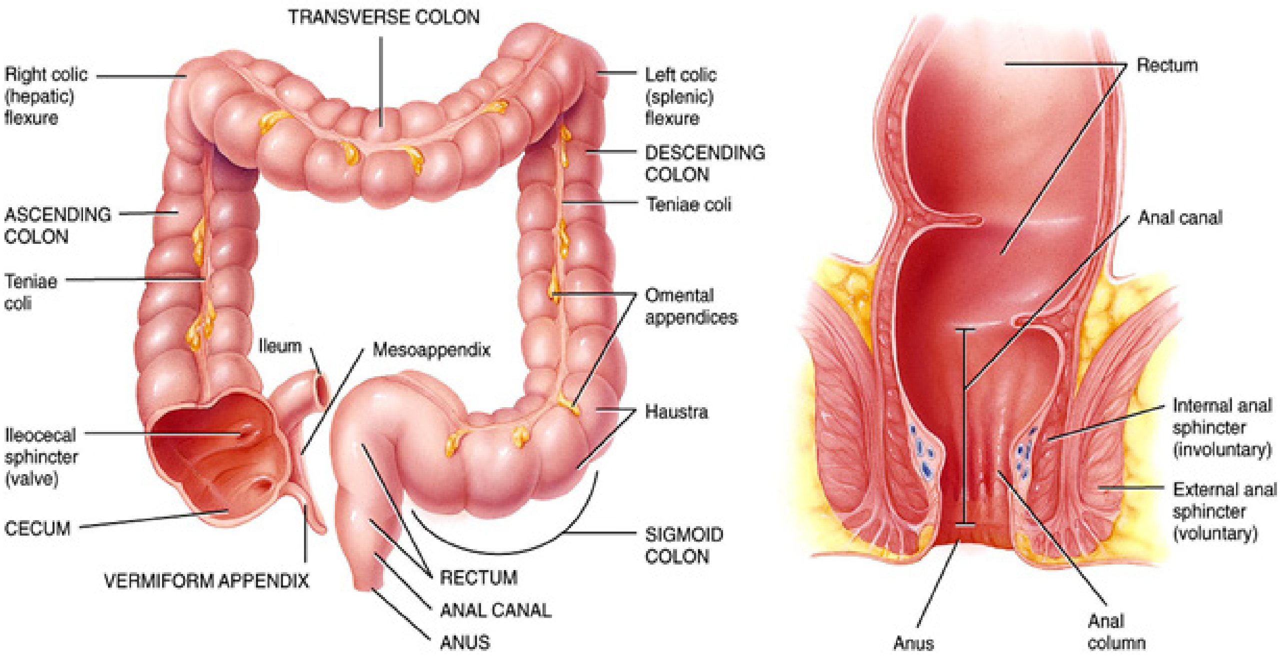
Anal canal

-Digested residue reaches it

-Main function: to absorb water and electrolytes



Anatomy of the large intestine



(a) Anterior view of large intestine showing major regions

(b) Frontal section of anal canal

Figure 24.22 Tortora - PAP 12/e

The large intestine functions primarily to propel indigestible food remains and then expel them as feces. As it does it also absorbs any excess water remaining.

It's about 1.5m in length. Its name arises from the size of its diameter; 6.5cm.

It begins at the ileocecal valve and terminates at the anus.

Functions

Absorption:

Reabsorb any remaining water.

Absorb vitamins and electrolytes & some drugs

No digestion, except by microbes

Water absorption important to feces consistency:

Too much water = diarrhea

Too little water = constipation

Pancreas

(exocrine and endocrine)

Lies in LUQ kind of behind stomach

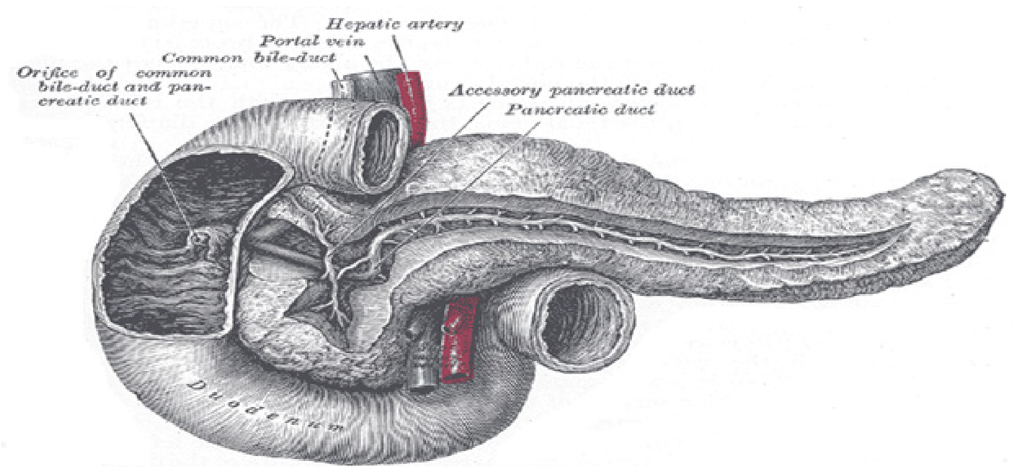
Is retroperitoneal, 60g, 12 to 15 cm long

Has a head, body and tail

Head is in C-shaped curve of duodenum

Body lies behind the stomach

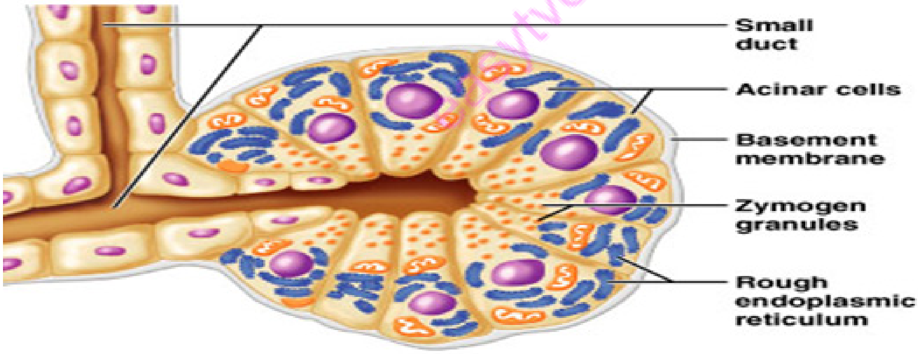
Tail extends left to touch spleen



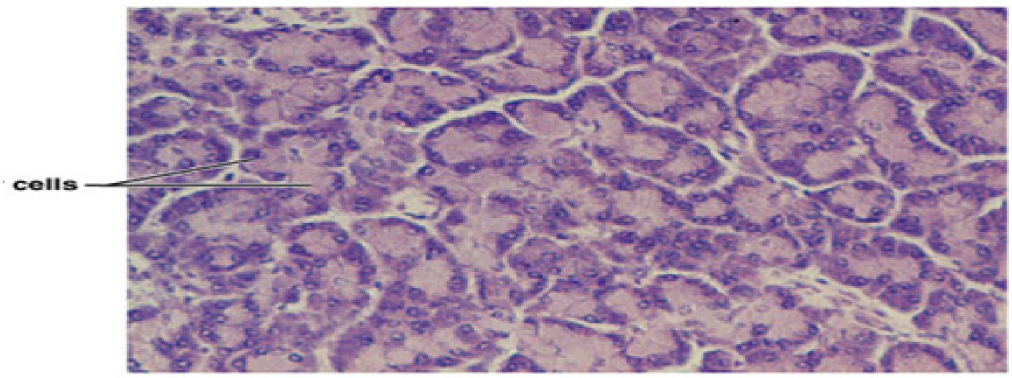
Pancreatic exocrine function

Consists of large lobules made of small alveoli with secretory cells that drains into tiny ducts which unite to form pancreatic duct.

Secretes pancreatic juice under PNS & SNS stimulation



(a)



(b)

Pancreas: Endocrine

Specialised cells; islets of langerhans

Ductless

Secretes insulin & glucagon for blood glucose control.

The Liver

– Largest gland in the body (about 1 and 2.3 kg), and has over 500 functions

– Inferior to diaphragm in RUQ and epigastric area protected by ribs

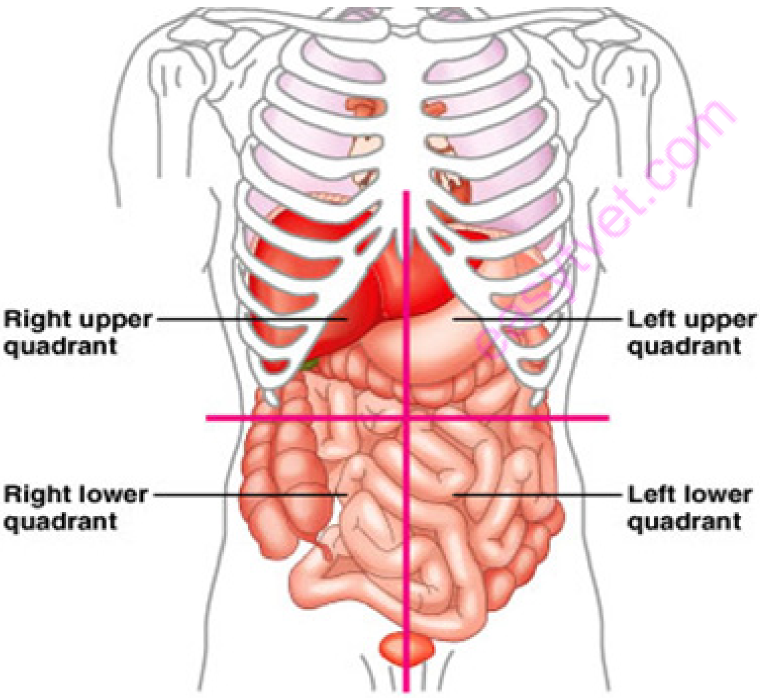
– R and L lobes

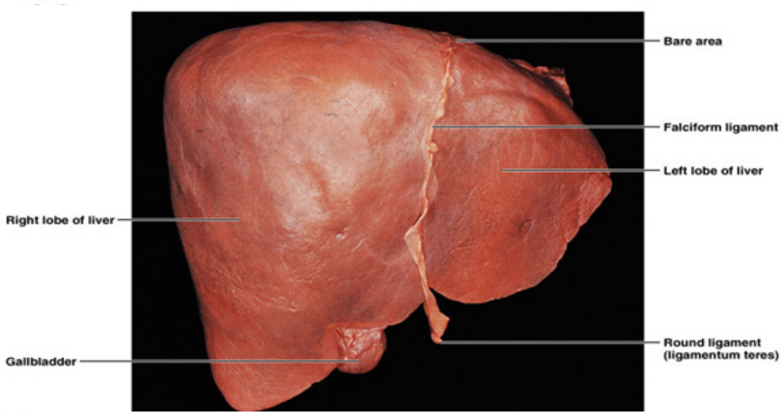
– Plus 2 smaller lobes

– Falciform ligament

– Mesentery binding liver to anterior abdominal wall

– Covered by peritoneum except “bare area” fused to diaphragm





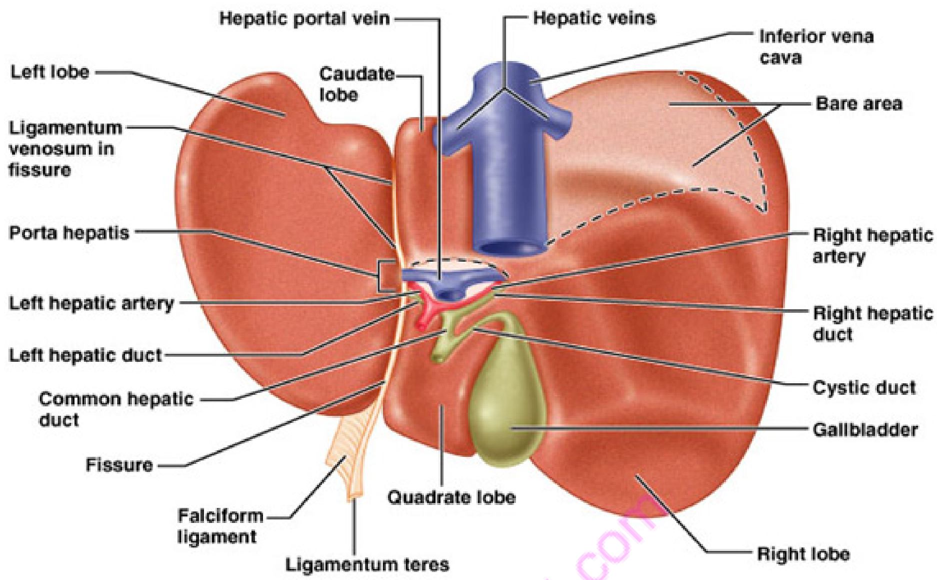
Relations:

Superiorly & anteiorly; diaphragm & ant.abdominal wall

Inferiorly: stomach, bile ducts, duedenum, right kidney, adrenal gland, hepatic flexure of colon

Posteriorly: oesophagus, inferior venacava, aorta, gall bladder, vertebral column, diaphragm

Laterally: lower ribs & diaphragm



Liver: Structure

A connective tissue capsule and visceral peritoneum almost completely surround the liver.

The capsule sends septa within the liver to provide structural support.

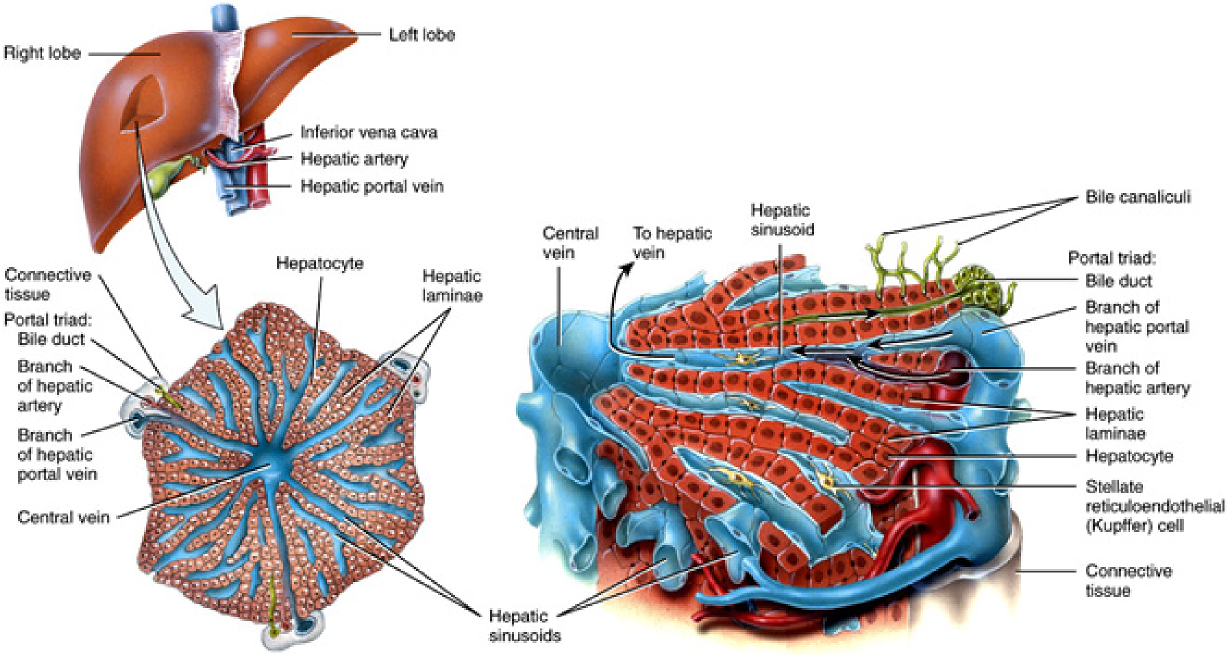
The septa divide the liver interior into hexagonal shaped liver lobules.

The center of each lobule contains a central vein. Extending out from the central vein like spokes (column) are the hepatic cords, which are composed of hepatocytes.

At each of the 6 corners of a lobule is a portal triad – a branch of the hepatic artery (a portal arteriole), a branch of the hepatic portal vein (a portal venule), and a bile duct.

The portal venules and the portal arterioles are linked to the central vein by capillaries known as liver sinusoids, which run btwn the hepatic cords.

Histology of the Liver



(a) Overview of histological components of liver

(b) Details of histological components of liver

Portal Triad

1. Portal arteriole
2. Portal venule

   Branch of hepatic portal vein

   Delivers substances from intestines for processing by hepatocytes

3. Bile duct

   Carries bile away

Liver Sinusoids

Large capillaries between plates of hepatocytes

Contribute to central vein and ultimately to hepatic veins and inferior venecava

Kupffer Cells

Liver macrophages

Old blood cells and microorganisms removed

Hepatocytes (Liver Cells)

Many organelles

Rough ER – manufactures blood proteins

Smooth ER – help produce bile salts and detoxifies blood-borne poisons

Peroxisomes – detoxify other poisons, including alcohol

Golgi apparatus – packages

Mitochondria – a lot of energy needed for all this

Glycosomes - role in storing sugar and regulation of blood glucose (sugar) levels

Produce 500-1000 ml bile each day

Functions of the liver

Carbohydrate metabolism: glucose is converted to glycogen for storage and vice versa under influence of insulin and glucagon respectively.

Fat metabolism: stored fat is converted to produce energy

Protein metabolism: It is broken down to produce energy during starvation

Breakdown of erythrocytes and defense against microbes: (kuppfer cells)

Detoxification of drugs and noxious substances

Inactivation of hormones: insulin, glucagon, cortisol, aldosterone, thyroid and sex hormones.

Production of heat: has high metabolic rate

Secretion of bile: synthesize bile in hepatocytes

Storage: glycogen, fat soluble vitamins A,D,E, & K, iron, copper, vitamin B12

METABOLISM

Metabolism = sum of all chemical reactions in body

To provide energy by chemical oxidation of nutrients

Make new replacement of body substances

Two Types of Metabolic Reactions

1**. Catabolism:** breakdown of organics materials

Hydrolysis: breakdown of large molecules into monomers

Cellular Respiration: oxidation of monomers in mitochondria

40% of energy ! ATP

60% of energy ! Heat (which maintains the core body temp. for optimal body activity; 36.8 °c)

2. Anabolism: synthesis of new organic material from small ones, requires energy (ATP).

Cell maintenance and repair

Growth

Formation of secretions

Nutrient reserves

Metabolic Pathway

Involves a series of chemical reactions (metabolic pathways).

The steps are controlled and involves gradual transfer of energy from ATP.

Regulated by hormones

Occurs continually in cells to maintain energy balance

Energy

Energy is the capacity to change something; it is the ability to do work.

Is measured in units of work (joules) or units of heat: kilocalories (kcal)

A kcal: amount of heat required to raise 1 litre of water by 1^o c.

The body generates about 3million kcal per day.

1 kcal= 4184 joules

1gm of carbohydrates= 17 kj (4 kcal)

1gm of proteins= 17 kj(4 kcal)

1 gm of fat= 38 kj (9 kcal)

Energy balance: body weight remains constant when intake = use.

Energy intake exceeds requirements, weight increases; weight decreases when intake does not meet requirements.

Metabolic Rate

Is the rate at which energy is released from the fuel molecules inside the cell.

Can be estimated by measuring O2 uptake and CO2 excretion.

BMR—Basal metabolic rate: is the rate of metabolism of a person at rest at a warm environment and in post-absorptive state. (12hrs)

The energy released in this state is sufficient to meet the needs of vital organs such as the heart, lungs, nervous system & kidneys.

The main sources of energy for the body include; carbohydrates (55-75 %), proteins (10-15 %) and fats (15-3 %).

Central Metabolic Pathways

Involves a series of steps in which fuel molecules are broken down forming a series of intermediate molecules with energy release.

The end result is energy production, carbon dioxide and water.

Energy is stored as ATP, some lost as heat and CO2 excreted through the lungs.

The main fuel molecule is glucose but if not present then amino acids, fatty acids and glycerol and occasionally nucleic acid may be used.

The Three Main Central Metabolic Pathways Are:

Glycolysis

The citric acid cycle (kreb's Cycle)

Oxidative phosphorylation

Definition of Terms

NAD or NADH- Nicotinamide Adenine Dinucleotide

FAD or FADH- Flavin Adenine Dinucleotide

Both NAD and FAD are co-enzyme in cellular respiration

ADP- Adenosine Diphosphate

ATP- Adenosine Triphosphate

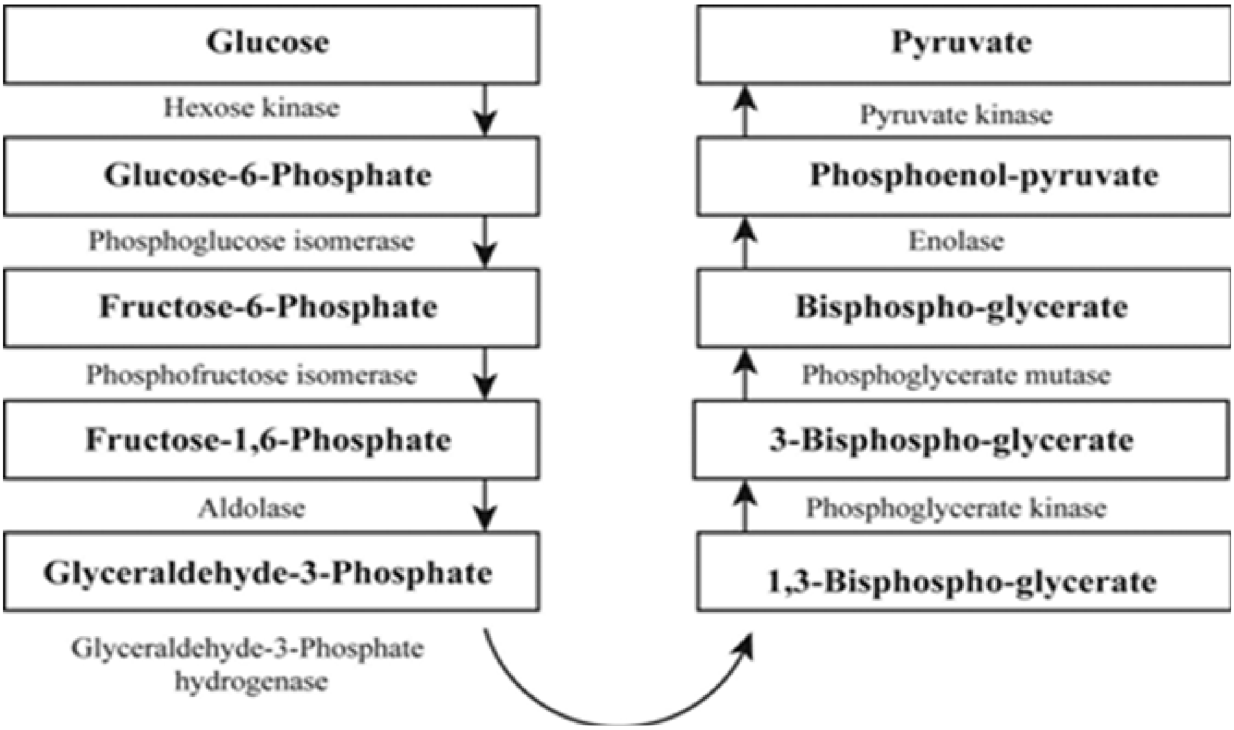
Glycolysis

Glycolysis is the metabolic pathway that converts glucose $C_6H_{12}O_6$, into pyruvate, $CH_3COCOO^- + H^+$.

The free energy released in this process is used to form the high-energy molecules ATP and NADH.

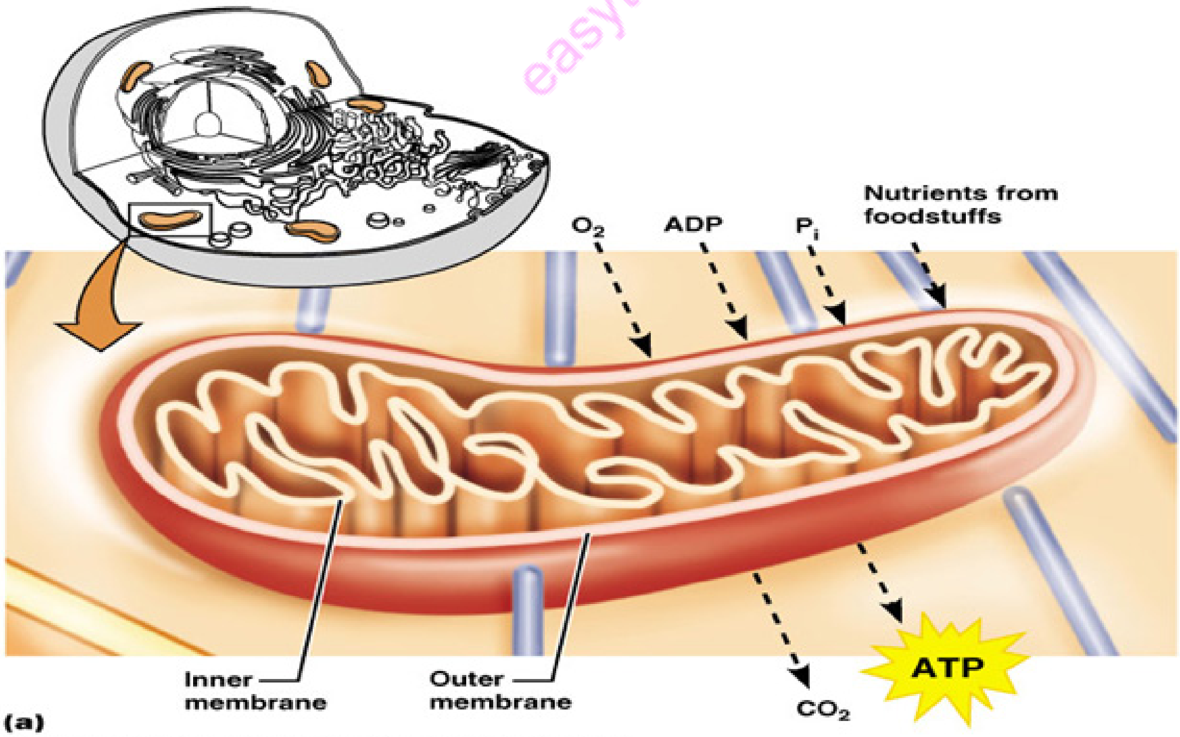
Glycolysis is a sequence of ten enzyme-catalyzed reactions.

Glycolysis

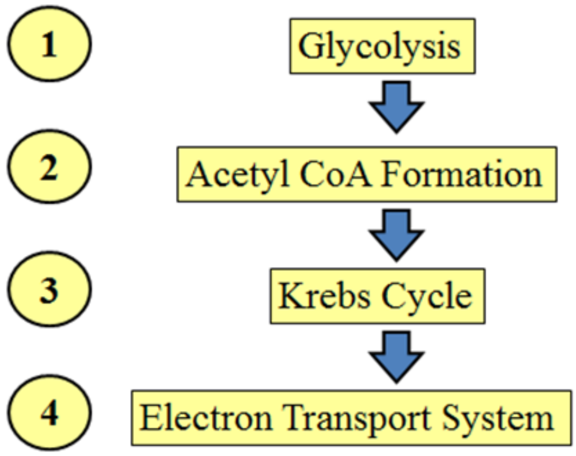


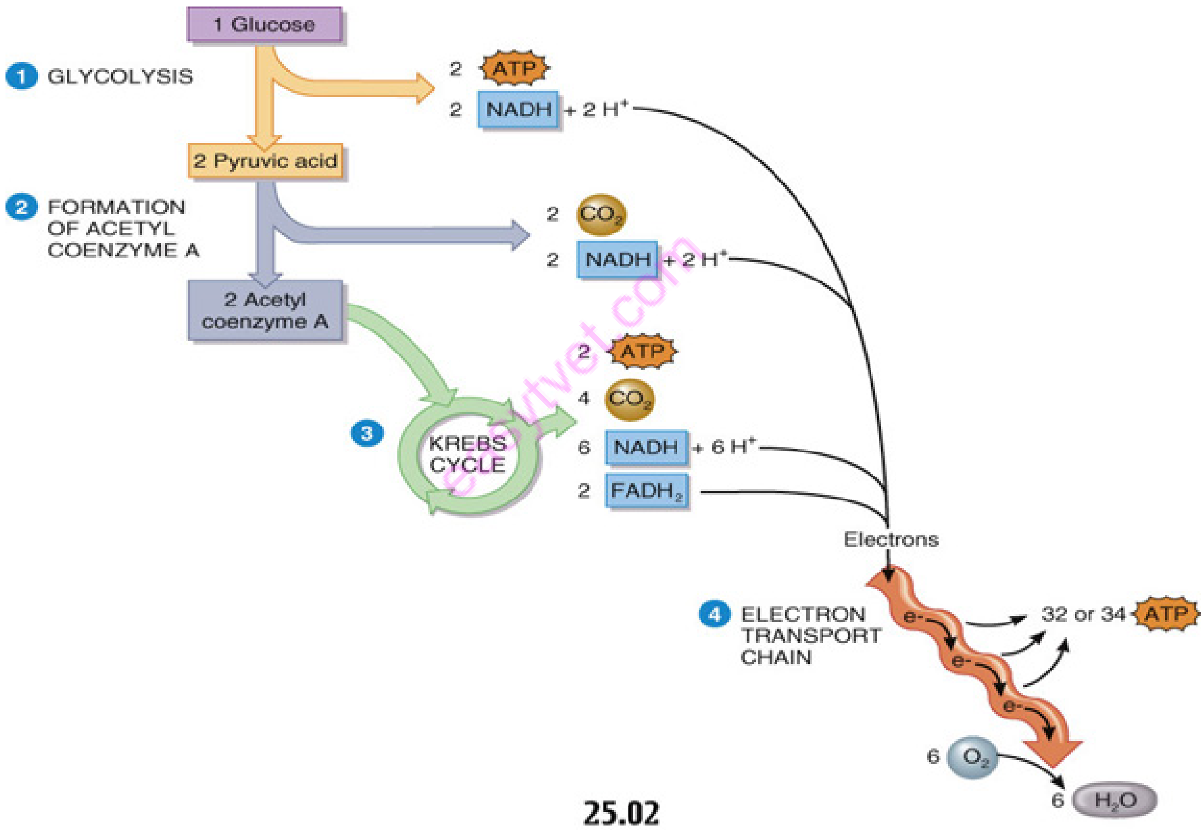
Cellular Respiration

$C6H12O6 + 6O_2 + 36ADP + 36Pi \longrightarrow 6CO_2 + 6H_2O + 36ATP$



Basic Steps Involved





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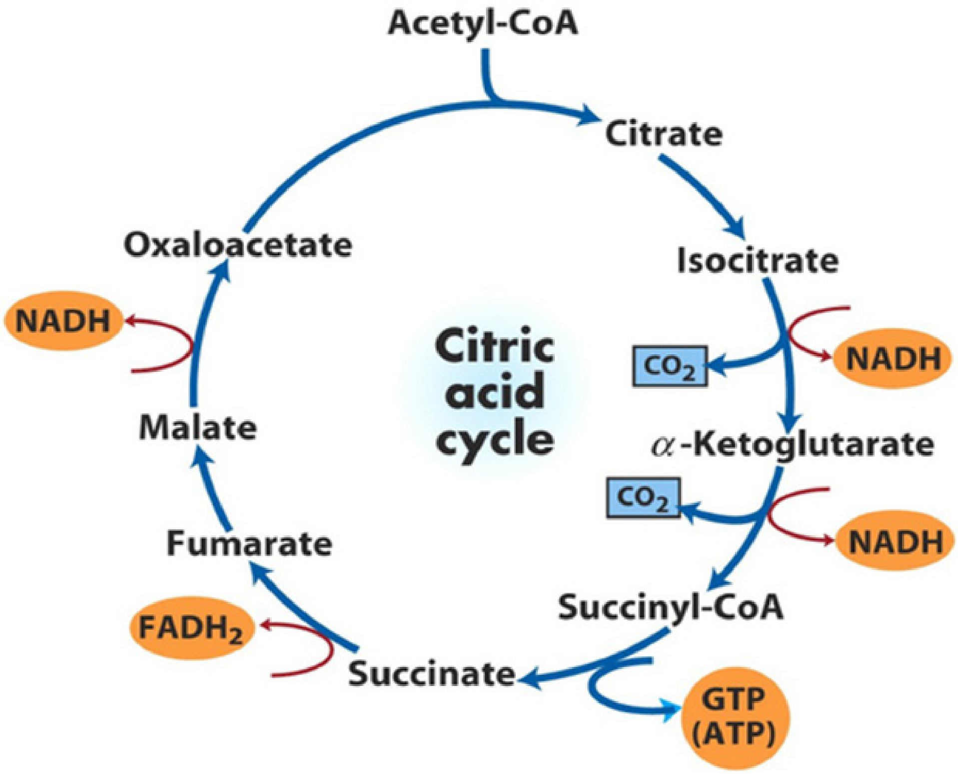
Overview of Glycolysis

Krebs Cycle

The citric acid cycle (CAC) – also known as the (TCA) cycle or the Krebs cycle – is a series of chemical reactions used by all aerobic organisms to release stored energy through the oxidation of acetyl-CoA derived from carbohydrates, fats, and proteins into adenosine triphosphate (ATP) and carbon dioxide.

Krebs Cycle



3. Oxidative Phosphorylation

Oxidative phosphorylation is the process in which ATP is formed as a result of the transfer of electrons from NADH or FADH 2 to O 2 by a series of electron carriers.

This process, which takes place in mitochondria, is the major source of ATP in aerobic organisms

Carbohydrate Metabolism

Required by all the body cells for metabolic processes

Formation of glucose from other non- carbohydrate sources such as amino acids or fatty acids is called gluconeogenesis.

Protein and Fat metabolism

In absence of carbohydrates they are metabolized to produce energy inform of ATP.

ENDOCRINE SYSTEM

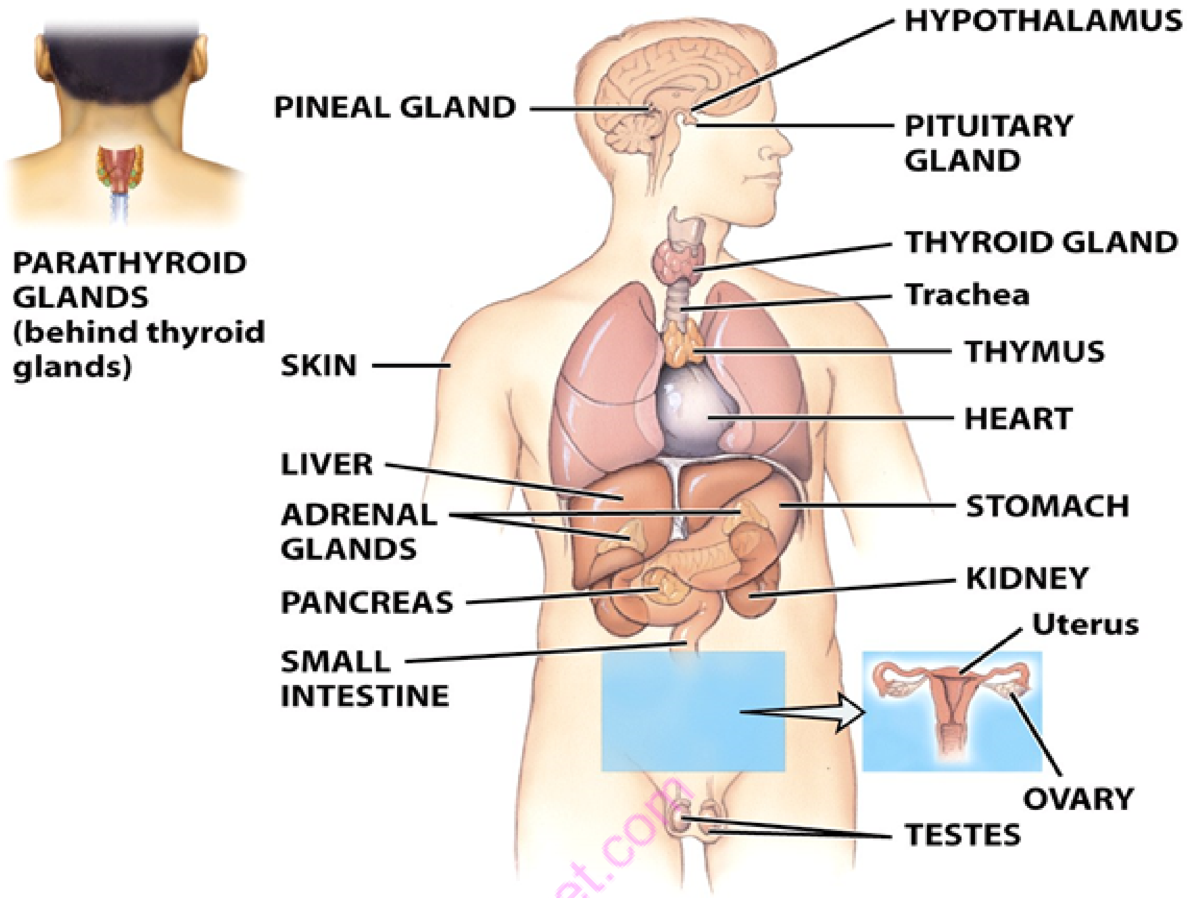


Figure 17-1 Anatomy and Physiology: From Science to Life
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Definition, Secretion and Function

The endocrine system refers to the hormone system of the body. Consists of widely separated glands with no physical connections

Hormones are chemicals produced by living cells in very small amounts. They are transported around the body in the blood.

Hormones regulate and co-ordinate different organs in the body.

Pheromones: organism to organism communication

Hormones: cell to cell communication molecules

Made in gland(s) or cells

Distant or local target tissue receptors

Activates physiological response

Endocrine Organs

Thyroid gland	Parathyroid gland
Adrenal medulla	Pituitary gland
Pancreas	Testes & ovaries
Pineal gland	

MAJOR ENDOCRINE GLANDS		
Gland	**Hormone(s)**	**Target Tissues**
Pituitary gland	Thyroid-stimulating hormone (TSH)	Thyroid gland
	Adrenocorticotropic hormone (ACTH)	Adrenal gland
	Follicle-stimulating hormone (FSH)	Gonads
	Luteinizing hormone (LH)	Gonads
	Antidiuretic hormone (ADH)	Kidneys
	Prolactin	Mammary glands
	Oxytocin	Mammary glands, Uterus
	Growth hormone (GH)	Bone, cartilage, muscle
Hypothalamus	Releasing hormones	Pituitary gland
Thyroid gland	Thyroxine	Most cells
Parathyroid gland	Parathyroid hormone (PTH)	Bone
Adrenal glands	Adrenalin (epinephrine)	Most cells
	Cortisol	Most cells
Pancreas	Insulin	Muscle, fat, liver
Testis	Testosterone	Reproductive tract, bone, muscle
Ovaries	Estrogen	Reproductive tract, mammary glands, bone
	Progesterone	Reproductive tract, mammary glands

Types of Hormones

Functional Types of Hormones

Endocrine Hormones – Travel through the blood to act at a site distant from the secreting cell or gland

Paracrine Hormones – Act on cells near the secreting cell

Autocrine Hormones – Act on the secreting cell

Neurocrine Hormones – Secreted by neural cells

Neurotransmitters

Neurohormones

Chemical Types of Hormones

Protein & Polypeptide

Amine (amino acid derived)

Steroid

Pituitary Gland & Hypothalamus

They act as a unit.

Controls the activities of other endocrine glands.

The pituitary is located in the sella-turcica of the skull below the hypothalamus, attached by a stalk.

Pea size, 500mg., and contains two lobes; adenohypophysis (the anterior lobe and glandular portion) and the neurohypophysis (the posterior lobe and nervous portion).

Contains an intermediate lobe in between.

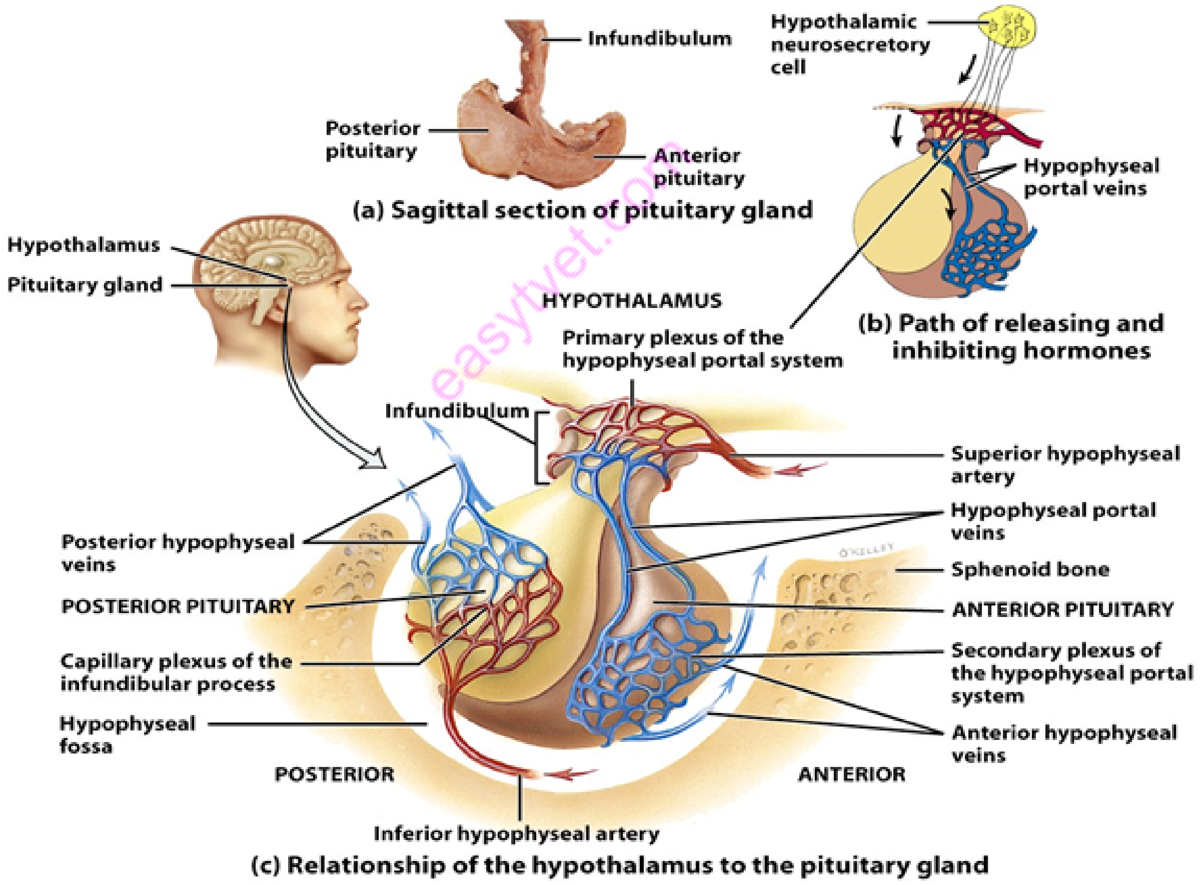
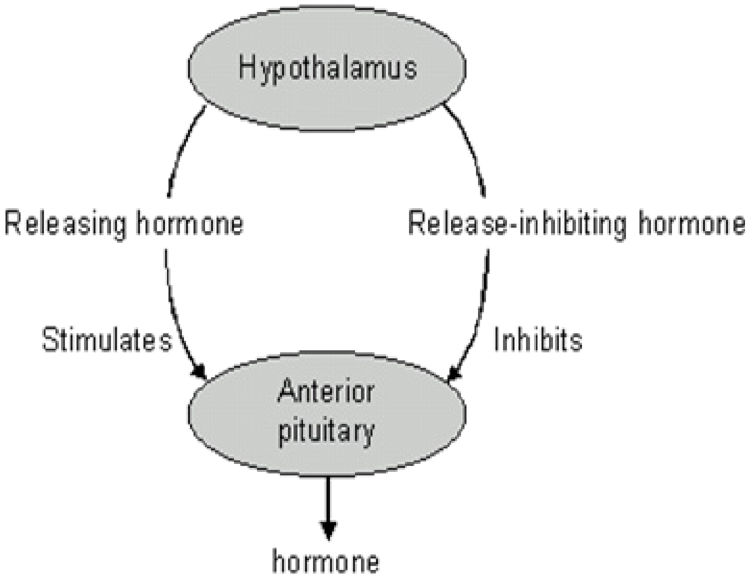


Figure 17-4 Anatomy and Physiology: From Science to Life

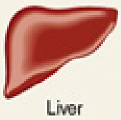
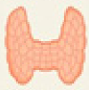
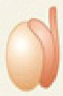
Anterior Pituitary

The hypothalamus produces hormones that travel in blood vessels to the anterior pituitary, stimulating it to produce other hormones.

The hormones produced by the hypothalamus are called hypothalamic-releasing & inhibiting hormones.



Summary of principal actions of the anterior pituitary hormones

Hormone and Target Tissues	Principal Actions
Human growth hormone (hGH)  Liver	Stimulates liver, muscle, cartilage, bone, and other tissues to secrete insulinlike growth factors (IGFs); IGFs promote growth of body cells, protein synthesis, tissue repair, lipolysis, and elevation of blood glucose concentration.
Thyroid-stimulating hormone (TSH)  Thyroid gland	Stimulates secretion of thyroid hormones by thyroid gland.
Follicle-stimulating hormone (FSH)  Ovaries  Testes	In females, initiates development of oocytes and induces ovarian secretion of estrogens. In males, stimulates testes to produce sperm.
Luteinizing hormone (LH)  Ovaries  Testes	In females, stimulates secretion of estrogens and progesterone, ovulation, and formation of corpus luteum. In males, stimulates interstitial cells in testes to secrete testosterone.

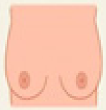
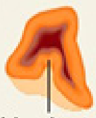
Hormone and Target Tissues	Principal Actions
Prolactin (PRL)  Mammary glands	Together with other hormones, promotes milk secretion by the mammary glands.
Adrenocorticotropic hormone (ACTH) or Corticotropin  Adrenal cortex	Stimulates secretion of glucocorticoids (mainly cortisol) by adrenal cortex.
Melanocyte-stimulating hormone (MSH)  Brain	Exact role in humans is unknown, but may influence brain activity; when present in excess, can cause darkening of skin.

Table 17-4 part 2 Anatomy and Physiology: From Science to Life

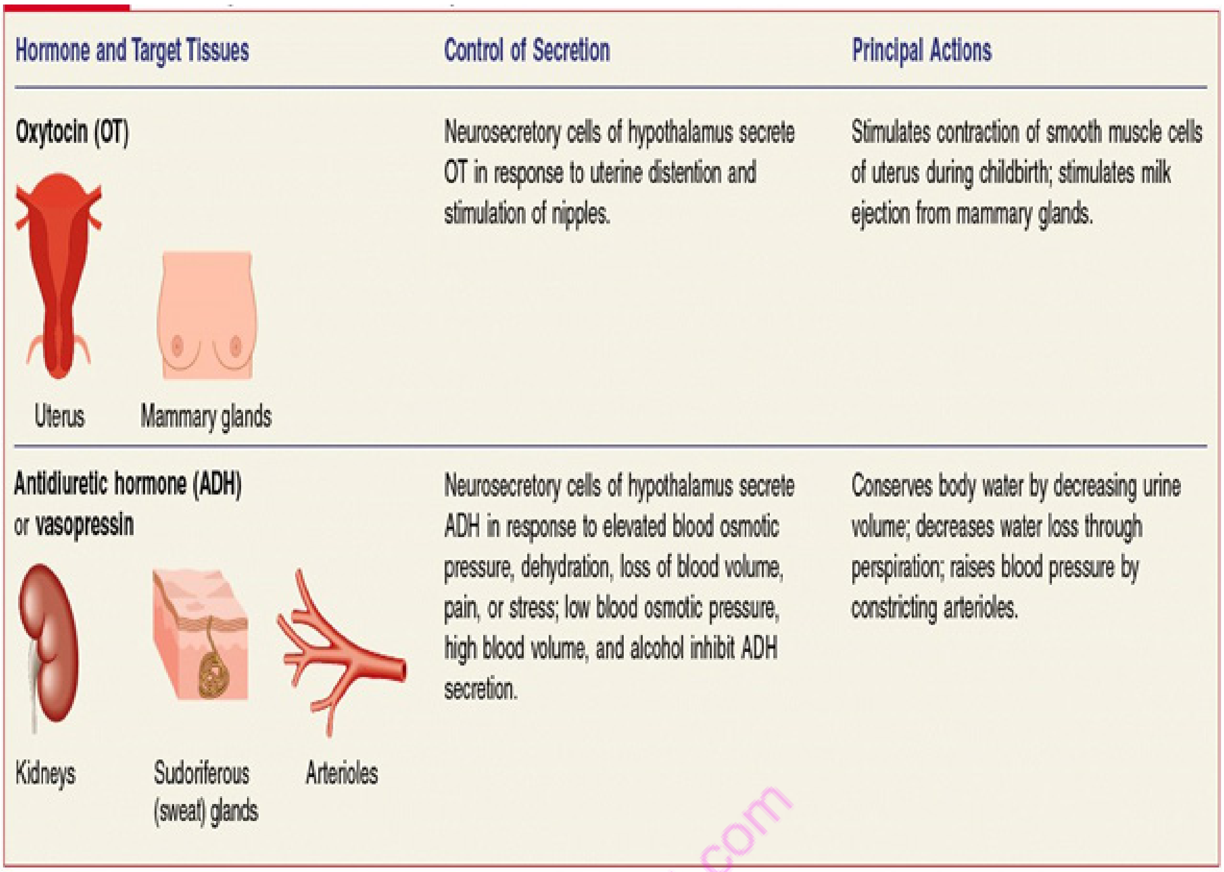
Posterior Pituitary

Also known as neurohypophysis. Stores and releases two hormones produced by hypothalamus

Anti-Diuretic Hormone (ADH)

Oxytocin.

__Summary of principal actions of the posterior pituitary hormones__



Hormone and Target Tissues	Control of Secretion	Principal Actions
Oxytocin (OT) Uterus Mammary glands	Neurosecretory cells of hypothalamus secrete OT in response to uterine distention and stimulation of nipples.	Stimulates contraction of smooth muscle cells of uterus during childbirth; stimulates milk ejection from mammary glands.
Antidiuretic hormone (ADH) or **vasopressin** Kidneys Sudoriferous (sweat) glands Arterioles	Neurosecretory cells of hypothalamus secrete ADH in response to elevated blood osmotic pressure, dehydration, loss of blood volume, pain, or stress; low blood osmotic pressure, high blood volume, and alcohol inhibit ADH secretion.	Conserves body water by decreasing urine volume; decreases water loss through perspiration; raises blood pressure by constricting arterioles.

Table 17-5 Anatomy and Physiology: From Science to Life

Thyroid Gland

Located in front of the larynx and trachea at C5,C6 & C7.

Butterfly shaped gland.

Follicular cells secretes colloid that will be used to produce

thyroxine (T_4)

triiodothyronine (T_3)

Thyroid Hormone's Effects

Metabolic rate: increased basal metabolic rate (BMR).

Calorogenic: increased heat production

Sympathomimetic: flight or fight

Cardiovascular: increases responsiveness of heart

Growth: essential for normal growth

Nervous system: development

Abnormalities of Thyroid Function

1. Hypothyroidism

Reduced bmr

Gain of weight

Slow, weak pulse

Constipation

Depression

Poor tolerance of cold

Fatigue, anorexia

Slow reflexes and mentation

Dry skin, brittle hair,

2. Goiter

Is a bulge in the neck caused by iodine deficiency

3. Hyperthyroidism

Increased BMR

Exophthalmos in Grave's dissease

Hair loss

Anxiety, physical restless, mental excitability

Warm sweaty skin, heat intolerance

Diarrhea

Tachycardia, atrial fibrillation, palpitations

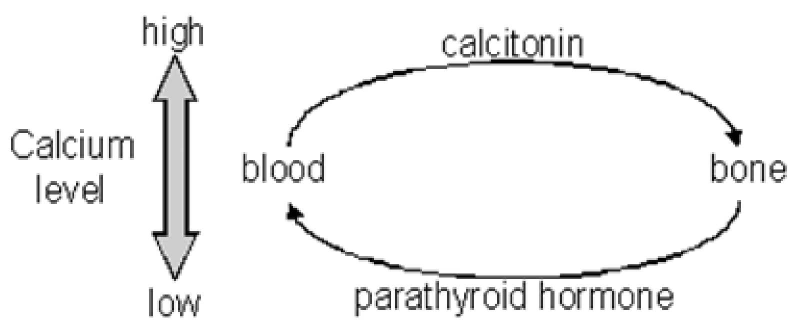
Weight loss, good appetite

Calcitonin

Secreted by parafollicular cells in the thyroid glands.

Lowers the blood calcium levels when raised

Promotes bone storage of calcium ions and inhibits calcium reabsorption by the kidneys



Parathyroid glands

Four small glands embedded on the posterior surface of the thyroid gland.

Calcium is needed for:

Muscle contraction

Nerve transmission

Blood clotting

Enzyme activity

Parathyroid Hormone (PTH)

Major regulator of calcium, magnesium, and phosphate ions in blood.

PTH increases blood levels of calcium when too low.

Increases calcium absorption in the small intestine, reabsorption of calcium in the kidneys and bone resorption (break down) to increase calcium levels in the blood.

Adrenal Glands

The adrenal glands are located superior to the kidneys.

They consist of an outer cortex and inner medulla.

Adrenal Cortex

Divided into three zones

Each secretes its own hormone from cholesterol.

- Mineralocorticoids
- Glucocorticoids
- Androgens

Glucocorticoid

Produced in response to stress.

Cortisone, hydrocortisone, corticosterone; cortisol

Stimulated by adrenocorticotropic hormone (ACTH)

Glucocorticoid Functions

Protein breakdown

Glucose formation-gluconeogenesis

Triglyceride breakdown-lipolysis

Weak mineralocorticoid activity

Resistance to stress

Anti-inflammatory effects

Depression of immune responses

Delayed wound healing

Mineralocorticoids (Aldosterone)

Maintains water and electrolyte balance.

Stimulates reabsorption of sodium ions in the kidneys and excretion of potassium ions in urine.

Sodium reabsorption is accompanied by water retention therefore aldosterone is used in regulation of blood pressure.

Stimulus for production is through high blood potassium levels and angiotensin.

Renin-angiotensin-aldosterone system

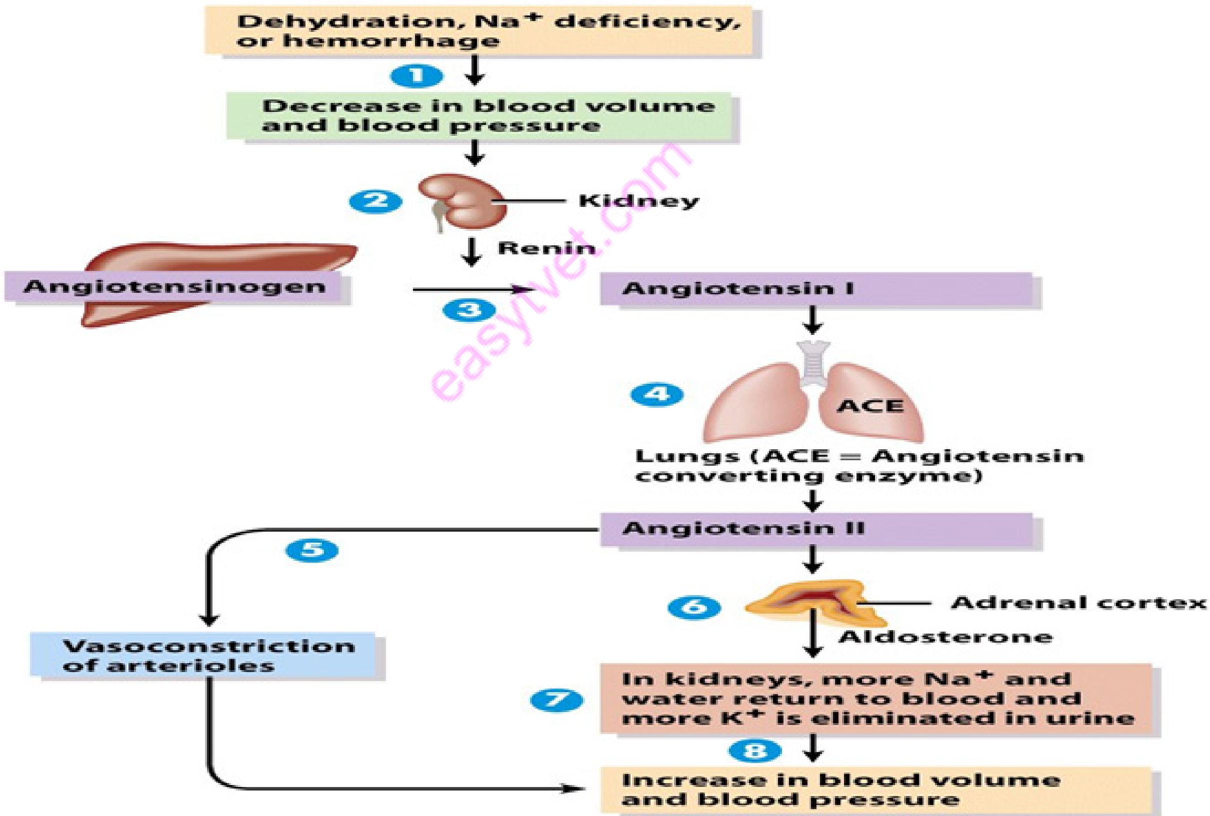


Figure 17-15 Anatomy and Physiology: From Science to Life
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Androgens (Sex Hormones)

Secreted in small amounts if compared with those secreted in the testes and the ovaries.

An example of androgen is testosterone in males responsible for the development of secondary sex characteristics in males like voice deepening and development of male sex organs.

In females androgens increases sex drive.

Adrenal Medulla

When stimulated it produces adrenaline and noradrenaline.

Adrenaline and Noradrenaline

Potentiates fight or flight response by:

Increasing heart rate

Increasing blood pressure

Diverting blood to essential organs: heart, brain, skeletal muscles

Increasing metabolic rate

Dilating pupils

Pancreas

The pancreas is posterior and slightly inferior to the stomach.

Histologically, it consists of islets of Langerhans (endocrine cells)-ductless; and acini (enzyme-producing cells).

Three types of cells in the endocrine portion are alpha cells, beta cells, and delta cells.

Alpha cells secrete glucagon, beta cells secrete insulin, and delta cells secrete growth hormone inhibiting factor (GHIF) or somatostatin.

RBS: 3.5 to 8 mmol/l (63 to 144 mg/100ml)

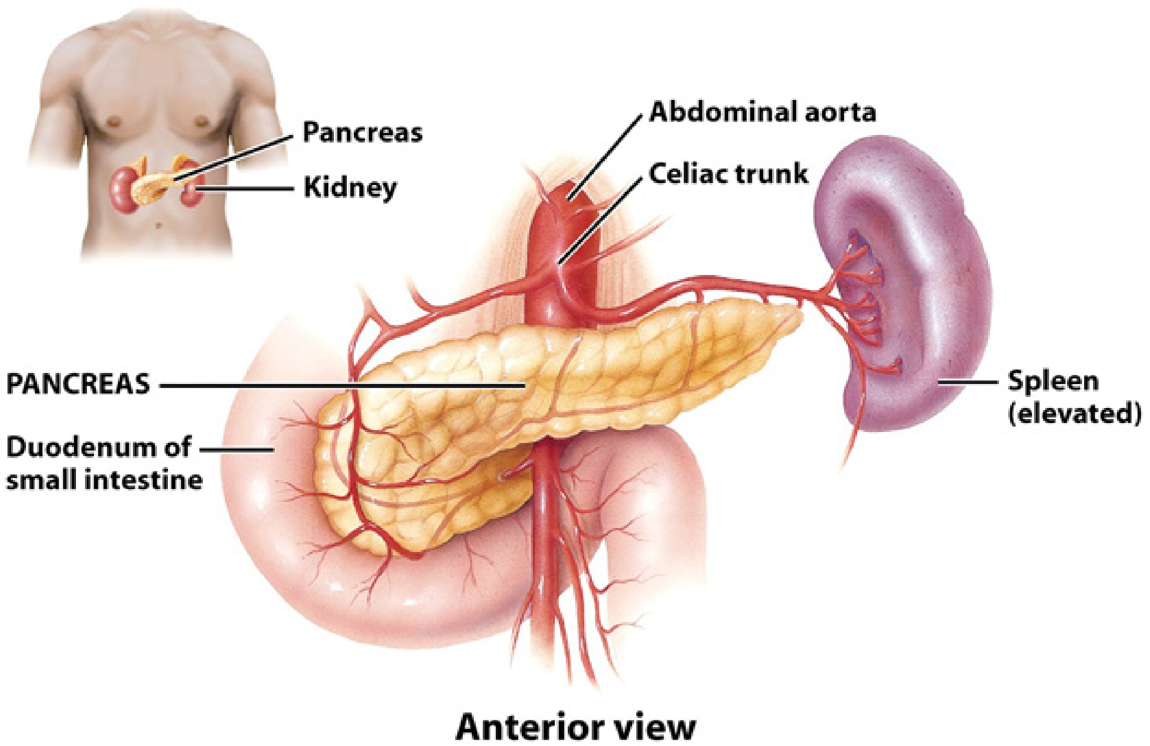

Figure 17-17a Anatomy and Physiology: From Science to Life
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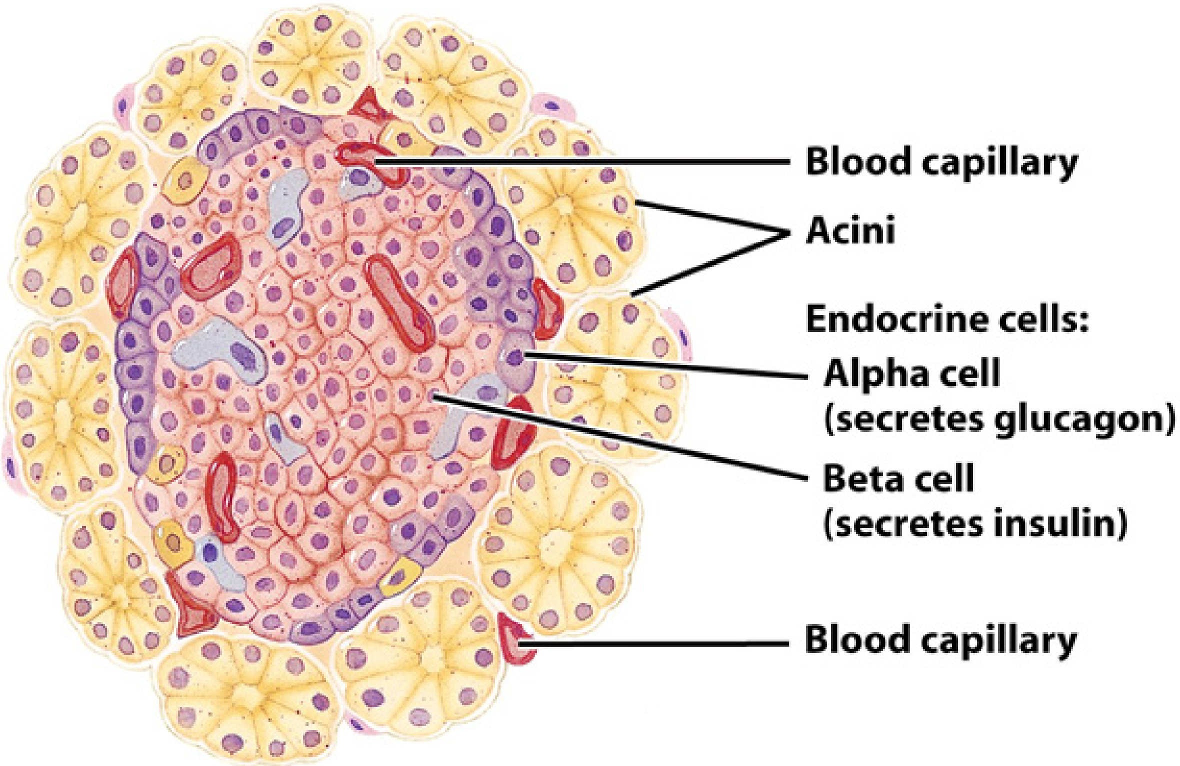


Pancreatic islet and surrounding acini

Figure 17-17b Anatomy and Physiology: From Science to Life

Insulin

Function:

It lowers raised blood sugar levels i.e. glucose

Promotes storage of nutrients.

Insulin: Action on Blood Sugar

Facilities glucose entry into cells: muscle and connective tissue

Stimulates glycogenesis

Inhibits glycogenolysis

Inhibits gluconeogenesis

Insulin: Action on Fat

Increases transport into adipose cells

Promotes triglyceride synthesis-lipogenesis

Inhibits lipolysis

Insulin: Action on Protein

Promotes uptake of amino acids by muscle and other tissue.

Promotes protein synthesis

Inhibits protein degradation

Glucagon

Increases blood glucose levels by:

Glycogenolysis

Gluconeogenesis

Summary of selected pancreatic islet hormones

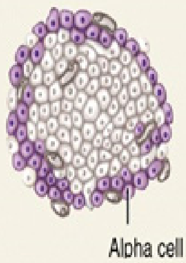
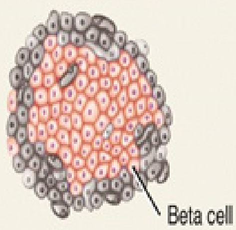
Hormone and Source	Control of Secretion	Principal Actions
Glucagon from alpha cells of pancreatic islets 	Decreased blood level of glucose, stimulation by sympathetic division of ANS during exercise, and mainly protein meals stimulate secretion. Insulin inhibits secretion.	Raises blood glucose level by accelerating breakdown of glycogen into glucose in liver, converting other nutrients into glucose in liver, and releasing glucose into the blood.
Insulin from beta cells of pancreatic islets 	Increased blood level of glucose, stimulation by parasympathetic division of ANS following high carbohydrate meals, hGH, and ACTH stimulate secretion.	Lowers blood glucose level by accelerating transport of glucose into cells, converting glucose into glycogen, and stimulating protein and fatty acid synthesis.

Table 17-9 Anatomy and Physiology: From Science to Life
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Pineal Gland

Located on the roof of the 3rd ventricle connected to it a short stalk containing nerves which terminate in the hypothalamus.

Atrophies after puberty

Hormone secreted is melatonin

Contributes to setting the body's biological clock

Promotes sleepiness in small doses

In animals with breeding seasons, melatonin inhibits reproductive functions outside the season.

Inhibits the growth and development of sex organs before puberty, by possibly preventing the synthesis or release of gonadotrophins.

Thymus Gland

Secretes thymosin hormone.

Used for development of T-lymphocytes for cell mediated immunity.

Local Hormones

Histamine: synthesised and stored by mast cells in the tissues and basophils of blood.

mediates inflammation, increases capillary permeability and causes vasodilation.

It also causes contraction of smooth muscle of bronchi and alimentary tract and stimulates secretion of gastric juice.

Gastrointestinal hormones: gastrin, cholecystokinin & secretin: influences the secretion of gastric juices.

Serotonin (5-hydroxyptamine, 5-HT)-present in the brain and intestinal wall. Causes intestinal secretion and contraction of smooth muscles.

Has a role in blood clotting.

Prostaglandins(PGs)

Lipid derivatives

Effects

Inflammatory response

Fever

Blood clotting

Others: leukotrienes – inflammatory response

Potentiates pain

Regulates blood pressure

Uterine contractions during labour

Thromboxane A2- platelet aggregation

THE GENERAL & SPECIAL SENSES

Types of Senses

1. General senses

   Touch (tactile)

   Temperature- thermoreceptors (heat)

Pressure- mechanoreceptors (movement)

Pain- mechanoreceptors

2. Special senses

Smell- chemoreceptors (chemicals)

Taste- chemoreceptors

Sight- photoreceptors (light)

Hearing- mechanoreceptors

Equilibrium- (balance) mechanoreceptors

Introduction

Senses – our perception of what is "out there"

Differences between General and Special Senses

General senses

Includes senses that are not specific

Receptors are not specialized or free nerve endings

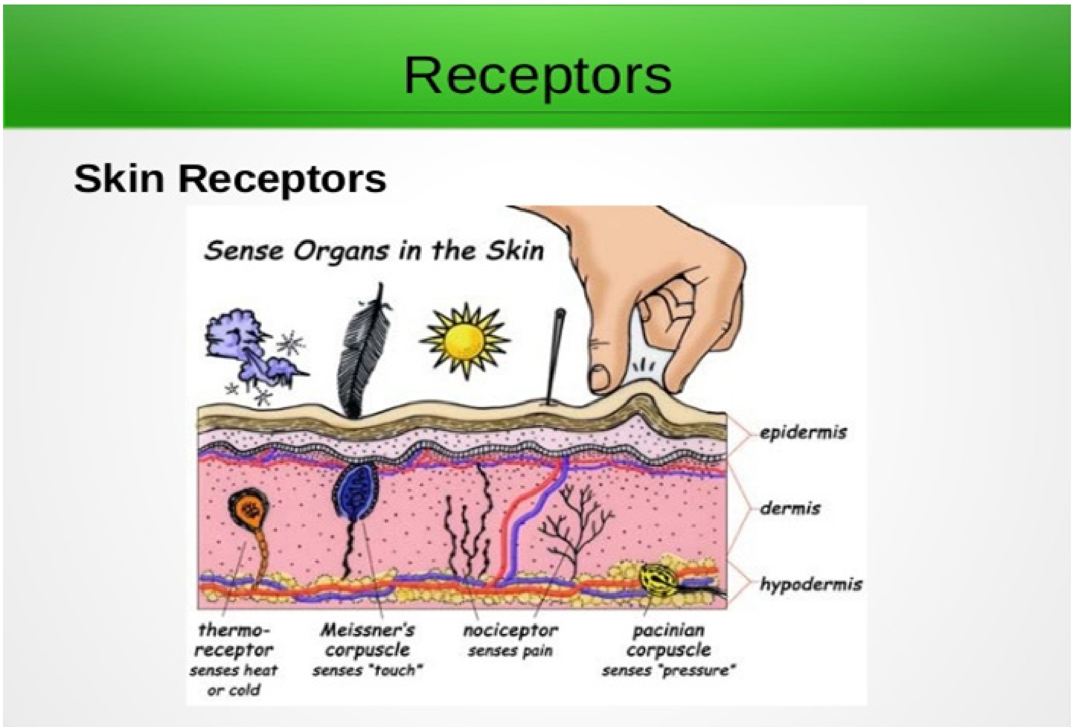
Pass information through spinal nerves

Special senses

Highly specialized receptors

Found within complex sense organs

Pass information through cranial nerves to cerebral cortex



Receptors

Sensory receptors are transducers

Change stimuli into electro-chemical impulses

Specific receptors can transduce only certain types of stimuli.

Interpretation of Sensory Information

Occurs in cerebral cortex in the brain.

Depends on the area of the cerebral cortex that receives the information.

Central Processing and Sensory Adaptation

Sensory adaptation – the loss of sensitivity after continuous stimulation

Occurs in some types of receptors

Role – prevents brain from being overloaded with unimportant information.

The Special Senses

Olfaction (the Nose)

Olfactory Receptors

Can detect at least 50 different primary smells.

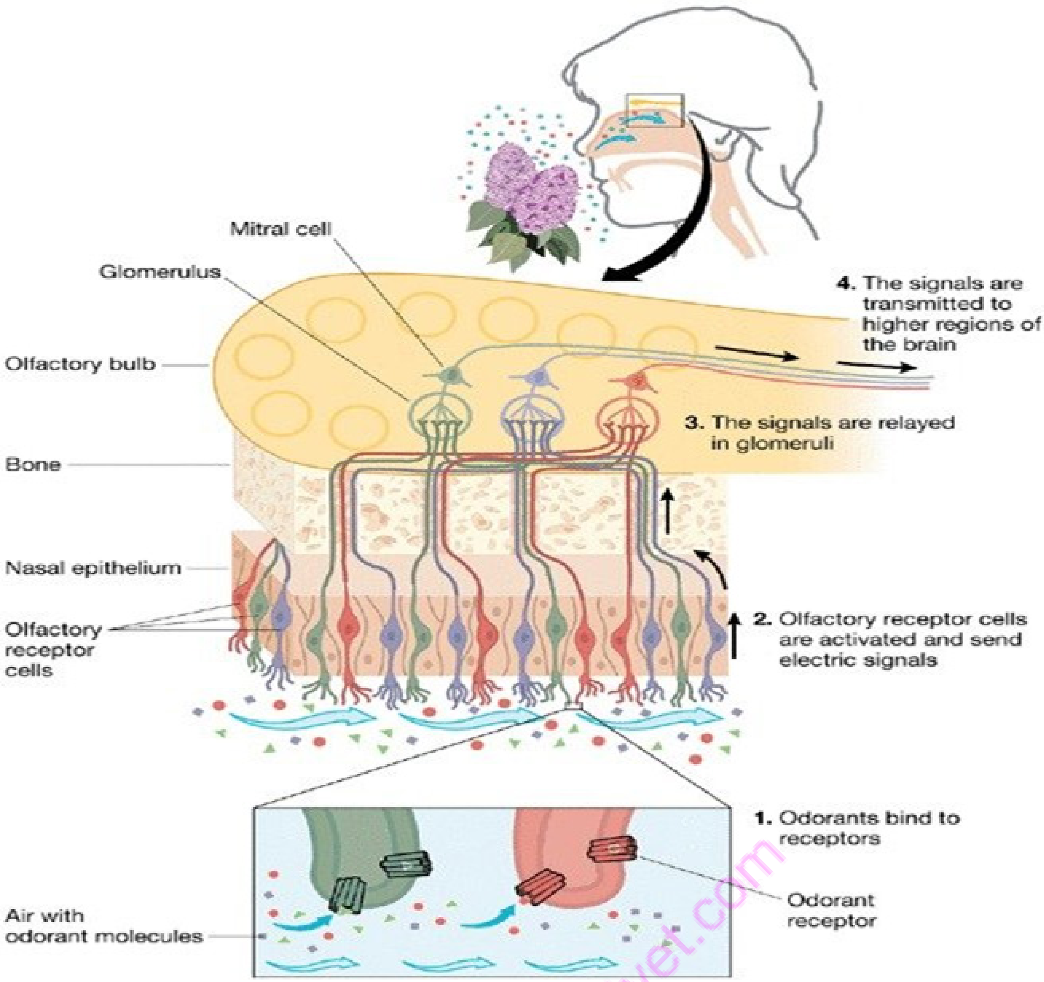
Located in the roof of nasal cavity.

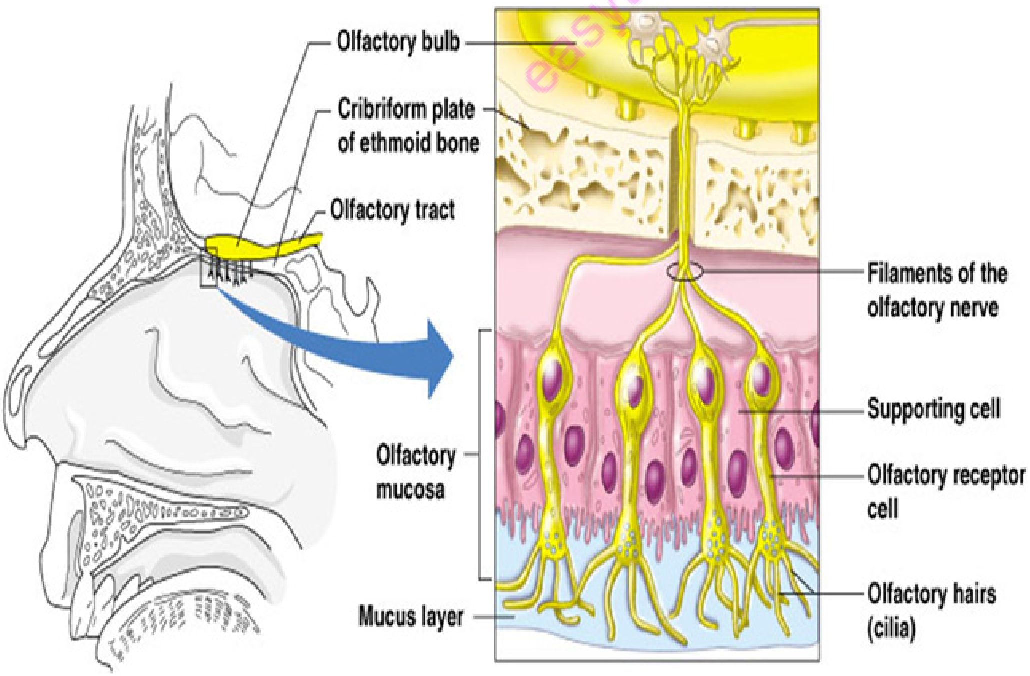
Molecules dissolve in the mucus or lipids of the epithelium

Olfactory neurons pass through the roof of the nasal cavity and synapse in the olfactory nerve.

Olfactory tracts go directly to the cerebral cortex

Interpretation occurs at the olfactory area of temporal lobe


Mitral cell
Glomerulus
Olfactory bulb
Bone
Nasal epithelium
Olfactory receptor cells
4. The signals are transmitted to higher regions of the brain
3. The signals are relayed in glomeruli
2. Olfactory receptor cells are activated and send electric signals
1. Odorants bind to receptors
Odorant receptor
Air with odorant molecules


Olfactory bulb
Cribriform plate of ethmoid bone
Olfactory tract
Filaments of the olfactory nerve
Supporting cell
Olfactory receptor cell
Olfactory mucosa
Mucus layer
Olfactory hairs (cilia)

TASTE (THE TONGUE)

Taste receptors are in the taste buds

Can detect 5 primary tastes

Sweet, sour, salty, bitter, umami

Located in papillae on the surface of the tongue

Taste buds contain the taste receptors

Molecules dissolve in saliva.

Cranial nerves relay sensory impulses to the cerebral cortex.

The Tongue and Taste Buds

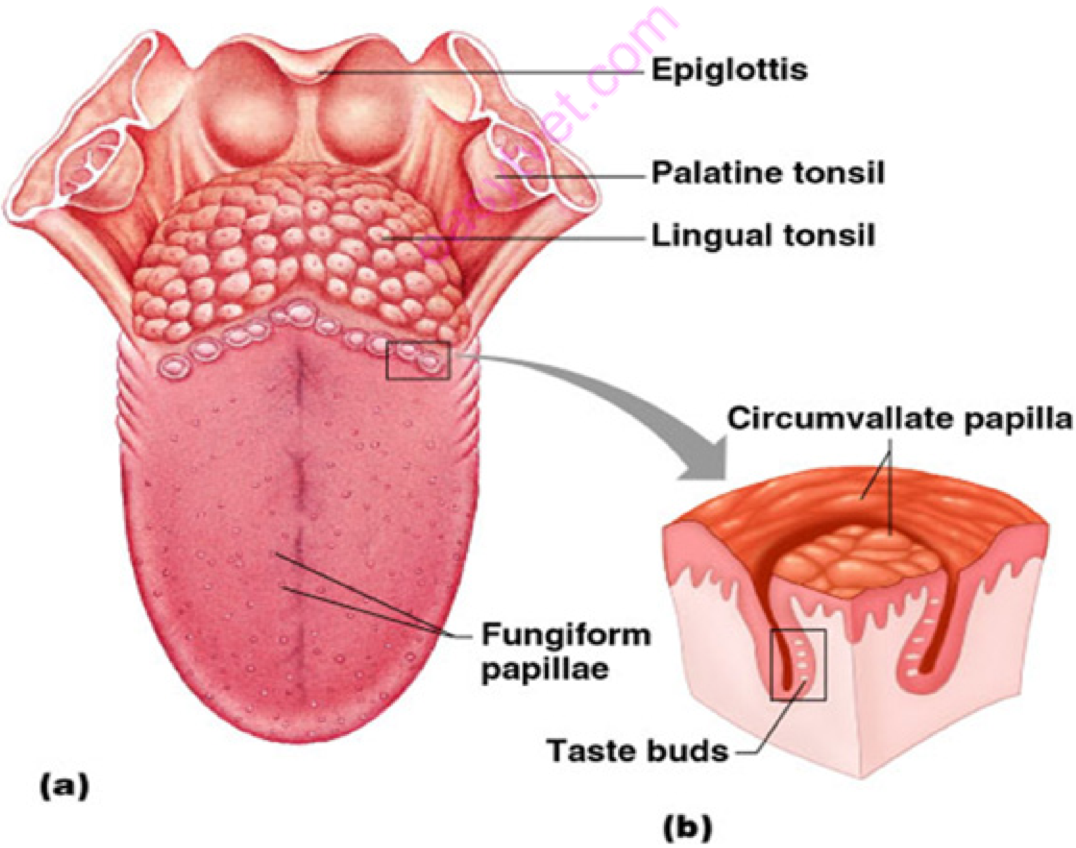
The tongue is covered with projections called papillae

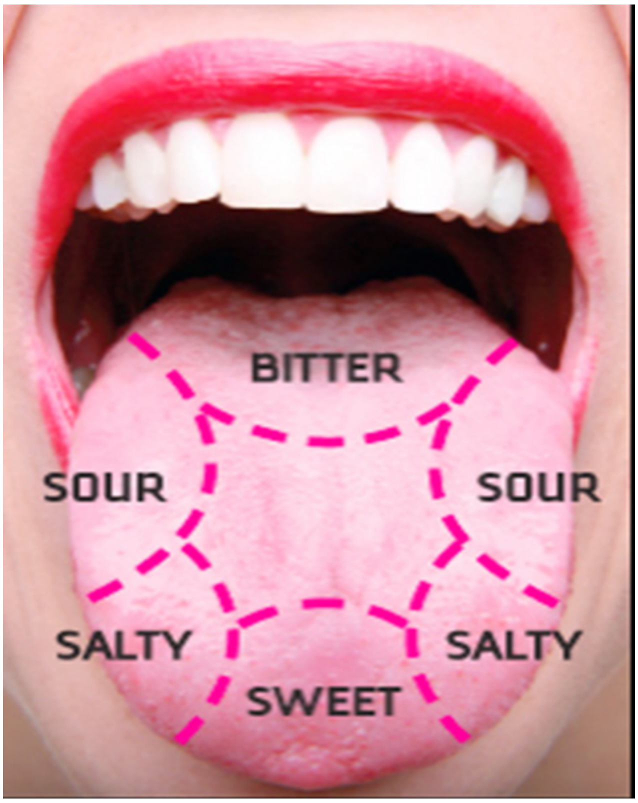
Filiform papillae – sharp with no taste buds

Fungifiorm papillae – rounded with taste buds

Circumvallate papillae – large papillae with taste buds

Taste buds are found on the sides of papillae



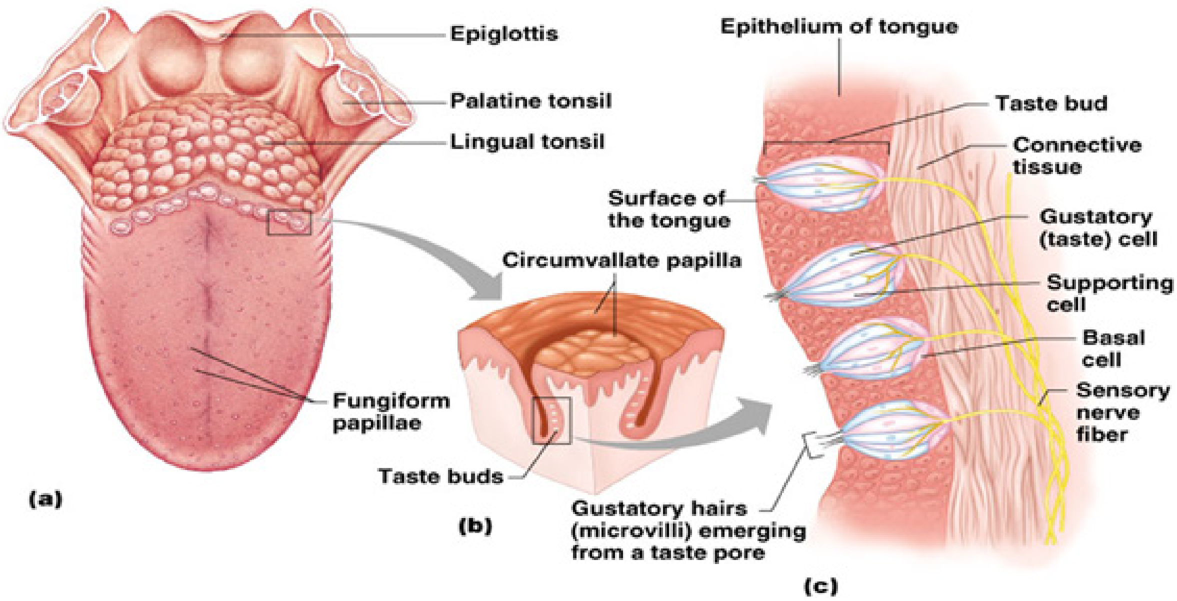


Structure of Taste Buds

Gustatory cells are the receptors

Have gustatory hairs (long microvilli)

Hairs are stimulated by chemicals dissolved in saliva



EQUILIBRIUM & HEARING (THE EAR)

External ear

The auricle directs sound waves into the external auditory meatus to the tympanic membrane

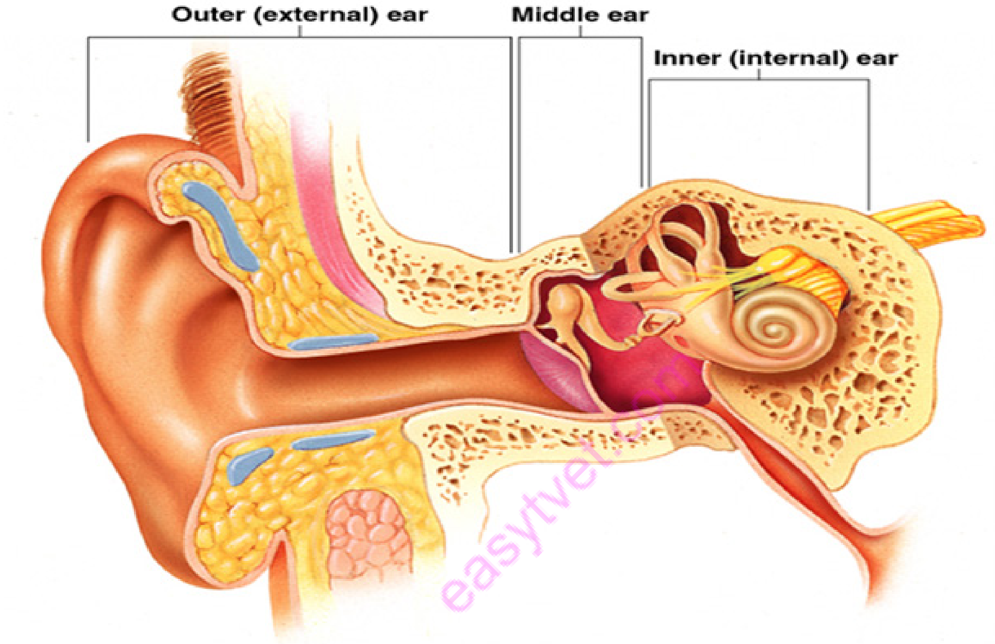
Middle ear

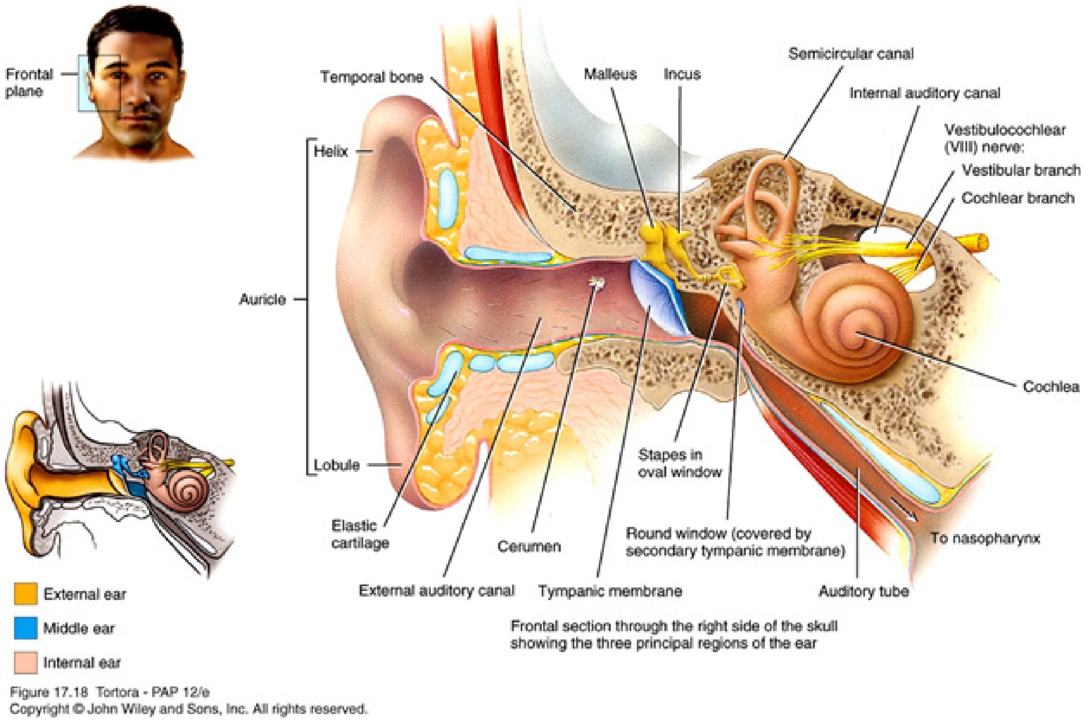
Contains the auditory ossicles

Malleus, incus, stapes

Connected to throat by the eustachian tube

Inner ear





The Inner Ear

Separated from the middle ear by the oval window

Consists of a series of canals filled with fluid

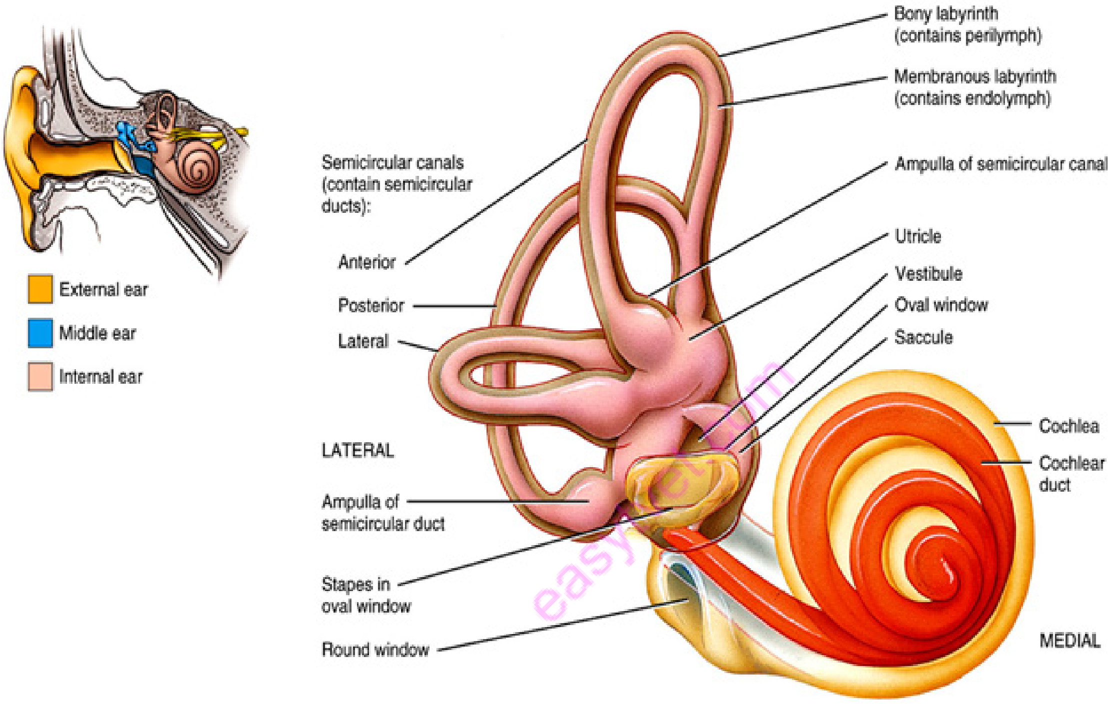
Three parts: the semicircular canals, the vestibule (both contain receptors for equilibrium/ balance) and the cochlea (contains receptors for hearing).

Semicircular canals

Contains receptors for head position

Cochlea

Contains the organ of Corti, the organ of hearing



(a) Components of the right internal ear

Figure 17.20 Tortora - PAP 12/e

The Semicircular Canals

Detects balance.

Arranged at right angles to each other

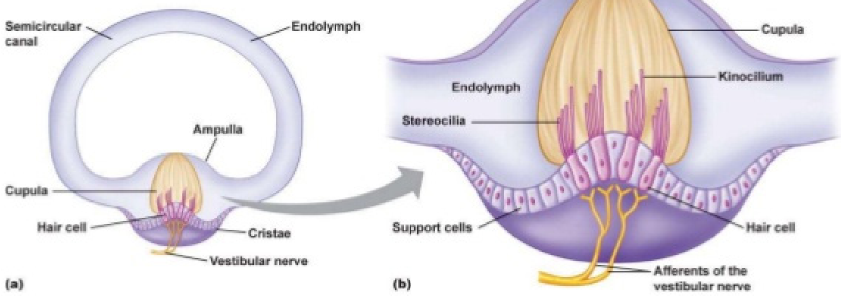
Contain hair cells embedded in gelatinous material with fluid over it.

Detect movement of the head

Bends the hairs, creating nerve impulses

Within the canals

- The canals are filled with **endolymph**.
- At the base of each canal is a swelling called **ampulla**壶腹.
- On the ampulla are the **sensory hair cells**感觉毛细胞 and enclosed by **gelatinous mass**胶质物.



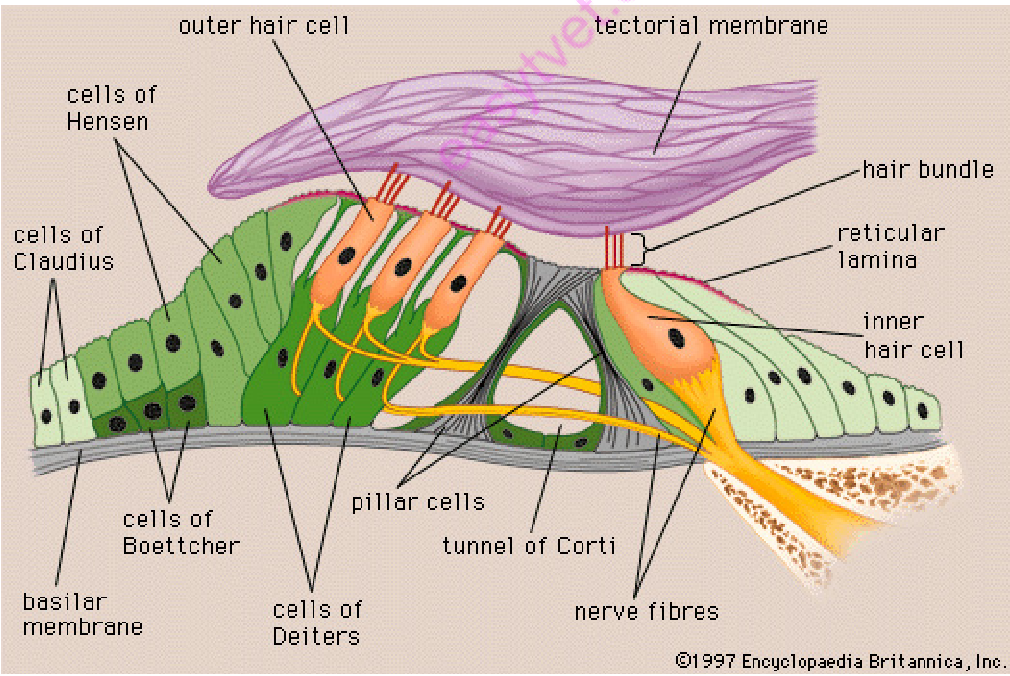
The Organ of Corti

Detects sound waves

Consists of hair cells on a basement membrane

Tips of hairs touch the tectorial membrane

When the basement membrane vibrates, the hair cells are bent, sending a nerve impulse



Summary of Hearing

Sound waves enter the external auditory meatus

Tympanic membrane vibrates

Auditory ossicles vibrate

Oval window vibrates

Fluid in inner ear vibrates

Basement membrane moves

Hairs rub against the tectorial membrane

Nerve impulse is sent along the auditory nerve to the brain.

Diseases of Hearing

External Otitis, the most common disorder of the outer ear, also know as Swimmer's ear. The process develops due to loss of the protective cerumen (wax) and excessive moisture in the ear canal.

Otitis Media is one of the most common diseases of children, due to chronic middle ear infection. Treatments: antibiotics, otomyringotomy (surgical insertion of rigid "ear tubes").

Conductive Hearing Loss, usually due to otosclerosis, progressive fixation of the stapes due to aging or disease.

4. VISION (THE EYE)

Accessory structures of the Eye

1. Eyelids protect the eye

    Conjunctiva lines the eyelid

    Lacrimal gland produces tears

2. Extrinsic muscles move the eyeball

Structure of the Eye

Consists of 3 tunics (layers)

1. Outer tunic – outermost layer

    Includes the cornea & sclera

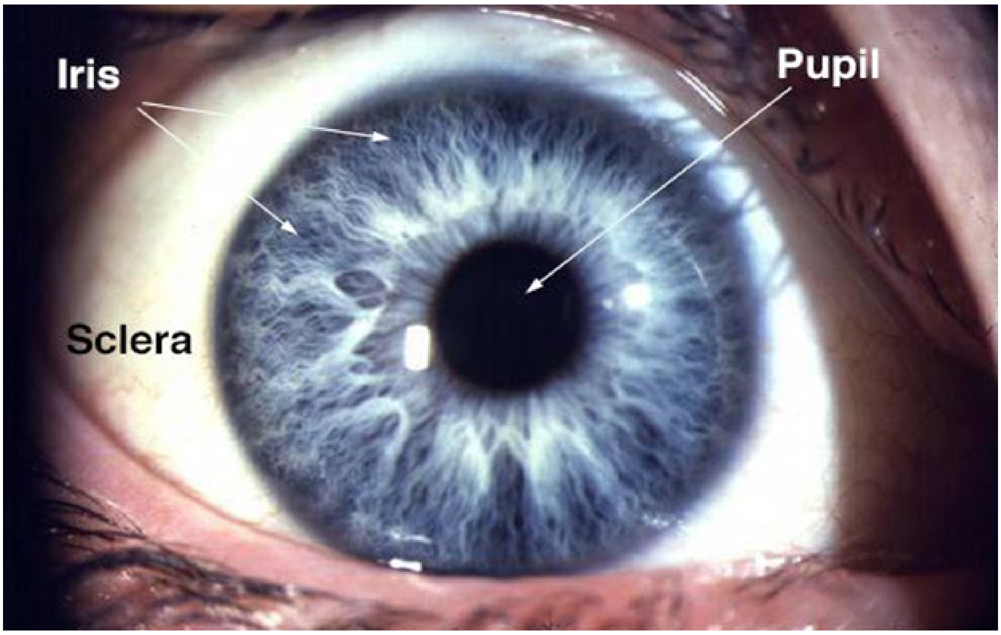
2. Middle tunic

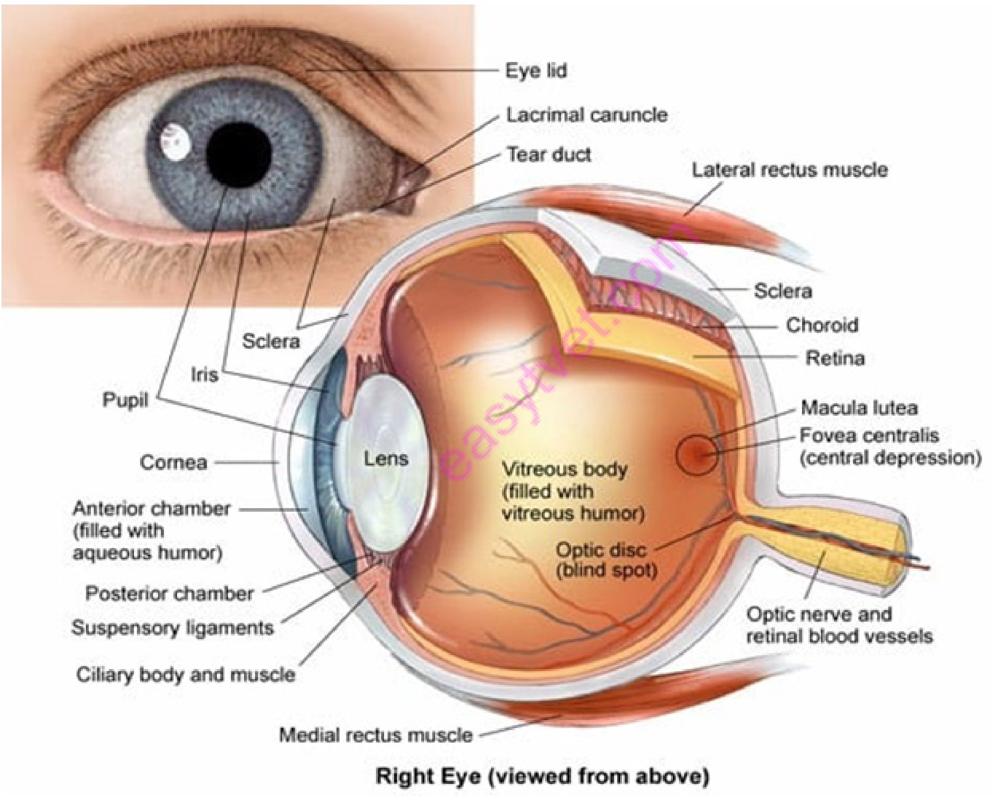
    Includes the choroid coat, ciliary body, lens, iris & pupil

3. Inner tunic (retina) – inner layer

    Contains the rods & cones (photoreceptors)

    Includes the optic disc (blind spot),





The Cavities of the Eye

The lens separates the interior of the eye into 2 cavities:

Anterior cavity in front of the lens

Contains aqueous humor

Posterior cavity behind the lens

Contains vitreous humor

The Vascular Tunic

Contains many blood vessels & nerves

The iris controls the size of the pupil

Suspensory ligaments attach the lens to the ciliary body.

Controls the shape of the lens

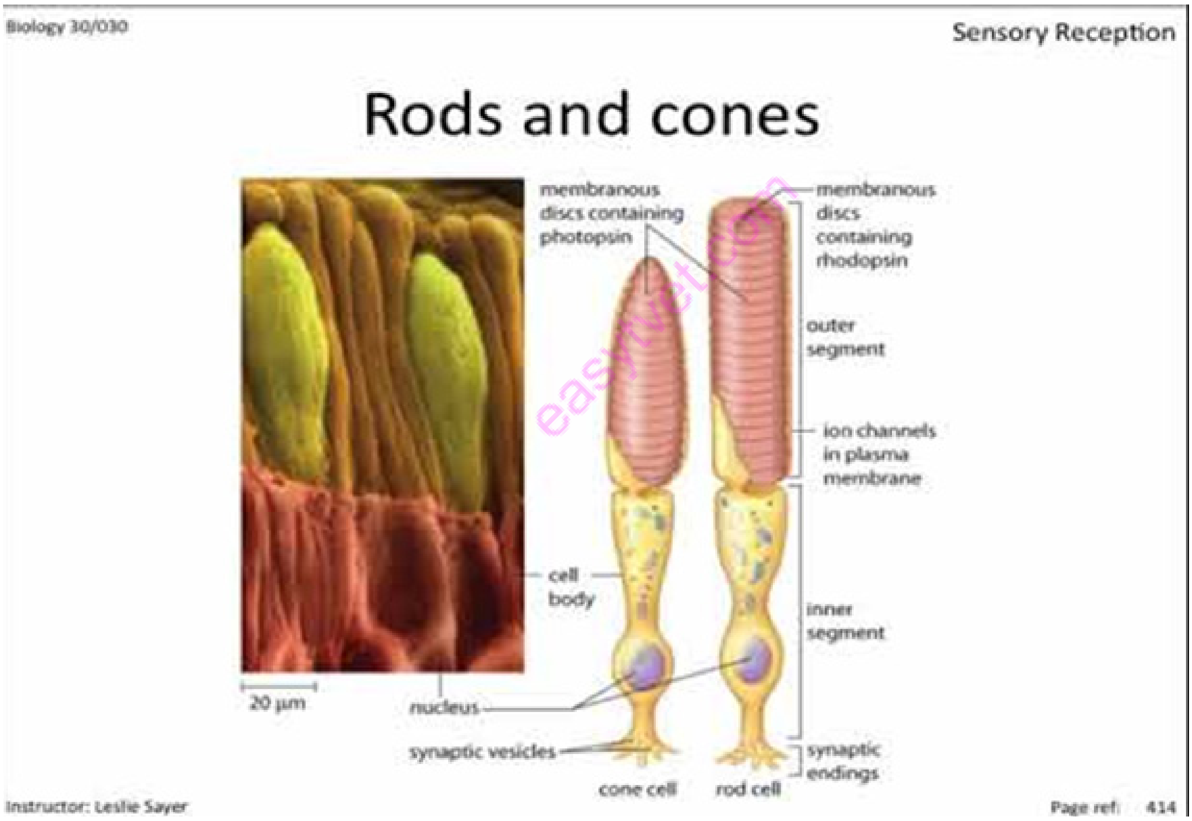
Allows focusing on near & distant objects.

Photoreceptors

Photoreceptor cells have two parts, the inner segment and the outer segment.

The inner segment contains the nucleus and other common organelles of a cell, whereas the outer segment is a specialized region in which photoreception takes place.

There are two types of photoreceptors—rods and cones—which differ in the shape of their outer segment.



The Retina—Photoreceptors

Cones

They contain photosensitive pigment called opsins.

Allow for sharp color vision in bright light

3 types, red, green and blue each with a different pigment.

Lack of any type leads to color blindness

Most dense in the center of the retina

Fovea centralis – area of the retina with only cones

NB: No photoreceptor cells are at the optic disk, or blind spot

Cones

They contain photosensitive pigment called opsins.

Allow for sharp color vision in bright light

3 types, red, green and blue each with a different pigment.

Lack of any type leads to color blindness

Most dense in the center of the retina

Fovea centralis – area of the retina with only cones

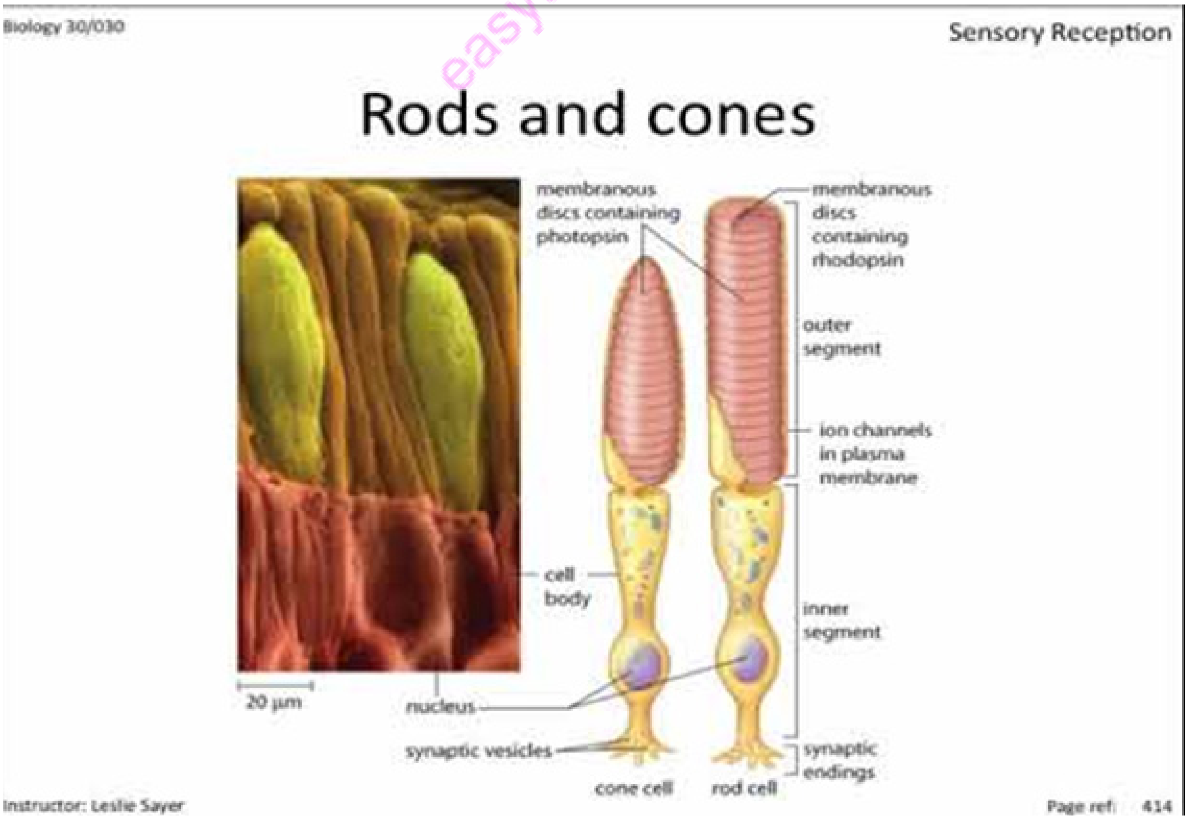
NB: No photoreceptor cells are at the optic disk, or blind spot

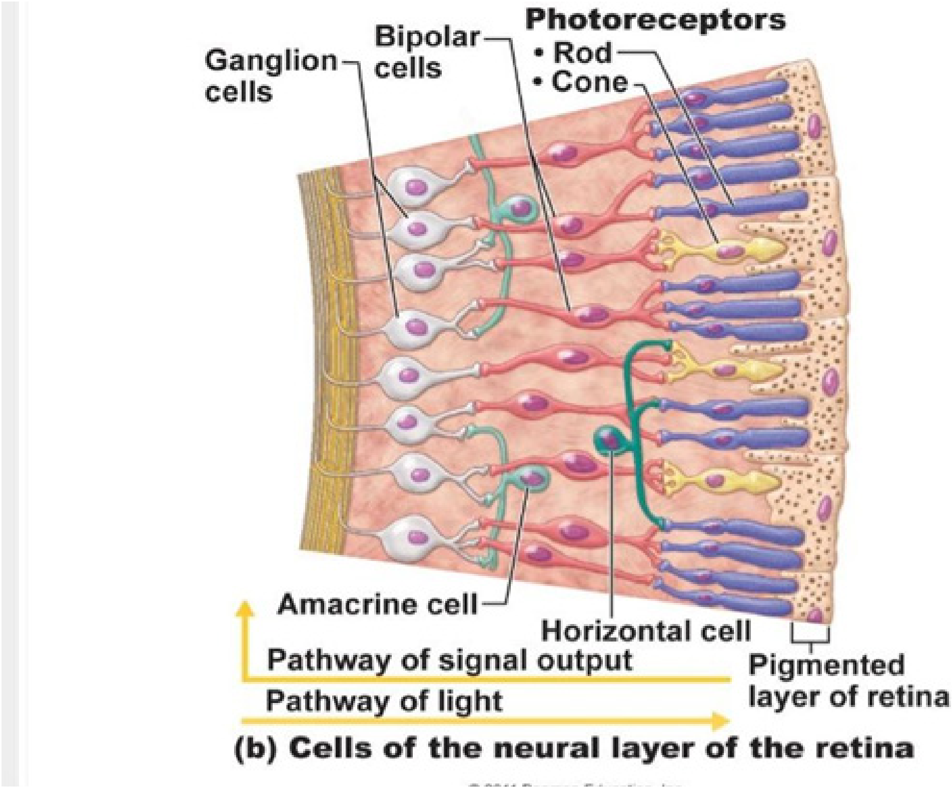
2. Rods

Provide for vision in dim light

Most dense at the periphery of the retina

Contain the photosensitive pigment called rhodopsin.





Summary of Vision

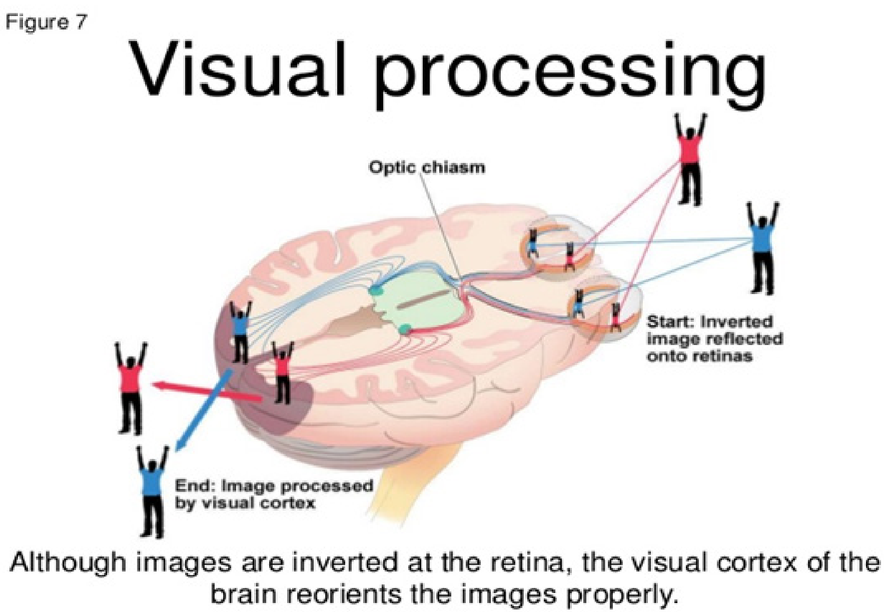
Light rays enters through the pupil

Light rays cross in the lens

Retina receives reversed & upside down image

Rods & cones are stimulated and they generate electrical impulses.

Optic nerve carries electrical impulses to the visual area of the cerebral cortex (occipital lobe).



Visual Pathway

Photoreceptors of the retina

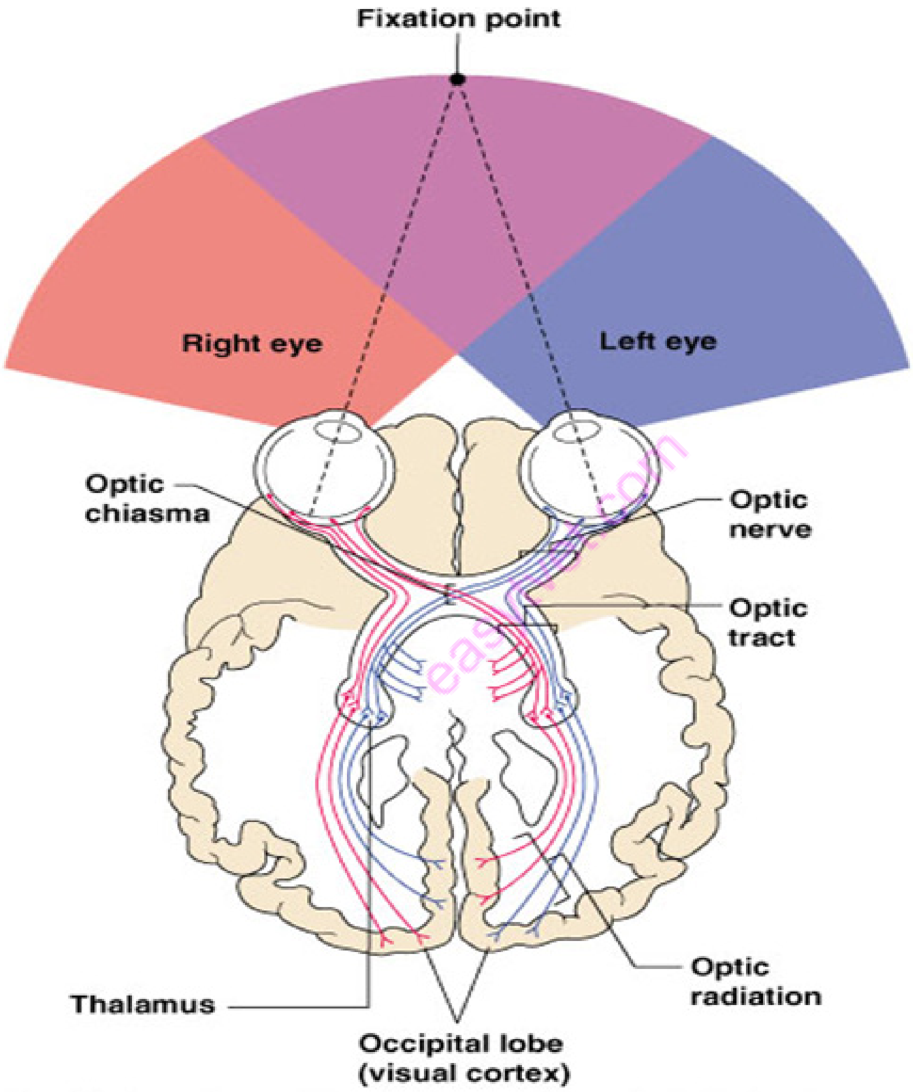
Optic nerve

Optic nerve crosses at the optic chiasma

Optic tracts

Thalamus (axons form optic radiation)

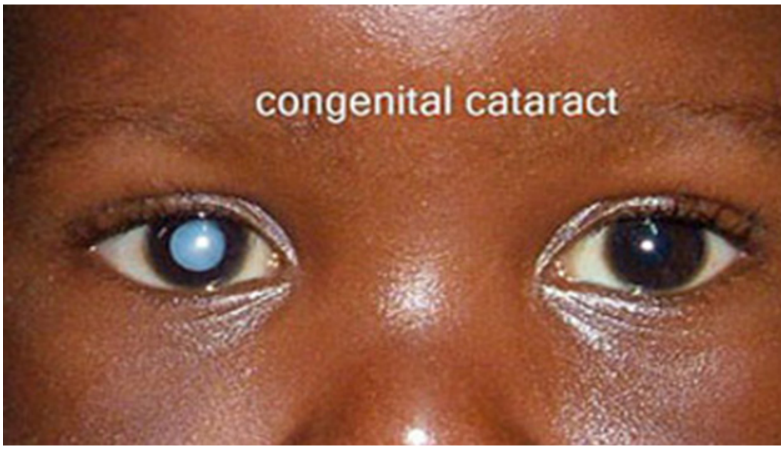
Visual cortex of the occipital lobe.



Abnormal Vision

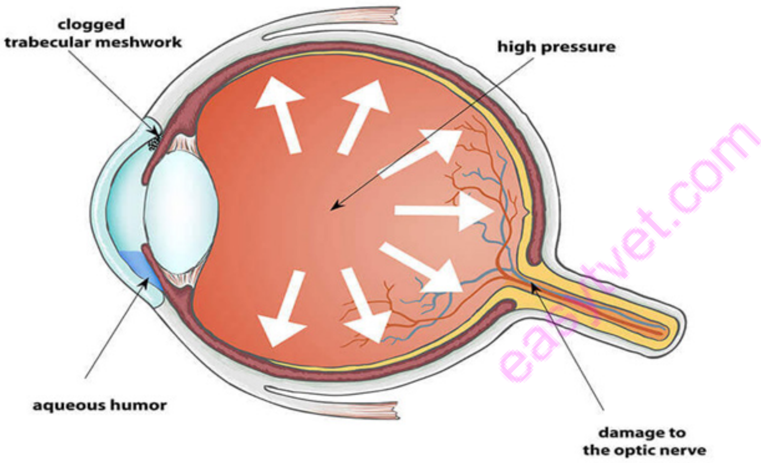
1. Cataracts

A clouding and hardening of all or part of the transparent lens located inside the eye, most often caused by the aging process, UV light exposure, etc.



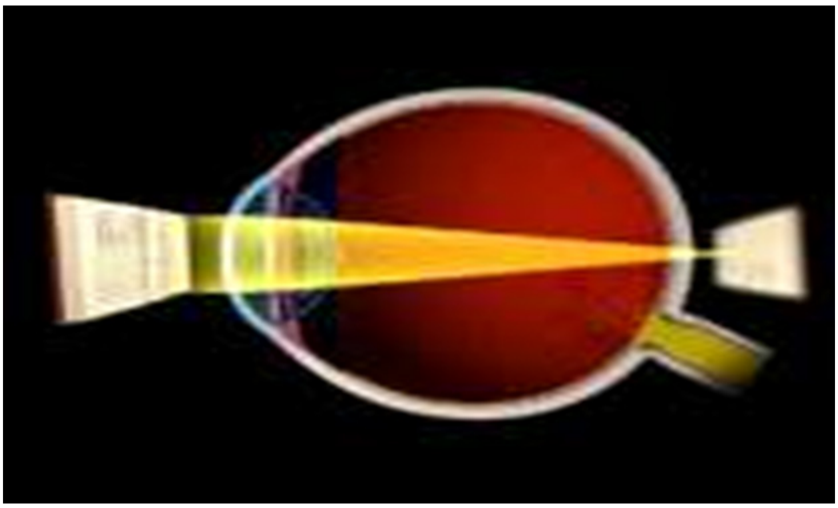
2. Glaucoma

A condition characterized by increased intraocular pressure- that can result in damage to the optic nerve and to retinal nerve fibers.



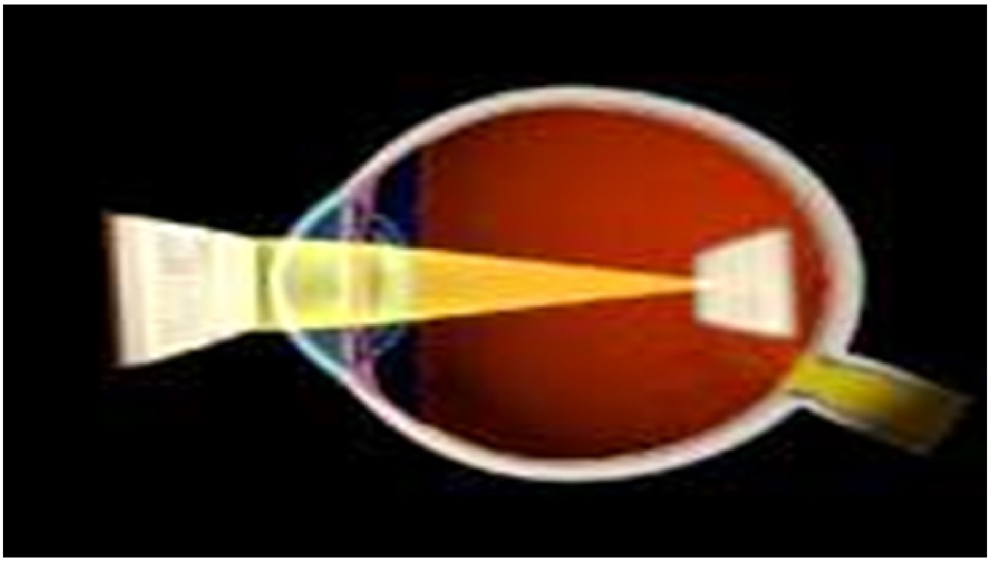
3. Hyperopia

Far sightedness. A condition in which rays of light are focused behind the retina, so distant objects appear clearer than near ones.



4. Myopia

Near sightedness. A condition in which light rays are focused in front of the retina instead of on it, so near objects appear more clear than far ones.



5. Retinoblastoma

Malignant tumor of the retina.

THE SKIN (INTEGUMENTARY SYSTEM)

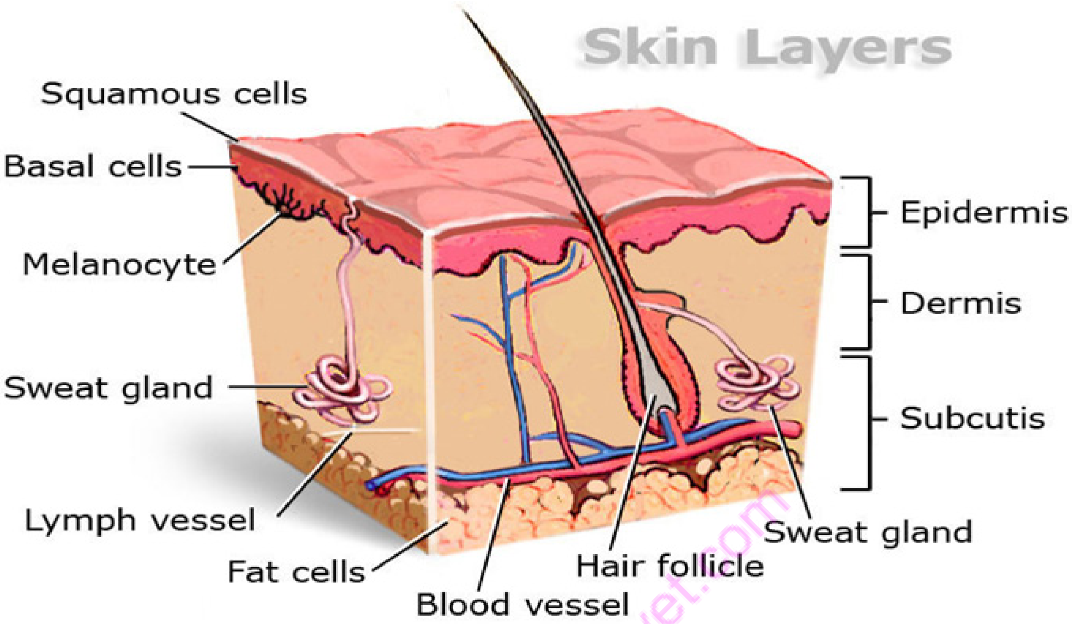
Introduction

Integument is skin

Skin and its appendages make up the integumentary system.

The three layers of the skin

Epidermis | Dermis | Hypodermis



Functions of Skin

1. Protection
2. Cushions and insulates and is waterproof
3. Protects from chemicals, heat, cold, bacteria
4. Screens UV rays
5. Synthesizes vitamin D with UV rays
6. Temperature regulation through sweating and vasodilation and vasoconstriction of vessels near the skin
7. Sensory reception (nerve endings)
8. Permitting Movement and Growth due to the elastic tissue that allow the underneath tissue to grow.
9. Excretion--wastes excreted through the skin include urea, water, uric acid and ammonia.

   Immunity--Those cells include epidermal dendritic cells, phagocytic cells and langerhans cells.

1. Epidermis

Keratinized stratified squamous epithelium

Four types of cells

Keratinocytes – deepest, produce keratin (tough fibrous protein)

Melanocytes - make dark skin pigment melanin

Merkel cells – associated with sensory nerve endings

Langerhans cells – macrophage-like dendritic cells

Layers of epidermis (from deep to superficial)

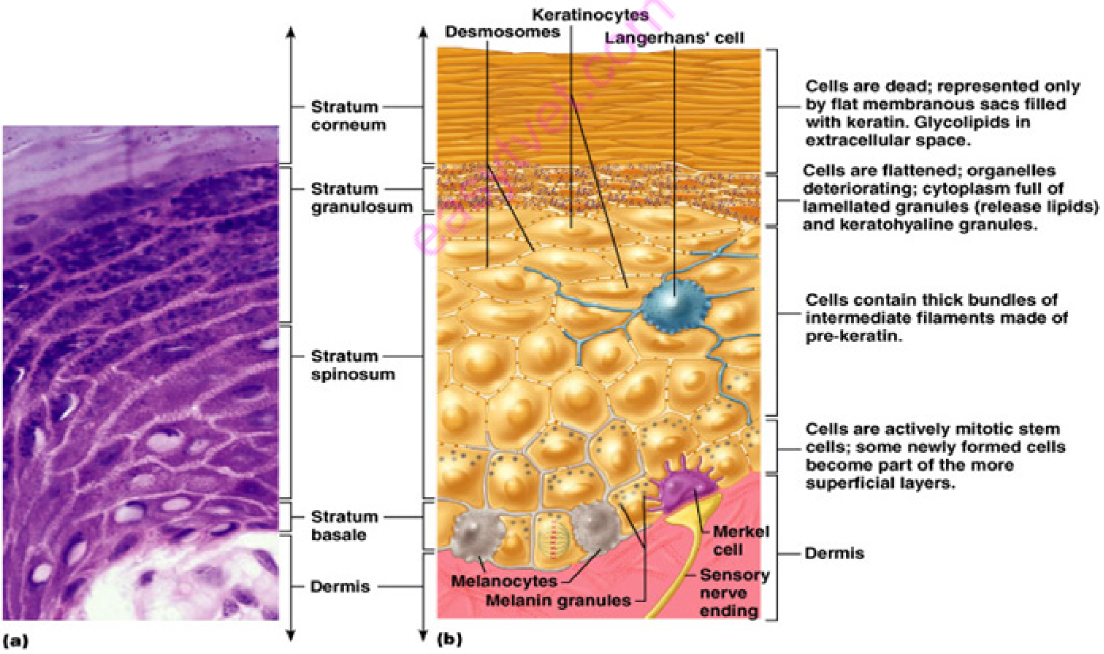
Stratum basale or germinativum – single row of cells attached to dermis; youngest cells

Stratum spinosum – spinous/prickle cell layer (bundles of protein) resist tension

Stratum granulosum – Contain granular layers of flattened keratinocytes producing keratin (hair and nails made of it also)

Stratum lucidum –clear or translucent layer (only on palms and soles)

Stratum corneum – horny layer (cells dead, many layers thick).



Remember

Four basic types of tissue

Epithelium – epidermis just discussed

Connective tissue - dermis

Muscle tissue

Nervous tissue

2. Dermis

Strong, flexible connective tissue: your “hide”

- Cells: fibroblasts, macrophages, mast cells, WBCs

- Fiber types: collagen, elastic, reticular

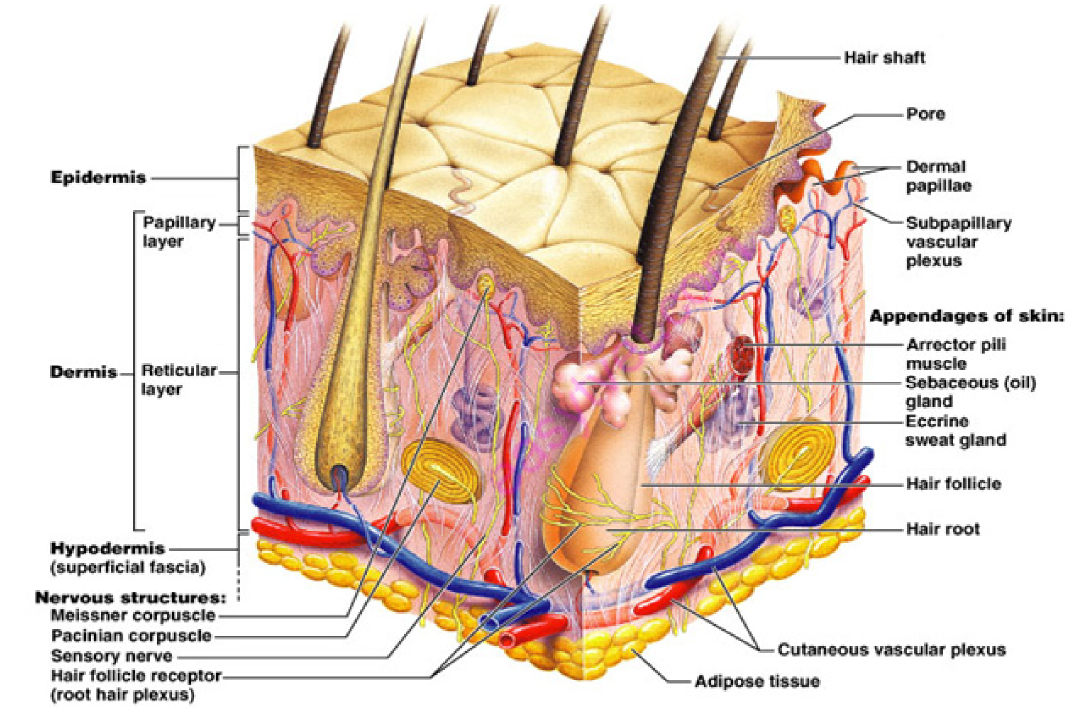
- Rich supply of nerves and vessels

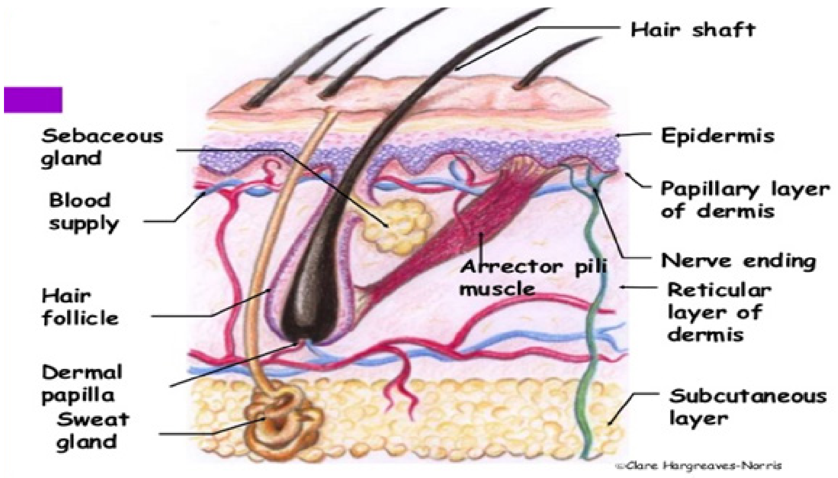
- Plays critical role in temperature regulation (the blood vessels)

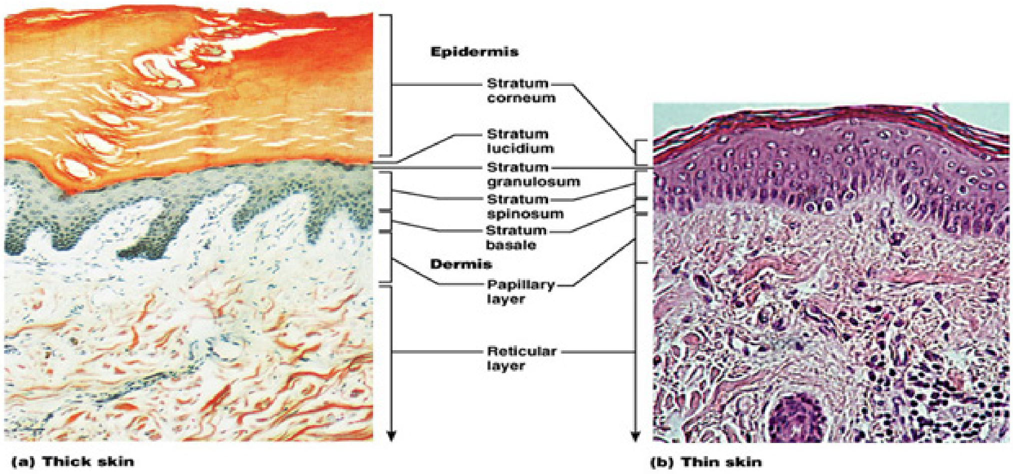
- Two layers of dermis

Papillary – areolar connective tissue; is loose connective tissue which hold organs in place and attaches epithelial tissue to other underlying tissues. This layer also includes dermal papillae

Reticular – “reticulum” (network) of collagen and reticular fibers.







Fingerprints, Palmprints, Footprints

Dermal papillae lie atop dermal ridges

Elevate the overlying epidermis into epidermal ridges

Are "sweat films" because of sweat pores

Genetically determined

Flexion Creases

Deep dermis, from continual folding

Fibers

Collagen: strength and resilience

Elastic fibers: stretch-recoil

Striae: stretch marks

Tension lines (or lines of cleavage)

The direction the bundles of fibers are directed.

The dermis is the receptive site for the pigment of tattoos

3. Hypodermis

"Hypodermis" (Gk) = below the skin

"Subcutaneous" (Latin) = below the skin

Also called "superficial fascia"

"fascia" (Latin) =band; in anatomy: sheet of connective tissue

Fatty tissue which stores fat and anchors skin (areolar tissue and adipose cells)

Different patterns of accumulation in male and female.

Skin Color

Three skin pigments

Melanin: the most important

Carotene: from carrots and yellow vegies

Hemoglobin: the pink of light skin

Melanin in granules passes from melanocytes (same number in all races) to keratinocytes in stratum basale.

Digested by lysosomes

Variations in color

Protection from UV light

NB: Although all races have the same number of melanocytes in their skin, the amount of melanin pigment synthesized varies greatly and albinos have little or no melanin pigment in their skin which make them suffer from a condition called albinism.

Melanin also determine the color of hair and iris of the eye.

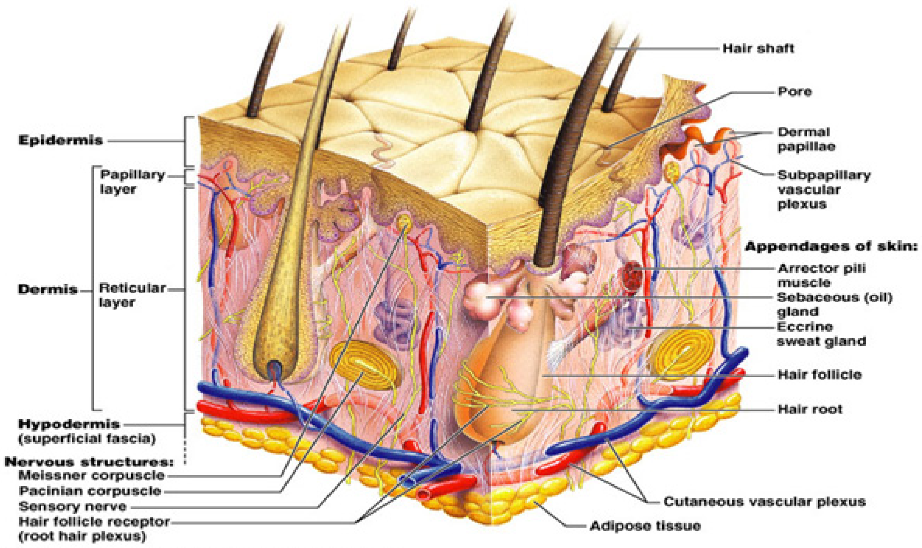
Skin Appendages

Skin appendages (or adnexa) are skin-associated structures that serve a particular function including sensation, contractility, lubrication and heat loss.

Derived from epidermis but extend into dermis.

They include:

- Hair and hair follicles
- Sebaceous (oil) glands
- Sweat (sudoriferous) glands
- Nails

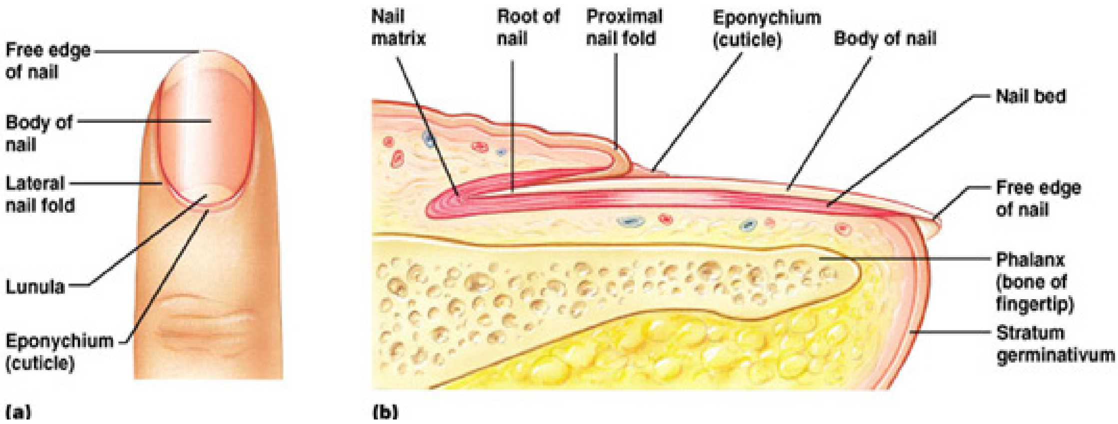


Nails

- Made of hard keratin

- Corresponds to hooves and claws

- Grows from nail matrix

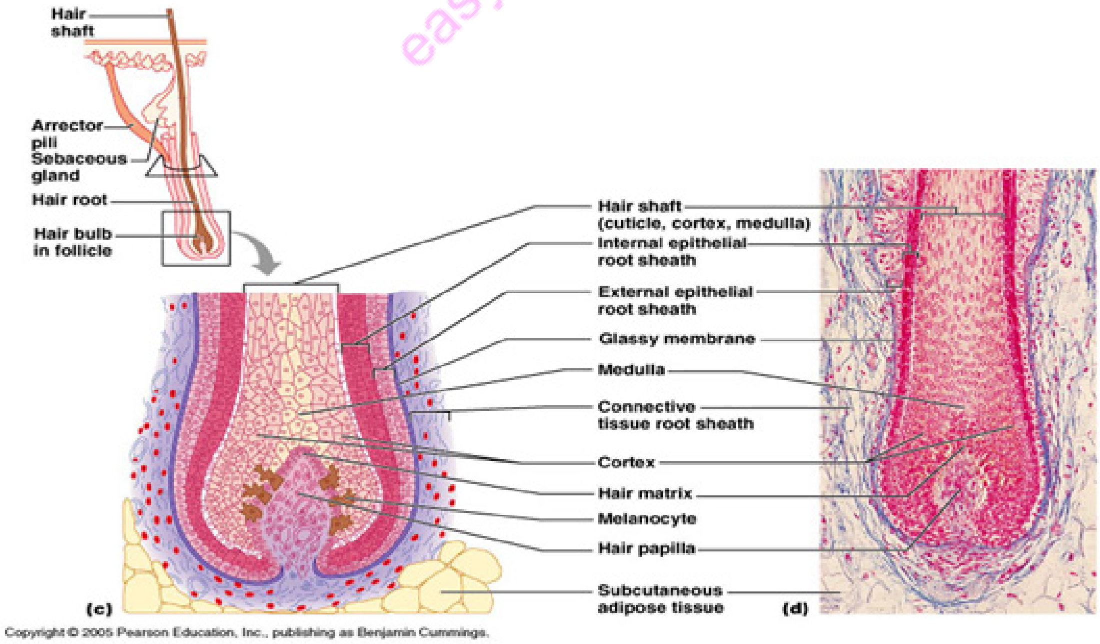


Hair and Hair Follicles: Complex

Derived from epidermis and dermis

They are found everywhere but palms, soles, nipples, parts of genitalia.

*"arrector pili" is smooth muscle that erect the hair follicle



Functions of hair

Warmth – less in man than other mammals

Sense light touch of the skin

Protection - scalp

Parts of the hair

Root imbedded in skin

Shaft projecting above skin surface

Make up of hair – hard keratin

Three concentric layers

Medulla (core)

Cortex (surrounds medulla)

Cuticle (single layers, overlapping)

Types of hair

Vellus: fine, short hairs

Intermediate hairs

Terminal: longer, courser hair

Hair growth: averages 2 mm/week

Active: growing

Resting phase then shed

Hair loss

Thinning – age related

Male pattern baldness

Hair color

Amount of melanin for black or brown; distinct form of melanin for red

White: decreased melanin and air bubbles in the medulla

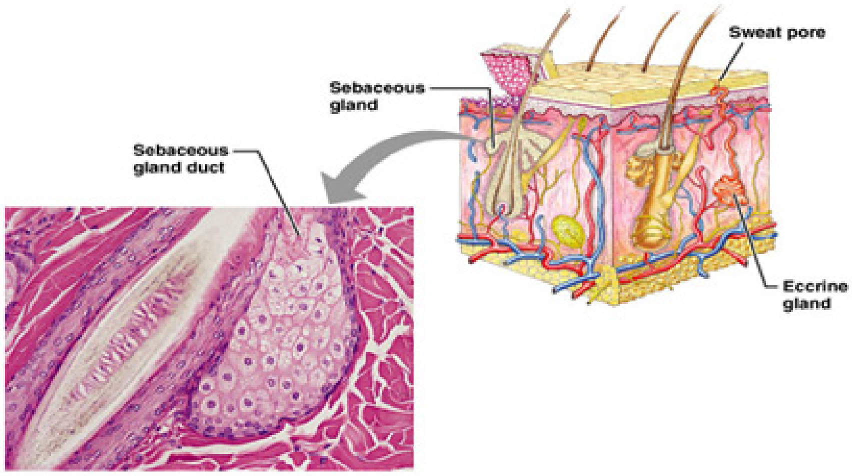
Genetically determined though influenced by hormones and environment

3. Sebaceous (Oil) Glands

Found on the entire body except palms and soles

Produce sebum by holocrine secretion---holocrine secretion is when gland secrete the whole cell.

Oils and lubricates



(a) Sectioned sebaceous gland

4. Sweat Glands

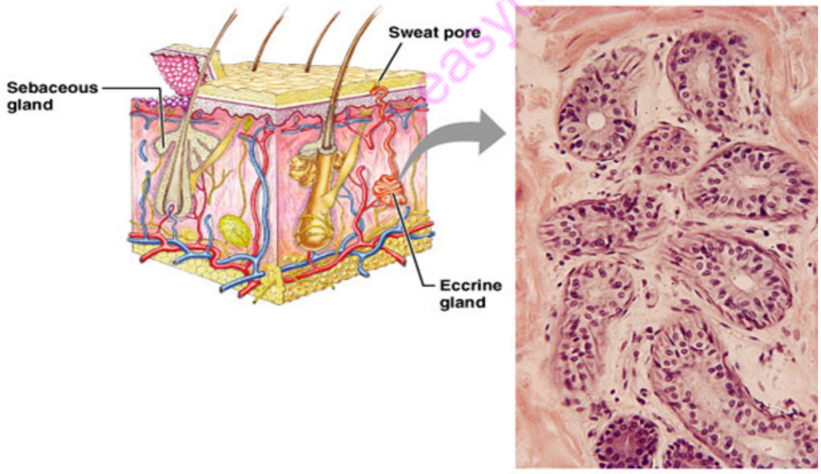
Entire skin surface except nipples and part of external genitalia

Prevent overheating

500 cc to 12 l/day! (is mostly water)

Humans most efficient (only mammals have)

Produced in response to stress as well as heat.



(b) Sectioned eccrine gland

Types of Sweat Glands

Eccrine or merocrine

- Most numerous

- True sweat: 99% water, some salts, traces of waste

- Open through pores

Apocrine

Axillary, anal and genital areas only

Ducts open into hair follicles

The organic molecules in it decompose with time – bad odor

Modified apocrine glands

Ceruminous – secrete earwax

Mammary – secrete milk

Disorders of the Integumentary System

- ***Burns***

Threatens life due to;

Catastrophic loss of body fluids

Dehydration and fatal circulatory shock

Infection

Types of burns

First degree – epidermis: redness (e.g. sunburn)

Second degree – epidermis and upper dermis: blister

Third degree - full thickness

- ***Infections***

Skin cancer

Tumors of the Skin

Benign, e.g. warts

Cancer – associated with UV exposure (also skin aging)

Aktinic keratosis - premalignant

Basal cell - cells of stratum basale

Squamous cell - keratinocytes

Melanoma – melanocytes: most dangerous; recognition:

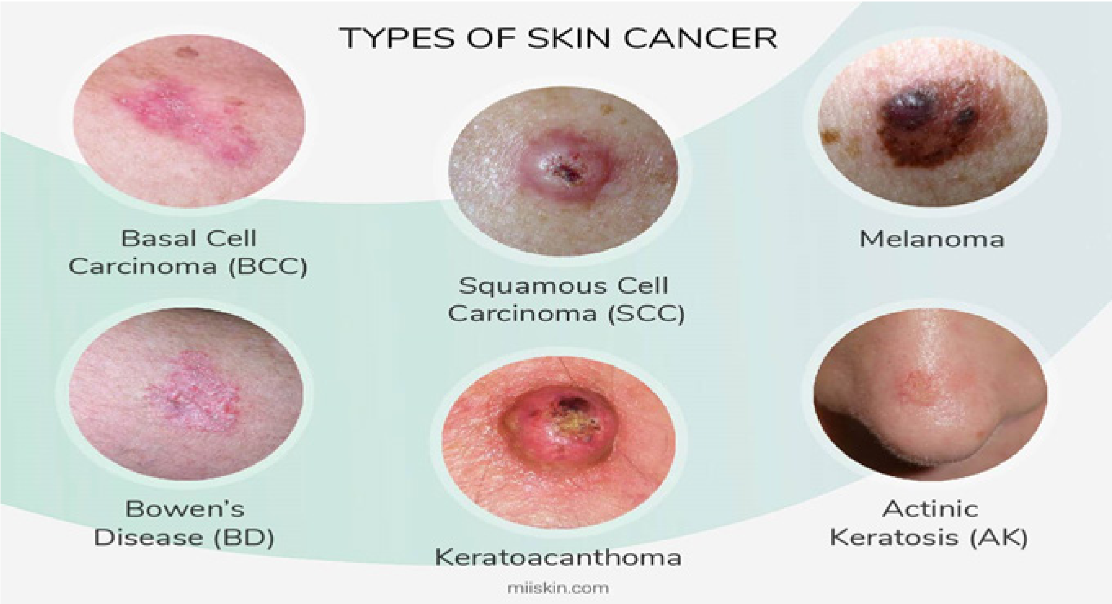
A - Asymmetry

B - Border irregularity

C - Colors

D - Diameter larger than 6mm

Skin Cancer



3.3.2.3 Self-Assessment

1. State the function of the following hormones in the digestive system
   A. Gastrin
   B. Secretin
2. State four (4) lymphatic organs and the function of each organ
3. State five (5) cells of the monocyte-macrophage system
4. State four (4) important electrolytes in the body and their
5. Outline the functions of any three hormones that influence selective reabsorption in the kidney
6. The following are common cardiovascular system disorders which one is not
   A. Hypertension
   B. Oedema
   C. Heart attack
   D. Stroke
7. State any four (4) functions of the pharynx
8. Describe the process of inspiration in the mammalian ventilation
9. Draw a well labeled diagram of a neuron
10. State four (4) types of membranes in the body
11. State four (4) factors affecting breathing

12. State any four types of synovial joints and the kind of movement they allow
13. State four (4) functions of the tongue
14. State the site of secretion of the following mammalian hormones and their functioning in the menstrual cycle
    i. Follicle stimulating hormone
    ii. Lutenising hormone
    iii. Oestrogen
    iv. Progesterone
15. State the function of the following cell organelles
    i. Cell membrane
    ii. Cilia
    iii. Nucleus
    iv. Golgi apparatus
16. State five (5) important electrolytes in the body and their function
17. State five functions of the small intestines
18. Mention six (6) anterior pituitary hormones
19. Differentiate between anabolism and catabolism
20. Briefly explain the five (5) essential parts of a reflex arc
21. List any ten (10) cranial nerves
22. Draw a well labeled diagram of the heart and use it to explain the blood flow through the heart.
23. State four (4) common pulse areas and where they are found
24. Briefly five (5) characteristics of normal urine
25. State five (5) hormones involved in hormonal regulation of tubular reabsorption and secretion in the kidney nephron
26. Mention three (3) organs of the lymphatic system and in each give a function
27. Define the following terms
    A. Integument
    B. Skin appendages
28. Explain the functions of skin

29. Which one of the following is TRUE about human skin
    A. Keratinocytes –macrophage-like dendritic cells
    B. Melanocytes - deepest, produce keratin (tough fibrous protein)
    C. Merkel cells – associated with sensory nerve endings
    D. Langerhans cells – make dark skin pigment melanin
30. Outline the components of integumentary system
31. Describe the layers of epidermis
32. Using a well labelled diagram, discuss the dermis
33. What are the functions of hair?
34. Describe the different types of sweat glands
35. Discuss the disorders of the integumentary system

3.3.2.4 Tools, Equipment, Supplies and Materials

Dummy human body, dummy internal organs, microscope, slides, cadaver, anatomy text books, white board, mark pen, charts, diagrams etc.

3.3.2.5 References

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CHAPTER 4:

DEMONSTRATE KNOWLEDGE OF FOOD MICROBIOLOGY TECHNIQUES

4.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to apply microbiological techniques. It involves demonstrating the knowledge of microorganisms in foods and food environments, physiology, genetics, biochemistry and behaviour of microorganisms, microbiology of food fermentation, microbiological aspects of food safety, methods of detection, identification and enumeration of food microorganisms.

4.2 Performance Standard

By the end of this unit of learning/competency, the trainee should demonstrate ability to carry out microbiological tests and analysis as per workplace guidelines; process different ferment food products based on resource materials; apply microbiological aspects of food safety based on ISO standards; and, identify and control microorganisms associated with food as per resource materials

4.3 Learning Outcomes (Elements in the OS)

4.3.1 List of the Learning Outcomes

i) Demonstrate the knowledge of microorganisms in food and food environment

ii) Demonstrate the knowledge of physiology, genetics, biochemistry and behaviour of food microorganisms

iii) Demonstrate the knowledge on microbiology of food fermentation

iv) Demonstrate the knowledge of microbiological aspects of food safety

v) Demonstrate the knowledge on methods of detection, identification and enumeration of food microorganism

4.3.2 Learning Outcome 1: Demonstrate the knowledge of microorganisms in food and food environment

4.3.2.1 Learning Activities

Learning activity	Special instructions
i) Identify and describe the terminologies in food microbiology • Define toxins & toxicants • Describe incubation period	
ii) Identify and describe basic types of food microorganism	Illustrate the shape of various microorganisms using very clear diagrams
iii) Identify and describe roles of microorganisms in food safety and spoilage	Consider both the beneficial and destructive roles of the microorganisms
iv) Apply the use of microscope	Mount and identify basic types of microorganisms on a microscope; o Bacteria o Virus o Yeast o Mold o Fungi o Protozoa

4.3.2.2 Information Sheet

Definitions

Incubation period is the period between exposure to an infection and the appearance of the first symptom

Toxins are natural products such as the ones found in poisonous mushrooms, or in a snakes' venom.

Toxicants are man-made products, artificial products introduced into the environment due to human activity; examples are industrial waste products and pesticides

Food safety: overall quality of food fit for consumption

Food spoilage: defined as damage or injury to food rendering in unsuitable for human consumption.

Microbiology: The study of microorganisms, which are microscopic, unicellular, and cell-cluster organisms

Food microbiology: is the study of the microorganisms that inhabit, create, or contaminate food. Of major importance is the study of microorganisms causing food spoilage

Basic types of food microorganisms

Bacteria

- Are single-celled prokaryotic organisms
- They have a rapid reproduction
- Are the major cause of foodborne diseases
- Are of many different types and there many ways of identifying them.

Protozoans

- Single celled eukaryotic organisms – larger than bacteria and are found in soil and water
- They cause diseases such as amoebic dysentery
- Fungi
- An eukaryotic organism with rigid cell walls
- Grow mainly as single-celled and reproduce by budding
- Examples include Yeast and molds
- They cause superficial infections such as athlete's foot, ringworm and thrush.

Parasites

- Organism that lives on or in another and uses that organism to provide nourishment
- Infections caused by parasites are called infestations. They include worms and parasites
- Viruses
- Smallest known infectious agents
- Cannot be seen by regular microscope
- Consist of only nucleic acid surrounded by a protein coat
- Viruses such as Norwalk virus are known to cause foodborne illnesses.

Roles of microorganisms in food safety and spoilage

Food borne infections are caused by the entrance of pathogenic microorganisms contaminating food into the body, and the reaction of the body tissues to their presence.

These can either be fungal, bacterial, viral or parasitic food borne infections tend to have long incubation periods and are usually characterized by fever.

Bacterial food borne infections include Cholera, salmonellosis, typhoid fever, shigellosis, Yersiniosis, Escherichia coli infection campylobacteriosis, Vibrio parahemolyticus and listeriosis

Mycotic food borne infections include Candida species, Sporothrix spp., and Wangiella species.

Viral food borne infections include hepatitis A, Norwak virus and poliomyelitis virus

Bacterial foodborne outbreaks occur in different forms;

a). Sporadic cases involving only one or two persons in a household

b). Family outbreaks in which several members of the family are affected

c). Large outbreaks caused by a widely distributed infective food item

d). Institutional outbreaks which may be caused by a contaminated single food item.

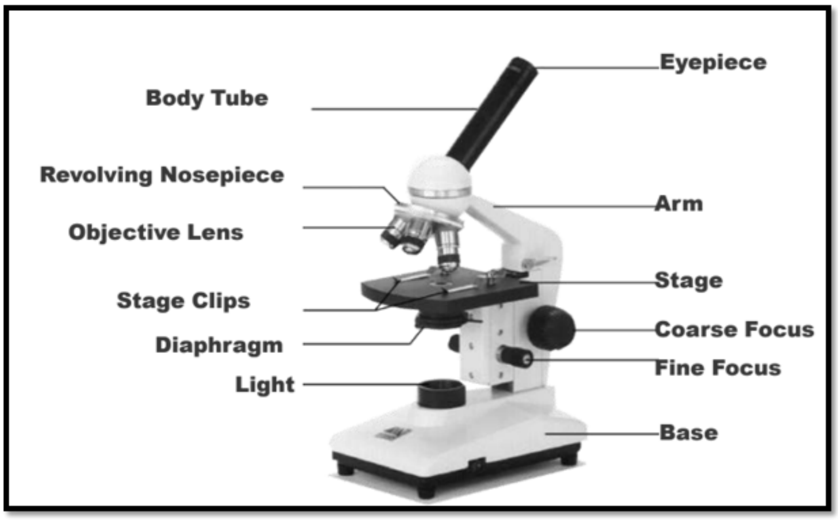
Viruses are common pathogens transmitted through food. Hepatitis A and Norwalk-like virus (Novovirus) are the most important viral food borne pathogens. These viruses are highly infectious and may lead to widespread outbreaks. Only a few viral particles are necessary for the disease to develop. High numbers of viral particles are further transmitted via feces of infected persons (up to 1011 particles per gram of feces. Specific lining cells are necessary for virus replication. Accordingly they cannot multiply in foods or water. Food borne virus are relatively stable and acid resistant outside host cells

Fungal intoxications are caused by consumption of metabolites produced by fungi, when growing in food. These metabolites are called mycotoxins. Grains, oilseeds, fruits and vegetables are mostly involved if they are stored at high humidity (≥ 0.75) or if they are not properly dried before storage. Poor dry storage practices of grains and other foods leads to mould growth and production of mycotoxins. Of significance to public health is aflatoxicosis.

Microscopy (structure, use, care and maintenance)

A microscope is an instrument that magnifies objects otherwise too small to be seen, producing an image in which the object appears larger. Most photographs of cells are taken using a microscope, and these pictures can also be called micrographs.

Parts of a microscope



Magnification

The microscope has three magnifications;

a. Scanning

b. Low

c. High

The ocular lens (eye piece) has a magnification hence total magnification is the ocular magnification multiplied by objective magnification as shown below.

	Magnification	Ocular lens	**Total magnification**
Scanning	4x	10x	40x
Low power	10x	10x	100x
High power	40x	10x	400x

General procedure for microscope use

- Make sure all backpacks and materials are out of the aisles and off the tops of desks.
- Plug your microscope into the outlet.
- Store with cord wrapped around microscope and the scanning objective clicked into place.
- Carry by the base and arm with both hands.

Focusing specimens

1. Always start with the scanning objective: Use the Coarse Knob to focus and then the fine adjustment knob until clear, image may be small at this magnification, but you won’t be able to find it on the higher powers without this first step.
2. Once you have focused on scanning, switch to low power- use the Coarse Adjustment Knob to refocus. Then use the Fine Adjustment Knob to make the image crystal clear. Again, if you haven’t focused on this level, you will not be able to move to the next level.
3. Now switch to High Power- (If you have a thick slide, or a slide without a cover, do NOT use the high power objective). At this point, ONLY use the Fine Adjustment Knob to focus specimens.

Drawing specimen

1. Use pencil - you can erase and shade areas

2. All drawings should include clear and proper labels (and be large enough to view details). Drawings should be labeled with the specimen name and magnification.

3. Labels should be written on the outside of the circle. The circle indicates the viewing field as seen through the eyepiece, specimens should be drawn to scale - ie.if your specimen takes up the whole viewing field, make sure your drawing reflects that.

Units for measurements of microorganisms include:

Micrometers - µm

Nanometers – nm

1mm = 1000µm

1µm = 1000nm

Simple microscopes have single magnifying lens (like a magnifying glass).Compound microscopes have two sets of lenses for magnification. Lens closer to the eye is called ocular lens (magnifying power of 10x) while the lenses closer to the object being viewed is called objective lens. (Most light microscopes used in biology have three or four objective lenses).

The Bright Field microscope

This is the commonest type and most used microscope.

Bright field light microscopes produce a dark image against brighter, backlit background.

They provide a 2-D image. It is commonly used to view stained cells.

The ocular lens magnifies the specimen 10x. You will always be looking through the ocular and objective lens simultaneously, so multiply ocular magnification x objective power to calculate the Total Magnification (xTM).

Rotary nosepiece of your microscope has four objective lenses attached. Shortest lens (red band) should have been pointing down when your scopes were last put away.

The quality of your image depends on the Numerical Aperture (NA) and resolution.

NA relates to the light gathering properties of the optical components of the microscope, whereas resolution is the ability to distinguish details within your specimen.

Using an immersion lens and oil can improve both your resolution and NA

Electron microscopes

Use an electron beam instead of light, which is focused using electromagnets.

The specimen has to be specially prepared and held inside a vacuum chamber from which the air has been pumped out (because electrons do not travel very far in air).

The image is formed as a photograph (called an electron micrograph) or as an image on a TV screen.

Are of two types

i. Scanning electron microscope (SEM)

ii. Transmission electron microscope (TEM)

Many microscopic images in textbook, journals and publications are obtained using electron microscopes. Electron beam wavelengths are shorter than light wavelengths, so better resolving power. Electrons go through very thin slice of specimen and detailed image is viewed on a screen.Beam of electrons across a whole specimen (sprayed with fine metal coating). Three dimensional views of surface features on a screen

Phase-Contrast microscope

This is used to study the behavior of living cells, observe the nuclear and cytoplasmic changes taking place during mitosis and the effect of different chemicals inside the living cells. One of the major advantages of phase contrast microscopy is that living cells can be examined in their natural state without previously being killed, fixed, and stained(usually kills cells) Offers more contrast than bright field microscopy. It is especially useful for examining living, unpigmented cells

Fluorescence Microscope

A fluorescence microscope is a light microscope used to study properties of organic or inorganic substances using the phenomena of fluorescence and phosphorescence instead of, or in addition to, reflection and absorption. In most cases, a component of interest in the specimen is specifically labeled with a fluorescent molecule called a fluorophore such as Green fluorescent protein, fluorescein

The specimen is illuminated with light of a specific wavelength or wavelengths which is absorbed by the fluorophore, causing them to emit longer wavelengths of light of a different color than the absorbed light.

Dark Field Microscopy

Type of microscopy which is the exact opposite of a bright field microscope

Dark background/field with the specimen being the only one illuminated.

Used in observing unstained specimens. Most microscopes have the potential to do dark field microscopy such as compound or stereomicroscopes.

Microscopy techniques

Wet Mounts

Smears

Staining

Care and maintenance of microscopes

i. Handle with care

Most microscope problems occur as a result of improper handling. When carrying your microscope, hold it by the base and the metal support arm. Do not pick it up by the stage, as this can cause misalignment. When transporting it, use a microscope bag.

ii. Keep lenses clear of slides

When using your microscope and adjusting the focus you will need to lower the objective lens down as far as it will go. However, you should never allow the lens to touch the slide you are looking at. Dirty lenses can be difficult to clean.

iii. Clean after using immersion oil

If using immersion oil, always ensure the objectives are cleaned immediately after use. Objective, eyepieces and condenser may be removed for cleaning. Use only lens paper and lens cleaner. Do not use solvents.

iv. Cover when not in use

All microscopes are sold with dust covers. Always keep your microscope covered when not in use even if the microscope is stored in a cabinet. Eye tubes also need to be kept free of dust so do not store a microscope without the eyepieces. If the microscope eyepieces must be removed, cover the tubes with caps or a plastic bag with a rubber band around the eye tube.

v. Look after the bulb

After using the microscope, turn off the illuminator and wait for it to cool for several minutes before putting it away. By allowing the bulb to cool you will extend its life. When turning the microscope on and off, use the switch not the power point. Do not switch the microscope on while using full light intensity. Never touch the bulb with your fingers as the body oils can burn into the bulb and reduce its life. Use a tissue. Keep a store of replacement bulbs and always use the correct bulb.

vi. Store in a clean, dry place

Make sure you do not store your microscope in an area that has corrosive chemical fumes that can destroy lenses or metal parts or beside solutions that may leak. Salt air and pervasive damp can also cause damage over time. Make sure your cabinet is ventilated.

4.3.2.3. Self-assessment

1. Define the following terms as used in food microbiology
    A. Incubation period
    B. Microbiology
    C. Food spoilage
2. _____________ are eukaryotic cells with rigid cell walls and they grow mainly as single-celled and reproduce by budding
    A. Protozoa
    B. Fungi
    C. Viruses
    D. Bacteria

3. The microscope which is used to study the behaviour of living cells, observe the nuclear and cytoplasmic changes taking place during mitosis is called___
   A. Phase-contrast microscope
   B. Electron microscope
   C. Fluorescence microscope
   D. Dark field microscopy
4. The metabolites of fungal intoxications are known as_______
   A. Aflatoxins
   B. Mycotoxins
   C. Toxins
   D. Aflatoxicosis
5. Describe the basic types of food microorganisms
6. Discuss the roles of microorganisms in food safety and spoilage
7. Discuss the different types of microscopes
8. Explain the care and maintenance of microscopes

4.3.2.4 Tools, Equipment, Supplies and Materials

Laboratories | Microscopes | Glass slides | Dye | Reagents | Specimen

Stationery

4.3.2.5 References

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4.3.3 Learning Outcome 2: Demonstrate the knowledge of physiology, genetics, biochemistry and behavior of food microorganisms

4.3.3.1 Learning Activities

Learning activity	Special instructions
Demonstrate understanding of physiology, genetics and biochemistry of microorganisms	Describe physiology, genetics an biochemistry of microorganisms
Describe bacterial anatomy	Illustrate the anatomical structure of a bacterial cells
Identify and describe factors that influence growth and activity of food microorganism	Consider how the food can be manipulated to eliminate factors that support growth of microorganisms
Describe the growth pattern of a typical bacterial colony	Identify the activities that may hinder the growth of a bacterial colony
Demonstrate and describe the gram stain method and AFB test	Carry out gram staining on various bacterial cells Mount the cells on a light microscope and Identify the cells Draw your observation and label the cells and AFB tests for various

4.3.3.2 Information Sheet

Introduction

Definitions

- Pathogens - are disease causing microorganisms (bacteria, viruses, parasite and fungi)
- Bacteria - single celled living microorganisms responsible for the decay of many plant and animal diseases.
- Virus - The smallest of the microbial food contaminants, viruses rely on a living host to reproduce.
- Parasite - An organism that needs a living host to survive.
- Fungi - can be single celled or multi cellular microorganisms can that can cause food spoilage and lives by absorbing nutrients from organic matter
- pH - – potential of Hydrogen. A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, with increasing alkalinity and decreasing with increasing acidity. The pH scale commonly in use ranges from 0 to 14.
- Spore - The spore is formed by some bacteria, thickens walls to protect from adverse condition such as extreme acidity and temperature.

- Vegetative Stage - is a condition favorable for bacteria to grow and multiply rapidly.
- Budding Reproduction – a form of asexual reproduction where in new bud or bump is formed from the mother cell.
- Water Activity – The amount of moisture available in food for microorganisms to grow.

Characteristics of predominant microorganisms in food

Based on the organization of their cellular structures, all living cells can be divided into two groups: eukaryotic and prokaryotic

Eukaryotic cell types include animals, plants, fungi, protozoans, and algae

Prokaryotic cell types include bacteria & blue green algae

Bacteria

- Bacteria cells are prokaryotic
- Bacteria consist of only a single cell (unicellular)
- Bacteria reproduce through “binary fission” when one cell divides to form two new cells
- All bacteria exist in a vegetative stage
- Some bacteria has the ability to form a spore where they can survive in an adverse or extreme conditions “spore forming bacteria”
- Bacteria are “photosynthetic”, they have the ability to make their own food through the use of the sunlight, thus bacteria also gives off oxygen.
  - An average bacterium measures 1 micrometer

Bacterial Shapes and Arrangement

Bacteria are majorly classified on the basis of;

i. Shape – coccus, bacillus, spirillum, vibrio

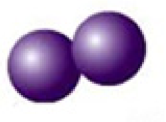
ii. Ability to retain certain dyes

iii. Ability to grow in presence or absence of air

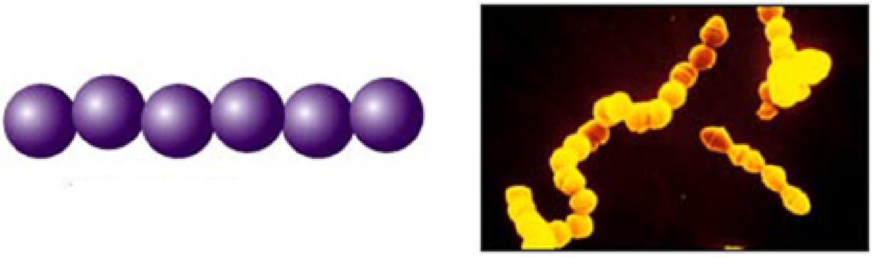
iv. Biochemical reactions

Shapes of bacteria

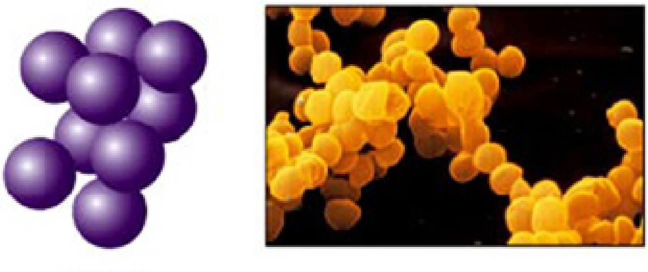
Coccus are spherical/round shaped



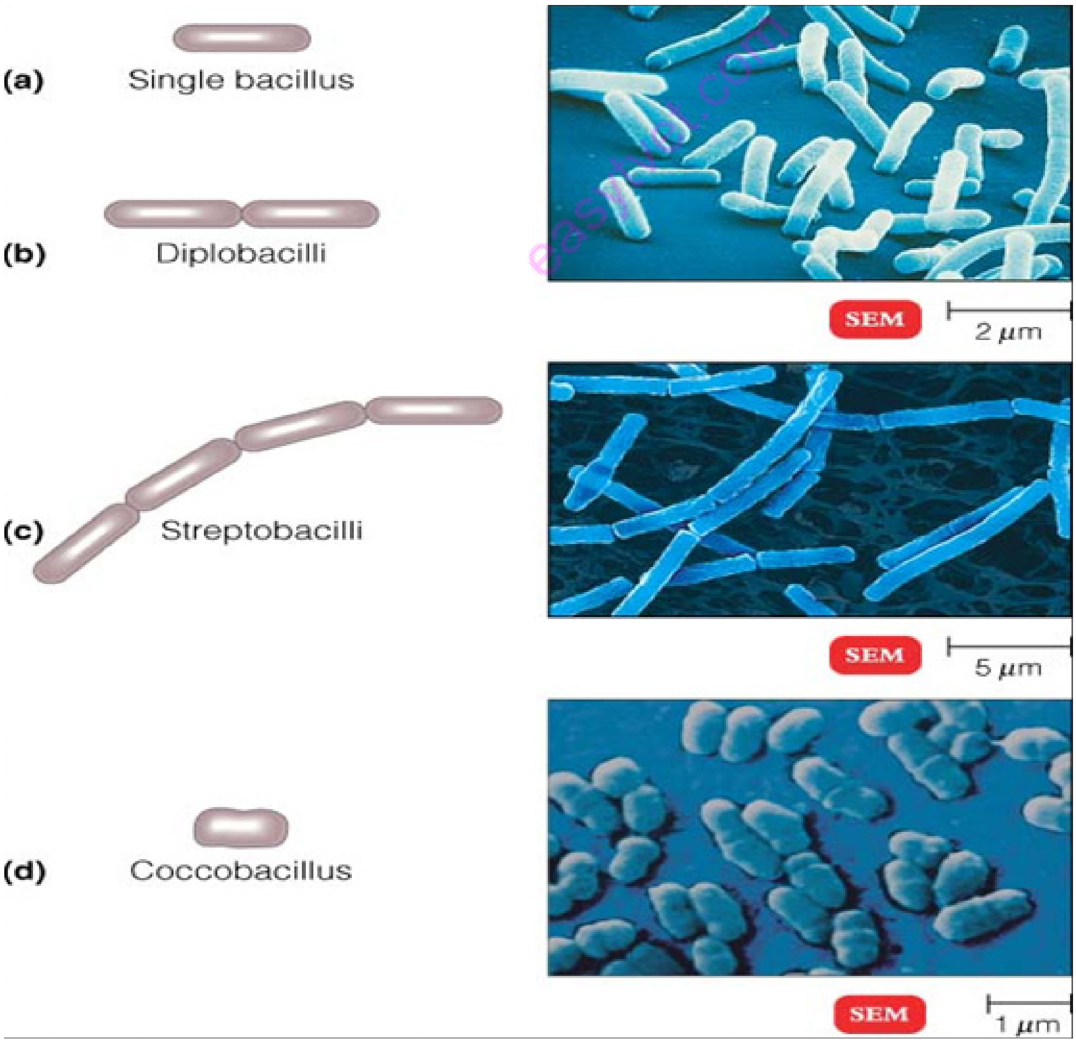
If they appear as a chain they are referred to as Streptococcus



If they appear in a Cluster form, they are referred to as Staphylococcus



- Bacillus – are rod shaped bacteria



- If a in a chain form, they are referred to as Streptobacillus
- Cocco bacillus is intermediate form of Coccus and bacillus
- Vibrio are curved
- Spirillums have a helical rigid shape
- Spirochetes have a helical flexible shape
- Actinomycetes are bacteria that have branching filamentous bacteria
- Mycoplasmas are bacteria that lack cell wall

BACTERIA CELL CYTOLOGY

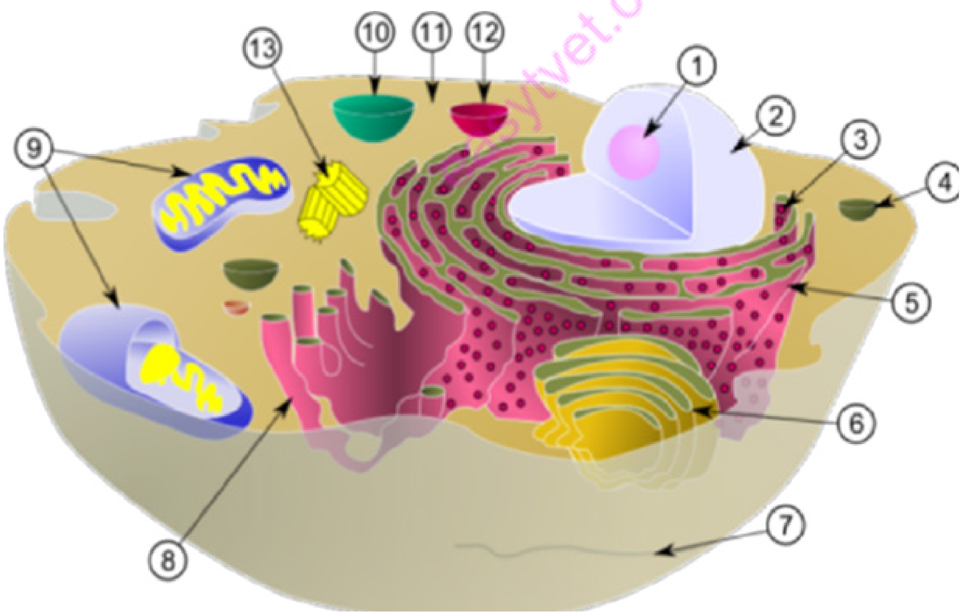
Prokaryotic Cells

Much smaller (microns) and more simple than eukaryotes

Prokaryotes are molecules surrounded by a membrane and cell wall.

They lack a true nucleus and don't have membrane bound organelles like mitochondria, etc.

Large surface-to-volume ratio: nutrients can easily and rapidly reach any part of the cells interior.



Schematic of typical animal (eukaryotic) cell, showing subcellular components

Organelles:

(1) Nucleolus	(2) Nucleus
(3) Ribosome	(4) Vesicle
(5) Rough endoplasmic reticulum (ER)	(6) Golgi apparatus

(7) Cytoskeleton

(8) Smooth ER

(9) Mitochondria

(10) Vacuole

(11) Cytoplasm

(12) Lysosome

(13) Centrioles

Size of Bacteria

Unit of measurement in bacteriology is the micron (micrometer, µm)

Bacteria of medical importance range form 0.2 – 1.5 µm in diameter and 3 – 5 µm in length

CELL WALL

Outermost layer, encloses cytoplasm

- Confers shape and rigidity
- 10 - 25 nm thick
- Composed of complex polysaccharides (peptidoglycan/ mucopeptide) - formed by N acetyl glucosamine (NAG) & N acetyl muramic acid (NAM) alternating in chains, held by peptide chains.
- It carries bacterial antigens – important in virulence & immunity
- Chemical nature of the cell wall helps to divide bacteria into two broad groups – Gram positive & Gram negative

Gram negative: contain outer membrane which is composed of lipopolysaccharides (due to many enzymes, antibiotics, salts, etc

Gram positive: have thick wall composed of several layers of mucopeptide and teicnoic

- Gram +ve bacteria have simpler chemical nature than Gram –ve bacteria.
- Several antibiotics may interfere with cell wall synthesis e.g. Penicillin, Cephalosporin

There two types of cells walls Gram positive cell wall and Gram negative cell wall

CYTOPLASMIC ORGANELLES

Cytoplasmic (Plasma) membrane

- Thin layer 5-10 nm, separates cell wall from cytoplasm
- Acts as a semipermeable membrane: controls the inflow and outflow of metabolites
- Composed of lipoproteins with small amounts of carbohydrates

Cytoplasmic Components

Ribosomes; site for protein synthesis

Mesosomes – Multilaminated structures formed as invaginations of plamisc membrane

- Principal sites of respiratory enzymes
- Coordinate nuclear & cytoplasmic division during binary fission
- More prominent in Gram +ve bacteria

Intracytoplasmic inclusions – reserve of energy & phosphate for cell metabolism e.g. metachromatic granules in diphtheria bacilli

Nucleus

Has no nucleolus and does also not have a nuclear membrane

Its' genome is single, circular double stranded DNA.

It is a haploid and divides by binary fission

Additional Organelles

- Plasmid

Extranuclear genetic elements consisting of DNA. They are transmitted to daughter cells during binary fission. May be transferred from one bacterium to another but are not essential for life of the cell. They confer certain properties e.g. drug resistance, toxicity

- Capsule & Slime layer

Is a viscous layer secreted around the cell wall.

It is polysaccharide / polypeptide in nature, sharply defined structure, antigenic and Protects bacteria from lytic enzymes, it inhibits phagocytosis and is stained by negative staining using India ink.

Slime layer is a loose undemarcated secretion.

- Flagella

Long (3 to 12 µm), filamentous surface appendages

They are organs of locomotion.

Chemically, composed of proteins called flagellins

The number and distribution of flagella on the bacterial surface are characteristic for a given species - hence are useful in identifying and classifying bacteria

Flagella may serve as antigenic determinants (e.g. the H antigens of Gram-negative enteric bacteria)

Presence shown by motility e.g. hanging drop preparation.

Types of flagella arrangement

Polar/ Monotrichous – single flagellum at one pole

Lophotrichous – tuft of flagella at one pole

Amphitrichous – flagella at both poles

Peritrichous – flagella all over

Amphilophotrichous – tuft of flagella at both ends

Additional Organelles

Fimbriae/ Pili

Thin, hair like appendages on the surface of many Gram-negative bacteria 10-20μ long, acts as organs of adhesion (attachment) - allowing bacteria to colonize environmental surfaces or cells and resist flushing.

Made up of proteins called pilins.

Pili can be of two types

i. Common pili; short & abundant

ii. Sex pili; small number (one to six), very long pili, helps in conjugation (process of transfer of DNA)

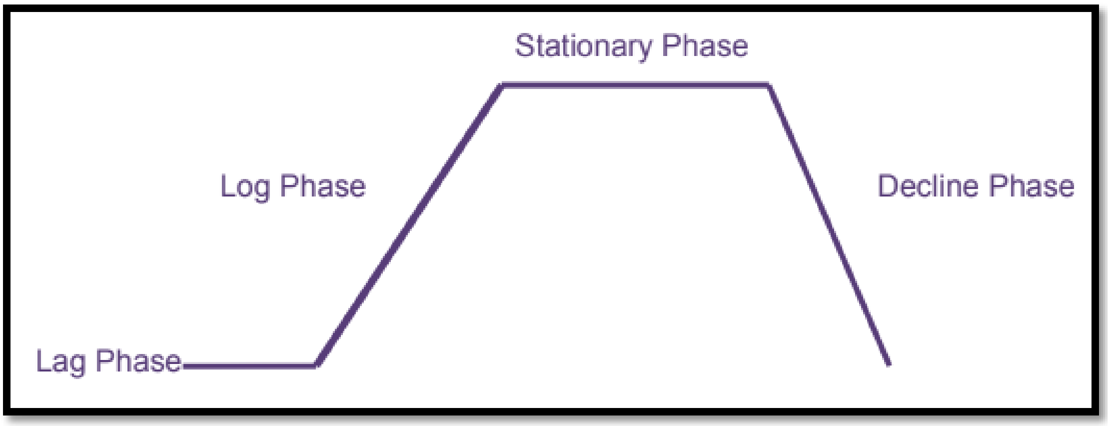
Additional Organelles

Highly resistant resting stages formed during adverse environment (depletion of nutrients).

They are formed inside the parent cell, hence called endospores. They are very resistant to heat, radiation and drying and can remain dormant for hundreds of years. Are formed by bacteria like Clostridia and bacillus

Phases of growth of bacteria

1. Lag Phase –bacteria adapt themselves to growth conditions. It is the period where the individual bacteria are maturing and not yet able to divide.
2. Log Phase or Logarithmic Phase –"exponential phase" growth is very rapid, doubling in numbers in every few minutes
3. Stationary Phase - the growth rate slows as a result of nutrient depletion and accumulation of toxic products. This phase is reached as the bacteria begin to exhaust t.he resources that are available to them.
4. Death or Decline Phase - bacteria run out of nutrients and die



Conditions bacteria needs to grow and multiply

1. Food
2. Acidity
3. Temperature
4. Time
5. Oxygen
6. Moisture

Food

Bacteria feed on Protein and Carbohydrates. Foods that contain these items can support the growth of microorganisms.

Potentially Hazardous Foods have the potential for contamination, they have the characteristics to allow microorganisms to grow and multiply.

How to Control the Growth of Bacteria in Food

1. Purchase from reputable suppliers
2. Avoid cross-contamination of food
3. Cook food to safe internal temperature and test with food thermometer

Acidity:

- Bacteria grows best at a slightly acidic and slightly neutral environment (pH 4.6 to 7.5)
- Some bacteria can develop a "spore" such as acidophilic bacteria, where it could grow and multiply in an acidic environment
- Bacteria such as E-Coli can grow in unpasteurized apple that has a pH value of 4.0

Growth of bacteria in different pH

	Total magnification
Below 4.6	Bacteria will not grow
Between 4.6 to 7.0	Bacteria will thrive
Between 7.0 to 9.0	Bacteria may survive

How to Control Acidity to Control the Growth of Bacteria:

1. Highly acidic foods such as vinegar and lemon inhibit the growth of microorganism.
2. Salad dressing made with vinegar, oil and garlic can make as a marinade for meat

Time

- Under ideal conditions, bacterial cells can double in number every 25 minutes to 30 minutes.
- Pathogens starts to multiply in four hours at the Temp. Danger Zone

How to Control Time to Control the Growth of Bacteria

1. Store received foods as quickly as possible to limit the time in Temp. Danger Zone
2. If the foods will not be cooked or served right away, store it inside the refrigerator or freezer
3. Check temperature on holding cabinets, make sure that it maintains the internal of 135ºF and above
4. Document food inside the storage room, practice First In First Out
5. Reheat foods at the internal temperature of 165ºF for 15 seconds

Temperature

- Temperature danger zone: temperature range 5°C to 60°C
- Food borne bacteria grow and reproduce.
- Temperature Abuse –foods that have not been to a safe temperature or kept at the proper temperature
- Psychrophilic bacteria – grow within the temperature range of 32ºF(0ºC) – 70ºF (21ºC) (spoilage organisms)
- Mesophilic bacteria – grow at temp. 70ºF(21ºC) – 110ºF(43ºC)
- Thermophilic bacteria – grows best above 110ºF (43º C)

How to control temperature to Control the Growth of Microorganism

1. Cold foods, must be stored at 5°C and below
2. Hot foods, must be held at 140°C (60°C) and above
3. Control the temperature of food during storing, preparing, cooking, holding, reheating and serving.
4. Check internal temperature regularly
5. Cook food at a required internal temperature with a food thermometer
6. Keep food out of Temperature danger zone

Oxygen

Bacteria differ in their oxygen requirement.

Anaerobic bacteria – cannot survive when oxygen is present because it is toxic to them.

Anaerobic bacteria grow well in vacuum packaged foods or canned foods where oxygen is not available.

Aerobic bacteria – need oxygen to grow

Facultative anaerobic bacteria – can grow with or without free oxygen but have a preference

Microaerophilic organisms – can survive in a very little amount oxygen

How to Control Oxygen to Control the Growth of Microorganism

1. Bacteria grow in different oxygen requirement, it is difficult to control this condition.
2. Bacteria such as Clostridium Botulinum and Clostridium Perfringens live without

The presence of oxygen, it is important to cool foods in a shallow pan.

Moisture

Moisture is important factor in bacterial growth. The amount of water available for bacterial activity.

- Water Activity level – is the measure of the amount of water that is not available for bacterial to grow. (0- 10)
- Potentially hazardous foods (PHF) – foods that have a water activity level of .85 or higher.

How to Control Moisture to Control the Growth of Microorganism

1. Lower the amount of moisture in food through freezing, dehydrating, adding sugar or salt.

The growth pattern of a typical bacterial colony.

Bacteria growing in batch culture produce a growth curve with up to four distinct phases.

Batch cultures are grown in tubes or flasks and are closed systems where no fresh nutrients are added or waste products removed.

Lag phase occurs when bacteria are adjusting to the medium. For example, with a nutritionally poor medium, several anabolic pathways need to be turned on, resulting in a lag before active growth begins

In log or exponential phase, the cells are growing as fast as they can, limited only by growth conditions and genetic potential. During this phase, almost all cells are alive, they are most nearly identical, and they are most affected by outside influences like disinfectants.

Due to nutrient depletion and/or accumulation of toxic end products, replication stops and cells enter a stationary phase where there is no net change in cell number.

Death phase occurs when cells can no longer maintain viability and numbers decrease as a proportion.

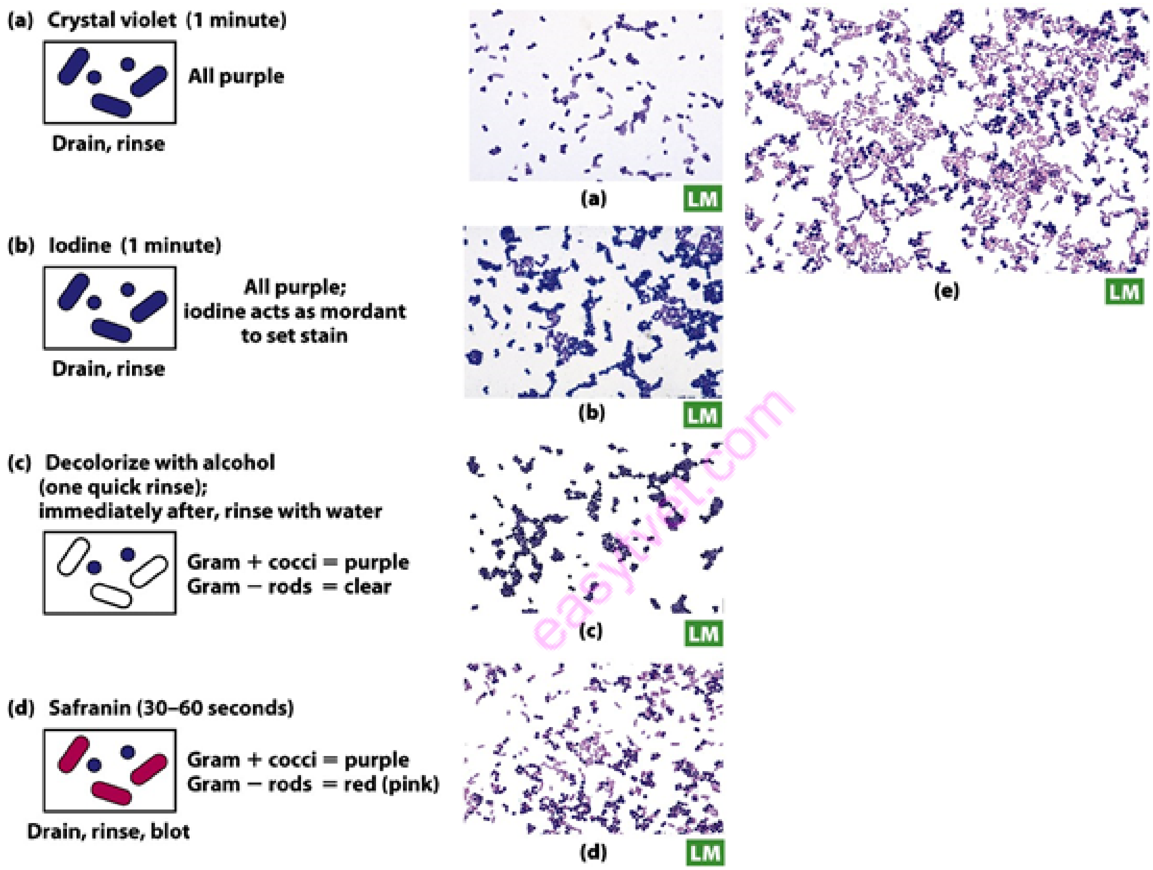
The gram stain method

i. Stain with crystal violet (1 minute). Drain and rinse with water

ii. Flood with iodine(mordant) for one minute

iii. Decolourise with alcohol(1 minute) and rinse with water immediately after

iv. Counterstain with safranin for about 30-60 seconds



AFB test

The Ziehl-Neelsen stain, also known as the acid-fast stain, was first described by two German doctors; Franz Ziehl (1859 to 1926), a bacteriologist and Friedrich Neelsen (1854 to 1894), a pathologist. It is a special bacteriological stain used to identify acid-fast organisms, mainly Mycobacteria. Mycobacterium tuberculosis is the most important of this group, as it is responsible for the disease called tuberculosis (TB). It is helpful in diagnosing Mycobacterium tuberculosis since its lipid rich cell wall makes it resistant to Gram stain. It can also be used to stain few other bacteria like Nocardia. The reagents used are Ziehl-Neelsen include carbolfuchsin, acid alcohol and methylene blue.

i. The sputum is spread evenly centrally over a slide about 20mm by 10mm in size.

ii. The slides are placed on a drier with smeared surface facing upwards, and air dried for about 30 minutes

iii. The smear is then fixed dried by heating

iv. The smear is then covered with carbol fuchsin

v. The smear is heated until there is vapor formation at about 60 degrees Celsius taking care not to overheat; avoiding boiling. And allow the stain to be on the side for about 5 minutes

vi. Clean water is then used to wash off the stain

vii. Cover the smear with 3% v/v acid alcohol for 2-5 minutes (or 20% sulfuric acid) or until the smear is sufficiently decolorized, i.e. pale pink.

Note: Check to see that no more red color runs off the surface when the slide is tipped. Add a bit more decoloriser for very thick slides or those that continue to “bleed” red dye

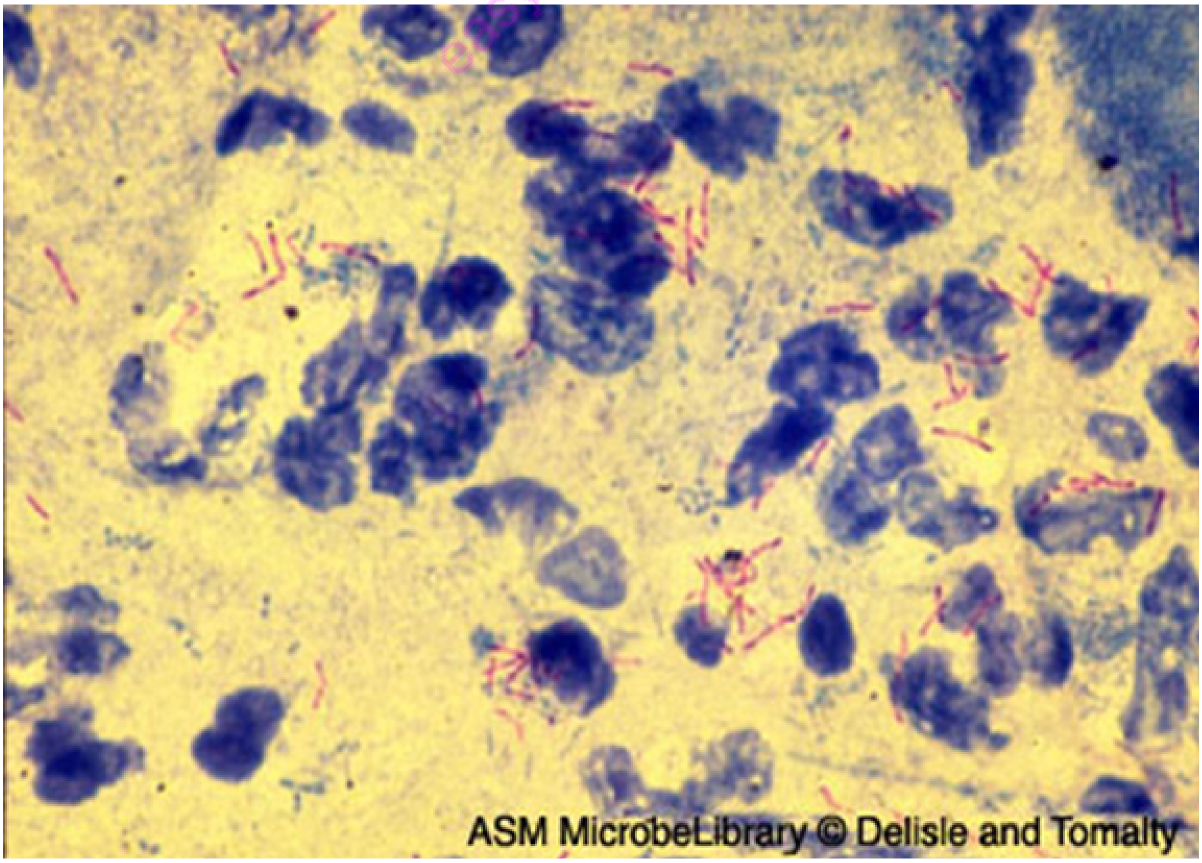
viii. The slide is washed with water

ix. The stain is covered with malachite green for 1 -2 minutes

x. Wash off stain with clean water

xi. Wipe the back of the slide clean, and place it in a draining rack for smear to air dry (DO NOT BOLT DRY).

xii. Examine the smear microscopically, using the 100x oil immersion objective (10X eye piece for a total of 1000X magnification) and scan the smear systematically.



Fungi

- Fungi are a group of organisms and micro-organisms that are classified within their own kingdom, the fungal kingdom, as they are neither plant nor animal.
- Fungi draw their nutrition from decaying organic matter, living plants and even animals.
- Many play an important role in the natural cycle as decomposers and return nutrients to the soil, they are not all destructive.
- Fungi usually reproduce without sex. Single-celled yeasts reproduce asexually by budding.

Examples of Fungi are:

1) Mold

- Eukaryotic cells
- Multicellular
- Non motile, filamentous and branched
- Composed of large numbers of filaments called hyphae which are aggregated and called mycelium.
- Reproduction occurs from spore formation.
- Mold cause spoilage in food and could cause illnesses
- They grow under almost any conditions, but grow well in sweet, acidic food with low water activity.
- Freezing temperatures prevent or reduce the growth of molds, but not destroyed
- Some molds produce called “aflatoxins”
- Example: penicllium spp.

2) Yeasts

- Eukaryotic cells
- Unicellular
- Round, oval (spherical) or elongated
- Non motile, can see budding formation
- Remain in yeast form at both room temperature (25°C) and body temperature (37°C)
- Reproduction is by asexual process called budding
- Yeast also cause food spoilage
- Yeast spoilage produce a smell or taste of alcohol. They appear in pink color discoloration
- They also grown well in sweet, acidic foods with low water activity level. Such as jellies, honey and fruit juices.

Example: Sacchromyces cerevisiae

Molds

Molds are multicellular filamentous fungi whose growth on foods usually is readily recognized by its fuzzy or cottony appearance. The main part of growth commonly appears white but may be colored, dark or smoky.

They are microscopic, plant-like organisms, composed of long filaments called hyphae. Mould hyphae grow over the surface and inside nearly all substances of plant or animal origin. Because of their filamentous construction and consistent lack of chlorophyll they are considered by most biologists to be separate from the plant kingdom and members of the kingdom of fungi. They are related to the familiar mushrooms and toadstools, differing only in not having their filaments united into large fruiting structures. For our purposes here, we shall consider as molds only fungi that are commonly encountered n the home and laboratory and that can be easily grown and studied.

When mold hyphae are numerous enough to be seen by the naked eye they form a cottony mass called a mycelium. It is the hyphae and resulting mycelia that invade things in our homes and cause them to decay.

Reproduction in fungi is complex and involves a great diversity of structures. At the most fundamental level we can say that most molds reproduce by spores. Spores are like seeds; they germinate to produce a new mold colony when they land in a suitable place. Unlike seeds, they are very simple in structure and never contain an embryo or any sort of preformed offspring. Spores are produced in a variety of ways and occur in a bewildering array of shapes and sizes. In spite of this diversity, spores are quite constant in shape, size, colour and form for any given mould, and are thus very useful for mould identification.

The most basic difference between spores lies in their method of initiation, which can be either sexual or asexual. Sexually initiated spores result from a mating between two different organisms or hyphae, whereas asexual spores result from a simple internal division or external modification of an individual hypha. The recognition of a mating and subsequent spore formation is often difficult for an observer, and is usually reserved for patient specialists. However, for practical purposes one can learn to recognize certain indications of the sexual process, namely, the four kinds of sexually determined spores that appear in mold fungi:

a. Oospores

b. zygospores

c. ascospores, and

d. basidiospores.

Viruses

- Microbes are single-celled organisms that can perform the basic functions of life — metabolism, reproduction, and adaptation.
- Viruses can't metabolize nutrients, produce and excrete wastes, move around on their own, or even reproduce unless they are inside another organism's cells.
- Viruses are the simplest and tiniest of microbes; they can be as much as 10,000 times smaller than bacteria.

- Viruses comes in many sizes and shapes
- Viruses consist of a small collection of genetic material (DNA or RNA) encased in a protective protein coat called a capsid.
- Some may survive in freezing and cooking
- They aren't even cells (non cellular entities).
- Most important are bacteriophages (bacterial viruses)

Parasite

- A parasite is an organism that lives by feeding upon another organism. Parasites living in the human body feed on our cells, our energy, our blood, the food we eat and even the supplements we take.
- There are several types of parasites: protozoa are single celled organisms that are only visible under a microscope, while worms come in all sizes from threadworms that measure less than one centimetre to tapeworms that grow up to 12 meters in length.
- They grow naturally in many animals such as pigs, cats and rodents
- They can be killed by proper cooking or freezing

How one gets parasites

- Contaminated or unfiltered water
- Contaminated soil
- Contaminated fruits and vegetables
- Raw or rare meat
- Pets Mosquitoes Contact with faeces
- Contact with someone with parasites

Factors that influence growth and activity of food microorganisms

Oxygen

Microorganisms have a range of oxygen requirement and on this basis can be grouped on the need for oxygen to grow.

Facultative anaerobic bacteria can grow in high oxygen or low oxygen content and are among the more versatile bacteria

In contrast, strictly anaerobic bacteria grow only in conditions where there is minimal or no oxygen present in the environment. Bacteria such as bacteroides found in the large bowel are examples of anaerobes.

Strict aerobes only grow in the presence of significant quantities of oxygen. Pseudomonas aeruginosa, an opportunistic pathogen, is an example of a strict aerobe.

Microaerophilic bacteria grow under conditions of reduced oxygen and sometimes also require increased levels of carbon dioxide. Neisseria species (e.g., the cause of gonorrhoea) are examples of microaerophilic bacteria.

Water Activity

Bacteria need water to dissolve the food they use for energy and growth. Water allows the food to get into the cells, is used for the many chemical reactions necessary for life and growth, and allows waste products to escape.

Food/Nutrients -- All bacteria require energy to live and grow. Energy sources such as sugars, starch, protein, fats and other compounds provide the nutrients.

Temperature:

Bacteria in general are capable of growing over a wide range of temperatures and are usually classified according to the temperature at which they grow.

Psychotropic bacteria are those that are capable of growing at 32°F - 45°F but their optimum is from 68°F to 86°F. They cause spoilage in foods stored under refrigeration.

Several pathogenic bacteria are psychotropic -- Yersinia and Listeria.

Mesospheric bacteria are bacteria are capable of growing at 60°F - 110°F and belong in this group. Most pathogenic bacteria grow at these temperatures.

Thermophilic bacteria grow at higher temperatures such as 110°F - 150°F.

Temperature is the most widely used method of controlling bacterial growth. Bacteria grow slowly at temperatures below 45°F and thermal destruction occurs at temperatures above 140°F. But in the temperature danger zone between 40°F and 140°F many bacteria are not controlled.

pH

pH is a measure of acid or alkali in a product. It is indicated on a scale from 0 to 14, with seven being neutral. If the pH value is below 7, the food is classified as acid; if it is above 7, the food is classified as alkaline. Most bacteria grow well at neutral pH, but many can reproduce in a pH range from 4.5 - 10.0.

4.3.3.3 Self-Assessment

1. The following are types of flagella arrangements except

   A. Filamentous B. Lophotrichous

   C. Amphitrichous D. Peritrichous

2. Spirillums _________________

A. Are curved in shape
B. Have helical rigid shape
C. Lack a cell wall
D. Have branching filamentous

3. AFB test is used in diagnosis of

A. Clostridium Botulinum
B. Shigellosis
C. Mycobacterium Tuberculi
D. Listeriosis

4. Differentiate between a eukaryotic cell and a prokaryotic cell
5. Explain how the bacterial cells are classified
6. Distinguish between cocci and rod bacterials
7. Differentiate between gram positive and gram negative bacterias
8. Highlight the factors that influence growth and activity of microorganisms
9. Identify the basis of bacterial cells classification
10. Illustrate the structure of bacterial cell using a well labelled diagram
11. Explain how AFB test is performed and how positive results are presented
12. Discuss fungi as one of the microorganisms of interest to food

4.3.3.4 Tools, Equipment, Supplies and Materials

- Microscopes | Laboratory reagents | Stationery | Laboratory equipment | Laboratory

4.3.3.5 References

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4.3.4 Learning Outcome 3: Demonstrate the knowledge on microbiology of food fermentation

4.3.4.1 Activities

Learning activity	Special instructions
Identify and describe Terminologies in food fermentation and its importance are	Define various terms used in food fermentation • Fermentation
Identify and describe microorganisms in fermentation process	Identify microorganisms that cause fermentation Describe the role these microorganisms play in fermentation
Fermentation processes in different types of food are identified and described	Demonstrate ability to describe the fermentation process • Types of fermentation Identify the products of fermentation • Dairy products • Meat and fishery products • Non beverage plant products • Beverages and related products • Breads Process fermented foods

4.3.4.2 Information Sheet

Meaning of terms in food fermentation

Fermentation: a process in which chemical changes are brought about in an organic substrate through the action of enzymes elaborated by microorganisms

Starter culture: a preparation of living microorganisms, which are deliberately used to assist the beginning of fermentation, producing specific changes in the chemical composition and the sensorial properties of the substrate to obtain a more homogeneous product.

Probiotics: refers to the consumption of products that contain live organisms that are or are believed to be beneficial to the consumer.

Microorganisms in fermentation process

Fermentation involves any partial breakdown of carbohydrates taking place in the absence of oxygen. It is a metabolic process that converts sugar to acids, gases or alcohol. Biochemically, fermentation is the metabolic process in which carbohydrates and related compounds are partially oxidized with the release of energy in the absence of any external electron acceptors.

Fermenting organisms are dependent on intrinsic and extrinsic parameters of growth.

Types of fermentation

- Top fermentation: refers to the use of a yeast strain that carries out its activity at the upper parts of a large vat, such as in the production of ale
- Bottom fermentation: a type of fermentation that requires the use of a yeast strain that will act in lower parts of the vat, such as in the production of lager beer.

Importance of fermentation

a) Extended shelf life

b) Improved aroma and flavor characteristics

c) Increased vitamin content

d) Increased digestibility

e) Reduced toxicity from some foods e.g. fermentation of cassava to make gari

• Fermentation processes in different types of food; dairy products, grains, meats, fruits and vegetable and beverages

Products of fermentation

1. Dairy products
2. Meat and fishery products
3. Non beverage plant products
4. Beverages and related products
5. Breads
7. Dairy products

Milk Biota

The microorganisms in raw cow's milk consist of those that may be present on the cow's udder and hide and on milking utensils or lines.

Under proper handling and storage conditions, the predominant biota is gram positive.

Raw milk held at refrigerator temperatures for several days invariably shows the presence of several or all bacteria of the following genera: Enterococcus, Lactococcus, Streptococcus, Leuconostoc, Lactobacillus, Microbacterium, Oerskovia, Propionibacterium, Micrococcus, Proteus, Pseudomonas, Bacillus, and Listeria.

Studies have revealed the presence of psychrotrophic spore formers and mycobacteria in raw milk. Campylobacteriosis and salmonellosis are well established as illnesses that may be contracted from milk and milk products. Listeriosis and hemorrhagic colitis outbreaks have also been traced to milk. Questions have been raised over the efficacy of milk pasteurization to destroy Mycobacterium paratuberculosis. The concern has to do with the fact that this bacterium causes Johne's disease in cattle, and appears to play a role in Crohn's disease of humans.

The spoilage of pasteurized milk products has two common origins;

1. First is the growth and metabolic activity of psychrotrophic organisms such as Pseudomonas, Alcaligenes, and Fiavobacterium spp. These gram-negative rods, which are usually lipolytic and proteolytic, are postpasteurization contaminants. The proteolytic organisms are able to cause a destabilization of the casein micelles and cause a "sweet-curdling" of the milk. However, the predominant spoilage is manifest by bitter and fruity off-flavors.
2. Second is the growth of heat-resistant organisms that are able to ferment lactose to lactic acid, and when the pH is reduced to about 4.6, the milk curdles. If mold spores are present, they may germinate and grow at the surface of the sour milk and elevate pH toward neutrality, thus allowing the more proteolytic bacteria such as Pseudomonas spp. to grow and bring about the liquefaction of the milk curd.

In extended-shelflife milk products (ultrahigh-temperature-pasteurized, UHT; spoilage by psychrotrophic spore formers is a significant problem. Organisms such as Bacillus cereus can survive the UHT process, and because of the longer shelf life, can initiate growth and produce toxins as well as causing "sweet-curdling" of the products.

Starter culture

- A lactic starter is a basic starter culture with widespread use in the dairy industry. For cheese making of all kinds, butter, cultured buttermilk, cottage cheese, and cultured sour cream
- Lactic starters always include bacteria that convert lactose to lactic acid, usually *L. lactis subsp. lactis, L. lactis subsp. cremoris*, or *L. lactis subsp. lactis biovar diacetylactis*.
- Where flavor and aroma compounds such as diacetyl are desired, the lactic starter will include a heterolactic such as *Leuconostoc mesenteroides subsp. cremoris, L. lactis subsp. lactis biovar diacetylactis, or Leuconostoc mesenteroides subsp. Dextranicum*
- Butter, buttermilk, and sour cream are produced generally by inoculating pasteurized cream or milk with a lactic starter culture and holding until the desired amount of acidity is attained.

1. Butter

- Milk cream is inoculated, the acidified cream is then churned to yield butter, which is washed, salted, and packaged.
- Butter undergoes fungal spoilage rather commonly by species of *Cladosporium, Alternaria, Aspergillus, Mucor, Rhizopus, Penicillium,* and *Geotrichum*, especially *G. candidum*

2. Buttermilk

- As the name suggests, it is the milk that remains after cream is churned for the production of butter.
- The commercial product is usually prepared by inoculating skim milk with a lactic or buttermilk starter culture and holding until souring occurs.
- The resulting curd is broken up into fine particles by agitation, and this product is termed cultured buttermilk.

3. Sour cream

- Cultured sour cream is produced generally by fermenting pasteurized and homogenized light cream with a lactic starter.
- These products owe their tart flavor to lactic acid and their buttery aroma and taste to diacetyl.

4. Yogurt (yoghurt)

- Produced with a yogurt starter, which is a mixed culture of *S. thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* in a 1:1 ratio.
- The coccus grows faster than the rod and is primarily responsible for initial acid production at a higher rate than that produced by either when growing alone, and more acetaldehyde (the chief volatile flavor component of yogurt) is produced by *L. delbrueckii* subsp. bulgaricus when growing in association with S. thermophiles.
- The coccus can produce about 0.5% lactic acid and the rod about 0.6-0.8% (pH of 4.2-4.5
- The product is prepared either by reducing the water content of either whole or skim milk by at least one fourth (may be done in a vacuum pan following sterilization of milk), or by adding about 5% milk solids followed by water reduction (condensing).
- The concentrated milk is then heated to 82°-93°C for 30-60 minutes and cooled to around 45°C.46
- The yogurt starter is now added at a level of around 2% by volume and incubated at 450C for 3-5 hours followed by cooling to 5°C.
- The titratable acidity of a good finished product is around 0.85-0.90%, and to get this amount of acidity the fermenting product should be removed from 450C when the titratable acidity is around 0.65-0.70%.10. Good yogurt keeps well at 5°C for 1-2 weeks.

Process of cheese making

Step 1

- Milk is prepared and inoculated with an appropriate lactic starter.
- The starter produces lactic acid, which, with added rennin, gives rise to curd formation.
- The starter for cheese production may differ depending on the amount of heat applied to the curds.
- *S. thermophilus* is employed for acid production in cooked curds because it is more heat tolerant than either of the other more commonly used lactic starters; or a combination of *S. thermophilusand L. lactis subsp. lactis* is employed for curds that receive an intermediate cook.

Step 2

The curd is shrunk and pressed, followed by salting, and, in the case of ripened cheeses, allowed to ripen under conditions appropriate to the cheese in question.

Examples of fermented dairy products

Food products	Raw ingredients	Fermenting organism
Acidophilus milk	Milk	*Lactobacillus acidophilus*
Bulgarian buttermilk		*L delbrueckii subsp.bulgaricus*
Cheeses (ripened)	Milk curd	Lactic starters
Kefir	Milk	*Lactococcus lactis, Ldelbrueckii subsp. bulgaricus, "Torula" spp.*
Kumiss	Raw Marles milk	*Lactobacillus leichmannii,L. delbrueckii subsp. bulgaricus, "Torula" spp.*
Yogurt	Milk, milk solids	*L. delbrueckii subsp.bulgaricus, S.thermophilus*

Health benefits of fermented milks

a) Benefits to lactose-intolerant individuals

b) They lower serum cholesterol, and

c) Possess an anticancer activity

d) Probiotics

The objective on priobiotics is the ingestion of the organisms, and they consist generally of various lactic acid bacteria and/or bifidobacteria.

Non beverage plant products

These include

- Olives
- Pickels
- Sauerkraut

Olives

Olives to be fermented are done so by the natural biota of green olives, which consists of a variety of bacteria, yeasts, and molds. The olive fermentation is quite similar to that of sauerkraut except that it is slower, involves a lye treatment, and may require the addition of starters. The lactic acid bacteria become prominent during the intermediate stage of fermentation. L. mesenteroides and P. cerevisiae are the first lactics to become prominent, and these are followed by lactobacilli, with L. plantarum and L. brevis being the most important.

Pickels

Pickles are fermentation products of fresh cucumbers, and as is the case of sauerkraut production, the starter culture normally consists of the normal mixed biota of cucumbers.

In the natural production of pickles, the following lactic acid bacteria are involved in the process in order of increasing prevalence: L. mesenteroides, E. faecalis, P cerevisiae, L. brevis, and L. plantarum. Of these the pediococci and L. plantarum are the most involved, with L. brevis being undesirable because of its capacity to produce gas. L. plantarum is the most essential species in pickle production, as it is for sauerkraut.

Sauerkraut

Sauerkraut is a fermentation product of fresh cabbage. The starter for sauerkraut production is usually the normal mixed flora of cabbage.

The addition of 2.25-2.5% salt restricts the activities of gram-negative bacteria, while the lactic acid rods and cocci are favored. Leuconostoc mesenteroides and L. plantarum are the two most desirable lactic acid bacteria in sauerkraut product, with the former having the shorter generation time and the shorter life span.

Beverages and related products

This category of fermented products include;

- Beer
- Wines
- Distilled Spirits
- Ale
- Cider, and

Beer and Ale

These are malt beverages produced by brewing. An essential step in the brewing process is the fermentation of carbohydrates to ethanol.

Because most of the carbohydrates in grains used for brewing exist as starches, and because the fermenting yeasts do not produce amylases to degrade the starch, a necessary part of beer brewing includes a step whereby malt or other exogenous sources of amylase are provided for the hydrolysis of starches to sugars. The malt is first prepared by allowing barley grains to germinate. This serves as a source of amylases.

The process by which the malt and malt adjuncts are dissolved and heated and the starches digested is called mashing.

When lactic acid bacteria are present in beers, the lactobacilli are found more commonly in top fermentations, whereas pediococci are found in bottom fermentations.

Wines

Wines are normal alcoholic fermentations of sound grapes followed by aging. A large number of other fruits such as peaches, pears, and so forth may be fermented for wines, but in these instances the wine is named by the fruit, such as peach wine, pear wine, and the like. Because fruits already contain fermentable sugars, the use of exogenous sources of amylases is not necessary, as it is when grains are used for beers or whiskeys. Wine making begins with the selection of suitable grapes, which are crushed and then treated with a sulfite such as potassium metabisulfite to retard the growth of acetic acid bacteria, wild yeasts, and molds. The pressed juice, called must, is inoculated with a suitable wine strain of S. "ellipsoideus." The fermentation is allowed to continue for 3-5 days at temperatures between 700F and 900F (210C and 32°C), and good yeast strains may produce up to 14-18% ethanol

Cider

Cider is a product that represents a mild fermentation of apple juice by naturally occurring yeasts. In making apple cider, the fruits are selected, washed, and ground into a pulp. The pulp "cheeses" are pressed to release the juice. The juice is strained and placed in a storage tank, where sedimentation of particulate matter occurs, usually for 12-36 hours or several days if the temperature is kept at 40° F or below. The clarified juice is cider. If pasteurization is desired, this is accomplished by heating at 170° F for 10 minutes. The chemical preservative most often used is sodium sorbate at a level of 0.10%. Preservation may be effected also by chilling or freezing. The finished product contains small amounts of ethanol in addition to acetaldehyde. The holding of nonpasteurized or unpreserved cider at suitable temperatures invariably leads to the development of cider vinegar, which indicates the presence of acetic acid bacteria in these products.

Distilled spirits

Distilled spirits are alcoholic products that result from the distillation of yeast fermentations of grain, grain products, molasses, or fruit or fruit products. Whiskeys, gin, vodka, rum, cordials, and liqueurs are examples of distilled spirits. Although the process for producing most products of these types is quite similar to that for beers, the content of alcohol in the final products is considerably higher than for beers. Rye and bourbon are examples of whiskeys. In the former, rye and rye malt, or rye and barley malt, are used in different ratios, but at least 51% rye is required by law. Bourbon is made from corn, barley malt, or wheat malt, and usually another grain in different proportions, but at least 51% corn is required by law. A sour wort is maintained to keep down undesirable organisms, the souring occurring naturally or by the addition of acid.

The mash is generally soured by inoculating with a homolactic such as *L. delbrueckii*, which is capable of lowering the pH to around 3.8 in 6-10 hours.57 The malt enzymes (diastases) convert the starches of the cooked grains to dextrins and sugars, and upon completion of diastatic action and lactic acid production, the mash is heated to destroy all microorganisms. It is then cooled to 75-80° F (24-27°C) and pitched (inoculated) with a suitable strain of *S. cerevisiae* for the production of ethanol. Upon completion of fermentation, the liquid is distilled to recover the alcohol and other volatiles, and these are handled and stored under special conditions relative to the type of product being made. Scotch whiskey is made primarily from barley and is produced from barley malt dried in kilns over peat fires. Rum is produced from the distillate of fermented sugar cane or molasses. Brandy is a product prepared by distilling grape or other fruit wines. Palm wine or Nigerian palm wine is an alcoholic beverage consumed throughout the tropics and is produced by a natural fermentation of palm sap. The sap is sweet and dirty brown in colour, and it contains 10-12% sugar, mainly sucrose. The fermentation process results in the sap's becoming milky-white in appearance due to the presence of large numbers of fermenting bacteria and yeasts.

Sake is an alcoholic beverage commonly produced in Japan. The substrate is the starch from steamed rice, and its hydrolysis to sugars is carried out by A. oryzae to yield the koji. Fermentation is carried out by Saccharomyces sake over periods of 30-40 days, resulting in a product containing 12-15% alcohol and around 0.3% lactic acid.

Bread

To make bread, flour and water are mixed with a live culture of yeast. The yeast uses ethanol fermentation to obtain energy form the sugars in the flour. It does so by breaking down the starch into glucose, which it can feed on. This energy gives yeast the energy it needs to live, and produces alcohol and carbon dioxide as waste. The yeast cells grow, the gluten protein pieces stick together to form networks, and alcohol and carbon dioxide are formed from the breakdown of carbohydrates (starch, sugars) that are found naturally in the flour. Enzymes present in yeast and flour also help to speed up this reaction. The carbon dioxide forms air pockets which then helps the dough to rise thereby making bread fluffy and light.

Meats

Fermented meat products are produced by first mixing meat, fat, salt, sugar, curing agents, and spices; filling the mixture in a casing; and fermenting it either naturally or by adding (during mixing) selected starter-culture bacteria.3 The acids produced by the starters during fermentation and the curing agents used help control the growth of pathogenic and spoilage bacteria that might be present in the meat. A good example of fermented meat product is sausages.

Benefits of fermentation

- Cholesterol synthesis inhaling
- Anticancer effects
- Decreases cooking time hence saves energy
- Prevention of infections
- Increased shelf life
- Adds microbes to the gut
- Improves flavor of food
- Eliminates antinutrients
- Increases micronutrients in food e.g. vit B
- Make food more digestible e. g in Lactose intolerance
- Produces carbon dioxide e.g. in bread, beer, champagne

4.3.4.3 Self-Assessment

1. Define the following terms;

   A. Fermentation

   B. Starter culture

   C. Probiotic

2. The microorganisms added to Swiss cheese to improve flavour and assist eye formation is

   A. *Lactobacillus cremoris*

   B. *Lactobacillus bulgaricus*

   C. *Streptococcus thermophillus*

   D. *Propionibacterium freudenreichii*

3. __________ are the most desirable lactic acid bacteria in sauerkraut product.

    A. *Leuconostoc mesenteroides* and *lactobacillus plantarum*

    B. Lactobacillus leichmannii and *l. Delbrueckii subsp.Bulgaricus*

    C. Lactobacillus acidophilus and *l. Delbrueckii subsp. Bulgaricus*

    D. S. Thermophiles and *L. lactis subsp. Lactis*

4. The yeast uses _______________ to obtain energy form the sugars in the flour during bread making

    A. Top fermentation

    B. Bottom fermentation

    C. Ethanol fermentation

    D. Anaerobic fermentation

5. Explain the two types of fermentation

6. Highlight the importance of fermentation

7. Discuss the fermentation of dairy products

8. Outline the health benefits of fermented milks

9. Discuss the following non beverage plant products of fermentation

    A. Olives

    B. Pickles

    C. Sauerkraut

4.3.4.4 Tools, Equipment, Supplies and Materials

1. Equipped laboratory
2. Cold chains
3. Stationery
4. Staining reagents
5. Culture systems
6. Workplace procedures manual

4.3.4.5 References

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4.3.5 Learning Outcome 4: Demonstrate the knowledge of microbiological aspects of food safety

4.3.5.1 Learning Activities

Learning activity	Special instructions
Demonstrate understanding of terminologies in microbial aspects and in food safety	
Identify and describe microbial aspects of food safety	Apply microbial aspects of food safety • During production • Processing and labeling • Food handling • Distribution and storage • Food preparation • Food use

4.3.5.2 Information Sheet

Definition

Probiotic: Probiotic is a concentrated supplements of beneficial live bacteria culture taken orally intended to improve our health

Microbial aspects of food safety

Food microbiology focuses on all the microbial aspects of food spoilage and quality. During harvesting, food processing and downstream operations food may become contaminated with a wide range of microorganisms.

Food supply consists basically of plants and animals or product derived from them, it is understandable that our food supply can contain microorganism in interaction with food. These microorganisms use food supply as a source of nutrients for their own growth. These will cause two possibilities:

a. Food spoilage

b. Benefits to human

Microorganisms can cause deterioration of food;

- When they utilize the nutrients of the food, it involved changes in the food compound like synthesis a new compound that cause spoiling of the food or produced enzymatic changes and contributing off-flavours by mean of breakdown of product.

For fresh foods the primary food quality changes may be categorized as:

- Oxidation of lipids and pigments in fat-containing foods resulting in undesirable flavours, formation of compounds with adverse biological effects or discoloration
- Bacterial growth and metabolism resulting in possible pH-changes and formation of toxic compounds, off-odours, gas and slime-formation.

Important microorganisms in food

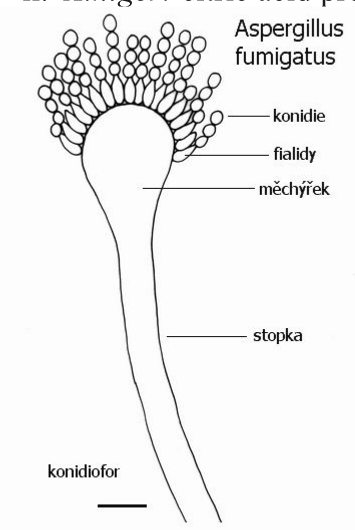
A. Important mold genera

1) Genus Aspergillus

- Widely distributed and contain many species important in food.
- Septate hyphae and produce asexual spores on conidia.
- Xerophilic; causing spoilage in grains, jams, nuts and vegetable.
- Example: *Aspergillus flavus* produce alfatoxin (a kind of mycotoxin)
- Strains used in food processing:

i. *A.oryzae:* hydrolyze starch in sake production.

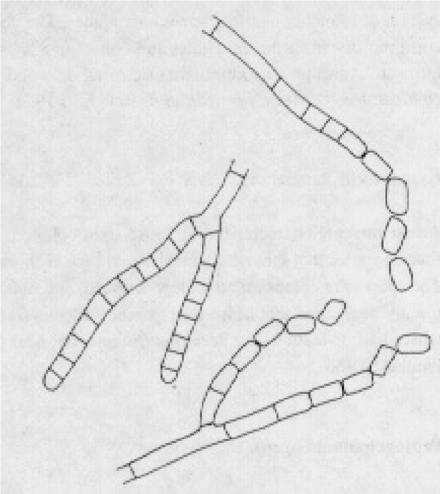
ii. *A.niger:* citric acid production.



Aspergillus

2) Genus Geotrichum

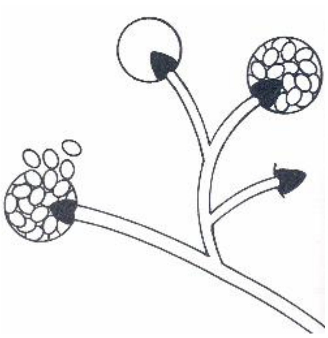
- *Septate hyphae* and produce arthrospore.
- Grow and forming a yeastlike cottony, creamy colony.
- Often grow on dairy products. Example: *Geotrichum candidum*



Geotrichum

3) Genus Mucor

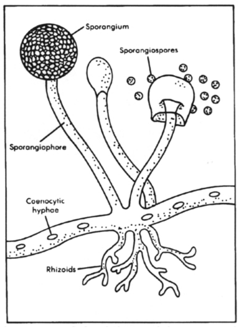
- Widely distributed
- *Nonseptate hyphae* and produce *sporangiophores*
- Some species are used in food fermentation and others can cause spoilage of vegetables e.g: *Mucor rouxii*



mucor

4) Genus Rhizopus

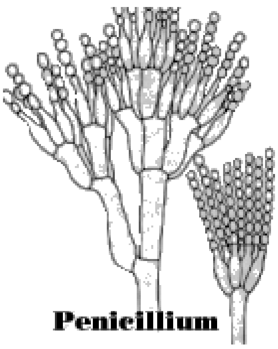
- Hyphae are aseptate and form sporangiophores
- Common in spoilage of foods and vegetables
- Rhizophus stolonifer : common black bread mould



rhizopus

5) Genus penicillium

- Widely distributed and contain many species
- Septate hyphae and form conidiophores on a brushlike conidia head. *Penicillium roquerfortii* and *Penicillium camembertii* are used in cheese production.
- Some species can cause spoilage in fruits, vegetables, grains, bread etc.
- The can also produce mycotoxin



B. Important yeast genera

1. Genus saccharomyces

- Cells may be round, ovate, and elongated.
- Reproduction is by budding or by acospore formation.
- S.cerevisiae is employed in many food industries e.g bread manufacturing, wines, alcohol etc.
- S.fragilis and s.lactis is important in milk and milk products because they are common spoilage microorganism.

2. Genus Torulopsis

- General spoilage yeast.
- Spoils a variety of food products e.g.: beer, milk products, fruit juices and some refrigerated foods.

3. *Genus Candida*

- Many spoil foods with high acid, salt and sugar form pellicle on the surface of liquids.
- Some can cause rancidity in butter and dairy products e.g: *Candida lipolytica*.
- Can form pseudohyphae or true hyphae with many budding cells.

4. *Genus Rhodotrula*

- Red, pink or yellow yeasts may cause discolourations on food such as in meat, fish and sauerkraut.

5. *Genus Pichia*

- Oval or cylindrical yeasts may form *pseudomycelia*.
- Ascospores are round or hat shaped.
- Form pellicle in beer, wine and brine.

C. *Important bacteria genera*

1. *Genus Bacillus*

- Different species may be mesophilic or thermophilic, lipolytic or proteolytic.
- Spores produce by this bacteria are generally heat-resistant.
- Some species may cause foodborne diseases *(Bacillus cereus)* and food spoilage in canned products *(Bacillus coagulans* and *Bacillus stearothermophillus)*
- The soil is an important source of this species.

2. *Genus clostridium*

- Rod shaped cells, anaerobic and form endospores.
- Found in soil, marine sediments, animal and plant products.
- Some are pathogens e.g.: *Clostridium botulinum* and *Clostridium perfingens* while others are important in food spoilage.
- *C.perfingens* cause stormy fermentation in foods (disruption of curd in milk)

3. *Genus Escherichia*

- Found in faeces, gram negative rod isolated from the intestinal tract of warm blooded animals.
- E.g. *Escherichia coli* used as an indicator of sanitation in the coliform and fecal coliform group.

- Many strains are non-pathogenic but some can be pathogenic to humans and animals (foodborne disease).

4. *Genus Lactobacillus*

- Rod shaped facultative anaerobic, non-motile, mesophilic.
- Can be homo or heterolactic fermentors.
- Found in plant sources, milk, meat and feces.
- Usage:
  i) Food bioprocessing: *L. bulgaricus, L. lactis*.
  ii) *Probiotics: L. acidophilus*
- Spoilage:
  i) Wine or beer production.
  ii) Cheese making.
  iii) Can survive pasteurization

5. *Genus Pseudomonas*

- Gram negative, aerobic, rod shaped, motile.
- Important in fish and meat spoilage.
- E.g: *P.aeruginosa* and *P.fluorescens*

6. *Genus Staphylococcus*

- S. aureus are frequently involved in foodborne diseases.
- It usually gives yellow to orange growth.
- Many beta haemolytic, coagulase positive strains are pathogenic and produce enterotoxin which causes food poisoning.

7. *Genus Streptococcus*

- *Streptococcus pyogenes* - important in foodborne diseases. A cause of human septic sore throat, scarlet fever. Can be found in raw milk.
- *Strep. Thermophillus* is important in cheese making and yogurt.

D. Groups of bacteria important in food

1. *Lactic Acid Bacteria*

    - Ability to ferment sugars to lactic acid e.g: important in cheese making but undesirable in term of spoilage of wines.
    - Major genera: *Leuconostoc, Lactobacillus, Streptococcus, Pediococcus*

2. *Acetic Acid Bacteria*
3. *Butyric Acid Bacteria*
4. *Propionic Acid Bacteria*
5. *Proteolytic Acid Bacteria*

    - Produce extracellular proteiases (enzymes which diffuse outside of the cells) and catalyzes the breakdown of protein.
    - Important genera : *Bacillus, Pseudomonas, Clostridium, Proteus*

6. *Lipolytic Acid Bacteria*
7. *Saccharolytic Bacteria*
8. *Thermophilic and Thermoduric Bacteria*
9. *Halophilic and Osmophilic Bacteria*
10. *Pigmented Bacteria*
11. *Slime or Rope Forming Bacteria*
12. *Gas Forming Bacteria*
13. *Fecal and Non-fecal Coliform group*

    - Definition: Short rods, aerobic or facultative anaerobes, gram negative, non-spore forming bacteria which ferment lactose with gas forming.
    - Major genera: Escherichia, Enterobacter
    - The fecal coliform groups includes coliforms capable of growth at an elevated temperature (44.5°C)

Importance of microorganisms in food

Good (desirable)	Bad (undesirable)
• Food bioprocessing	• Foodborne disease
• Food biopreservation	• Food spoilage
• Probiotics	

A. Desirable effects of microorganisms on food

1) Food bioprocessing: new food products are produced using biological process. In this process, food-grade microorganisms are used to produce different types of fermented food using raw materials from animal and plant sources (this process known as "starter culture"). Beside, microbial enzymes are also being used to produce food and food additives.

2) Food biopreservation: this is a food biological preservative by using antimicrobial metabolites (taken from certain microorganisms in order to control pathogenic and spoilage microorganisms in foods).

3) Probiotics: this is a concentrated supplement of beneficial live cells of bacteria (friendly bacteria) culture taken orally intended to improve our health by promoting our body's natural immunity and improving digestion system

Probiotics is a friendly bacteria which plays a vital role in keeping us fit and health. They improve digestion as well.

Examples of probiotics in food

Milk- baby milk nowadays is added with Lactobacillus acidophilus and Bifidus bacteria.

Yogurt- rich with live bacteria culture such as Lactobacillus bulgaricus and Streptococcus thermophillus.

Cheese- friendly bacteria that is added in cheese is Lactobacillus.

Buttermilk- Lactobacillus bulgaris

Advantages of probiotics

1. By increasing the absorption of mineral and vitamins and it also can improve digestion system especially of milk product. In our food, only vitamins that properly absorbed and digested are useful. Probiotics also improve lactose intolerance.
2. Taking probiotics can support out immune system which is fight bad bacteria and infection in keeping s cope from being run down. It produced antimicrobial substances that can deter various bad bacteria. It is so important because many of the disease begin in the intestinal tract.
3. Produced specific protein that act as antigen and stimulates the immune system.
4. Increase the absorption of calcium, important mineral in the prevention of osteoporosis.
5. Preventing intestinal tract infections that are cause by Candida spp. and Helicobacter pylori.
6. Normalising bowel elimination problems and promoting regularity.
7. Clean the colon and improve constipation.
8. Fights pathologicals moulds, yeast, fungu, viruses, parasites and bacteria.

9. Stimulates β— lymphoctes and related antibody production.

10. Supporting healthy liver function.

11. Alleviating bowil wind, bloating and bleaching.

12. Assisting in cholesterol management.

Side effect of probiotics to human

Even though probiotic are beneficial bacteria, sometimes it can cause indirect or long term side effect especially if taken inappropriately.

Factors that can produce side effect:

b) Probiotics supplement in food are not safe or not working inside the body.

c) Product that has been taken (food) did not deliver probiotics to specific area to perform its function.

d) Not all probiotics product in market today are created sufficiently enough for body necessity. Some of them are over concentrated and some are less than minimal requirement.

Side effect that occurs include:

a) Excessive drainage syndromes.

b) Headache.

c) Diarrhea.

d) Bloating.

e) Constipation.

f) Production of intestinal gas.

Bacteria in the intestine

The variable and greatest number of bacteria lives in large intestine.

Lactobacillus acidophilus guard small intestine.

Bifidobacter protect large intestine.

Lactobacillus bulgarium is a travelling transient bacteria that aids the two it bases through our body.

B. Undesirable effects of microorganisms in food

1) Foodborne illnesses: a disease cause by consumption of contaminate during various stage of handling between production and consumption by many pathogenic microorganisms (bacteria, molds and viruses).

2) Food spoilage: a condition in which food is contaminated due to

   a. Growth of microorganisms in food

   b. The action of microbial heat stable enzymes

In this case, microorganisms use food as a source of nutrients for their own growth

Primary sources of microorganisms found in food

Microorganisms may be found everywhere in a very wide range of habitats. These may include;

- Soil and water
- Plants and plant products
- Intestinal tract of man and animals
- Food utensils
- Animal feeds and hides
- Air and dust

1. Soil and water

Grouped together because of atmospheric cycling. Soil and water are common sources of important pathogenic and spoilage microorganisms, which is why it is important to thoroughly wash raw foods with good quality water. Air and dust are important sources of microorganisms during food processing and can influence food quality in the home as well.

Soil contains several varieties of microorganisms. Soil is used to grow agricultural product and raise animals. Microbes can get into food from soil and multiply; their numbers can be very high. Soil contaminated with fecal material can be the source of enteric pathogenic bacteria and viruses in food.

Water is used to process, produce and store food. Other uses include: irrigation, drinking, washing, canning and freezing. It is also used as ingredients in many processed food. Therefore, water quality is greatly influence the microbial quality of foods.Chlorine treated potable water should be used in processing, washing, sanitation etc. because improperly treated water can contain pathogen and spoilage of microorganisms.

2. Air and dust

Air and dust are important sources of microorganisms during food processing and can influence food quality in the home as well.

3. Plants and plant products

The inside tissue of plant / animal is sterile. Some plants produce natural antimicrobial metabolites that can limit the presence of microbes. Fruits and vegetables harbour microorganisms on their surface. The type and number varies with soil condition, type of fertilizers and water used. Pathogens can be present if soil is contaminated with untreated sewage. Disease plants, damaged plants during harvesting, unfavorable storage condition can increase the number of microorganisms. Although most soil and water borne microbes will contaminate plants, very few types actually persist on them. Those that persist, such as lactic acid bacteria and some yeasts, must be able to adhere to the plant material and to utilize it for growth.

4. Food Utensils/equipment

This is another important source for cross contamination of raw and cooked foods e.g. cutting blocks, food trays where raw food was held. A wide variety of equipment is used in harvesting, processing, transportation and storage of foods. Many types of microorganisms from air, raw foods, water and personnel can get into the equipment and contaminate foods. When processing equipments are used continuously for a long period of time, microorganisms present initially can multiply and act as a source of contamination

5. Intestinal tracts of humans and animals

Poor sanitation practices (use of polluted water, poor personal hygiene) lead to contamination from these sources. And many pathogens are transmitted by this route. Animals and birds carry many types of microorganisms in the digestive system, in teat canal / udder, skin, hooves, hair and scales. Disease situation such as mastitis in cows can change the ecology of the microflora. Poor husbandry can lead to fecal contamination. Milk can be contaminated with fecal material on the udder surface. Meat contaminated with intestinal content of animals. Eggs can be contaminated from the eggshell

Steps to prevent this type of contamination

a. Good condition of animals and birds husbandry.

b. Properly slaughter.

c. Washing with clean water.

d. Removal of digestive system without contaminating other tissue.

e. Proper sanitation during entire processing.

f. Proper cleaning of udder before milking.

g. Collecting of eggs soon after laying. Washed and stored using recommended procedure.

h. Fish and marine product should be harvested from unpolluted water.

6. Food handlers /human

Food comes in contact with different people handling the foods, such as people processing the food, food handlers in restaurants, catering services, suppliers and producers. Personnel in food processing plants can contaminate foods during handling and processing. • Human has been the source of pathogenic microorganisms in foods that later caused foodbourne diseases especially ready to eat foods. It is suggested that human beings shed 103 – 104 viable organisms per minute. The numbers and types of organisms shed are closely related to the subject's working environment. Microbiota on hands, garments, etc. reflects the habits of the individual. This can include microorganisms from virtually any environmental source.

Factors affecting this kind of contamination

a. Improperly cleaned hands
b. Lack of personal hygiene and aesthetic sense.
c. Dirty clothes and hair.
d. Presence of minor cuts.
e. Infections on hands and face.
f. Mild generalized diseases e.g.: flu and throat infection.

Prevention

a. Proper training of personnel in personal hygiene.
b. Regular check up.
c. Maintain efficient sanitary.

7. Animal feeds

Very important source of Salmonella in poultry and of Listeria monocytogenes (from silage) in dairy and meat animals.

Steps

8.Animal hides

E.g. Microbiota of raw milk influenced by that of the udder.

9. Sewage

If used as fertilizers in crops, microorganisms in sewage water can contaminate food especially enteropathogenic bacteria and viruses. Especially organically grown food and many imported fruits and vegetables.

Prevention:

a. Avoid using sewage as fertilizer

b. Washing

c. Treat sewage to kill pathogens

The concept of food safety and hygiene

Once food has been harvested, gathered or slaughtered, enzymes and bacteria become active in this food which cause it to deteriorate in texture and composition until it eventually becomes unfit for consumption. This deterioration is known as decay and leads to eventual food spoilage.

Food is considered safe for human consumption when it is free from substances like contaminants, toxins and micro-organisms that can cause undesirable reactions in the body when such foods are eaten. To ensure that food is safe for consumption, it should be:

- Protected from contamination by harmful bacteria, poison and other foreign bodies
- Prevented from having any bacteria present multiplying to an extent which would result in the illness of consumers or the early spoilage of the food
- For some foods: thoroughly cooked to destroy any harmful bacteria present
- Discarded when spoilt and/or contaminated

If food safety systems are not in place during processing. Hundreds if not thousands of consumers are at risk. A single incident of personal injury traced back to a specific food processor may put that company out business and result in criminal prosecution of the owners and management.

Systems which assure the safety and wholesomeness during food processing fall into three categories;

a) Good manufacturing practices (GMP's)

b) Sanitation procedures

c) Hazard Analysis Critical Control Points (HACCP)

Good manufacturing Practices

GMP's are guidelines to assure that food for human consumption is safe and has been prepared, packed and held under sanitary conditions. These guidelines deal with personnel involved in food processing, physical plant and grounds as well as facility construction and design.

Personnel GMP's: Personnel working in food processing can be a significant source of food contamination. This includes production employees, maintenance employees, supervisors and management. It is the responsibility of processing facility management to educate and train all food handlers about sanitary handling of food. Employees experiencing diarrhoea, vomiting, open - skin sores, boils, fever or disease must report these symptoms to their supervisor and must NOT be allowed to work with edible food products. All food handlers should have clean outer garments or aprons and thoroughly wash their hands before entering a food processing area, especially after using toilets. No jewellery (earrings, pendants. rings etc.) or wrist watches are allowed in the food processing areas as these items may fall into food products unnoticed. Clean, intact gloves as well hair restraints should be used by all personnel in the food processing area.

Sanitation procedures

Cleaning and sanitation are some of the most important programs in any food processing plant. Regular and scheduled equipment cleaning and sanitizing assures that food products are being processed under hygienic conditions. Adequate time must be given to the sanitation crew to allow for a thorough job. Cleaning and sanitation is best done by a specially trained sanitation and cleaning crew NOT by production personnel.

Cleaning and sanitizing involves five basic steps

- Physical debrils removal
- Rinse
- Detergent/mild abrasion
- Post rinse
- Sanitizing

HACCP

The prevention of physical, chemical and microbial contamination of produce during processing is essential to assuring the production of a safe product. A HACCP program is only effective if sanitation and good manufacturing processes are implemented and verified. It is recommended that each food processor identify one person in their operation to have formal HACCP training and be in charge of a team that is responsible for implementing the HACCP program. HACCP programs should be a simple as possible, without an excessive number of critical control points. Each HACCP program is unique and must be tailored to your specific operation's needs. A model for dried apples has been provided as an example of a HACCP program which can be used as a starting point for you to develop a HACCP program for your food processing operation.

General Do's and Dont's to Assure Food Safety During Processing

- Follow state regulations regarding the type of licenced facility you may use for food processing (for example, no home or farm kitchens).

- Educate and train employee’s in proper food handling practices and personal hygiene.
- Strictly adhere to Good Manufacturing Practices (GMP’s).
- Design food processing and storage areas to allow for easy cleaning and sanitation.
- Monitor raw material suppliers for adherence to Good Agricultural Practices.
- Keep processing facility grounds clean and free from clutter.
- Processing facilities should be completely enclosed from the outside environment by walls.
- Windows or other glass should not be present in the food processing area.
- Processing facility floors, walls and ceilings must be cleanable and in good repair.
- Adequate lighting should be rresent and be protected in case of breakage.
- Pipes, ducts and fixtures should not be suspended over processing areas.
- Use only potable (safe to drink) water.
- Monitor water quality regularly.
- Plumbing should be of adequate size and design for sanitary food processing (floor drains, separate sanitary sewers, etc.).

Indicators of food microbial quality and safety

Shelf life indicators are used to assess food sanitation and should meet the following criteria;

- They should be present and detectable in all foods whose quality (or lack thereof) is to be assessed.
- Their growth and numbers should have a direct negative correlation with product quality.
- They should be easily detected and enumerated and be clearly distinguishable from other organisms.
- They should be enumerable in a short period of time, ideally within a working day.
- Their growth should not be affected adversely by other components of the food flora.
- Managing microbial food spoilage

Identifying spoilt food

Food that is spoilt can be identified in different ways:

- Off odours: Foods tend to develop undesirable off-flavours and/or odours as they spoil
- Discolouration: Food undergoing spoilage normally changes in colour
- Slime / Stickiness: Gravy or soups sometimes become thick and slippery to touch
- Unusual taste: Food that is undergoing spoilage often changes in taste

- The production of gas: Some foods - especially when stored in sealed containers develop some gases which will be noticeable when opening the container
- Mould growth: Other foods, e.g. bread develop fungi like growth which is easy to see with the naked eye

Foods at high risk of food spoilage

Some foods are prone to faster spoilage by micro-organisms than others. Foods that spoil fast are usually referred to as "high risk foods." Most often these are ready to eat foods or rich protein foods and require refrigerated storage. Examples of these foods are:

- (Cooked) meat, including poultry
- (Cooked) meat products including gravy, stews
- Milk and milk products
- Eggs and products made from raw eggs
- (Cooked) Fish

General guidelines for food storage

Foods should be stored differently on the basis of how fast they will spoil or develop off flavors. Foods can be categorized into 3 groups:

1. Perishable (e.g. milk, meat, raw fish)
2. Semi-perishable (e.g. vegetables and grains)
3. Non-perishable foods (tinned or dried food)

Perishable foods: e.g. eggs, milk, cream, fresh meat. These have the shortest shelf life and must be used within a few days. These should be stored in a clean cool place. In the absence of refrigerators, such foods can be placed in clean containers, saucepans or pots.

The containers can then be placed in a basin of cold water covered with a clean piece of cloth. In all circumstances, milk and meat should be consumed within 2 days.

Semi-perishable foods: e.g. bread, cakes, fresh fruit and vegetables. Breads and cakes should be stored in a bread bin or tin. Fruit and vegetables may be stored in a rack or basket. When put in storage, care should always be taken to remove and discard the particular foods that start showing signs of spoilage so as to avoid cross-contamination.

Non-perishable foods: e.g. dry, bottled and tinned foods can be stored in a cupboard on their own or in airtight containers

Further food categories and their storage methods

The recommended storage conditions for foods often vary; the variations even differ for the same foods depending on the freshness or dryness of the particular food.

Storage of cereals, bread, flour, and rice

- Bread needs to be stored in its original package at room temperature. It should be used within 5 to 7 days or else it will grow moulds (a sign of spoilage)

- Cereals - depending on the quantities and level of dryness - may be stored at room temperature in tightly closed containers to keep out moisture and insects. Properly dried cereals packaged in sacs can be stacked on racks in a dedicated food store. Due attention should be taken to keep out rodents (rats) that normally feed on stored grain
- Raw rice can be stored in closed containers at room temperature and used within one year. Once cooked, rice should be eaten immediately in the absence of refrigeration
- Storing fresh vegetables
- Proper storage of fresh vegetables helps to maintain their quality and retain nutrient value. Most fresh vegetables need to be stored under low temperatures in areas which are neither humid nor damp. If available, fresh vegetables can be stored in a clay pot fridge.
- Root vegetables (potatoes, sweet potatoes, onions, etc.), squashes and eggplant can be stored in a cool, well-ventilated place between layers of grass
- Onions should be left to dry thoroughly under the sun to avoid rotting in storage and when well dried can be kept for about 3 months
- Tomatoes continue to ripen after harvesting and should be stored at room temperature
- Storing fresh fruits
- All fresh fruits generally need to be stored in a cool area, preferably in a clay pot fridge
- Fruits have a tendency to either be contaminated by other foods and or to absorb odours from other foods. They therefore need to be kept separately
- Care must be taken to keep milk in clean covered containers that should be left to stand in a cool place. Unrefrigerated milk should be used within a day

Storing meat and fish

• Meat (including poultry), fish, eggs and milk are the best sources of proteins in the human diet. Given their high protein and moisture content, these products are highly perishable. It is for this reason that these products will spoil faster than others - however well prepared and stored. One big contributor to the faster spoilage of fresh cuts of meat is the fact that these usually contain spoilage bacteria on the surface that can grow quickly, producing slime and causing spoilage after a few days. Meat should be prepared and eaten within 24 hours of purchase/slaughter.

- Ground and thinly cut pieces of meat are more susceptible to spoilage given the larger surface area for bacterial action. Meat and meat products should be used within a few days. If the meat cannot be used within a day, it is advisable to dry, smoke or salt it before storing it

- Like meat, fresh fish should be eaten immediately. Never store fish in water as this leads to loss of nutrients from the fish. In order to store fish for longer, it should be smoked.
- Storing Root Tubers (Cassava, Sweet Potatoes)
- Most root tubers may not be stored well for long after harvest, however root tubers keep longer than other vegetables, fruits, meat, milk, etc.
- When tubers will not be prepared within a few days, care should be taken to avoid bruising them. It is advisable to harvest cassava before it becomes fibrous, with part of the aerial stem still attached. This helps preserve the tubers in good condition.
- Cassava tubers can also be piled into heaps and watered daily to keep them fresh or coated with a paste of mud to preserve their freshness. They can keep for about 4-7 days.
- Unbruised sweet potatoes can be kept in a cool, dry place for up to 4-7 days. Care should be taken to remove any sprouting buds.
- In times of bumper harvests, tubers cannot be kept for long; it is advisable that these are peeled and sliced in small pieces and then sun dried on canvas or cleaned floors.
- Once well dried, the sliced dry tubers can be kept in sacks and stored for up to 3-4 months without spoiling.
- Storing milk and milk products
- Milk is a highly perishable food and yet very nutritious. To prolong its shelf life, milk should never be left at room temperature for a long time as it spoils quickly

Measures to prevent deterioration of food by microorganisms

- Minimize the contact between microorganisms and food
- Eliminate microorganisms from foods
- Understand about preservation of the food

4.3.5.3 Self-Assessment

1.Describe the primary sources of microorganisms

2.During processing, foods can get contaminated because of

A. Workers

B. Equipment

C. Packaging material

D. All of the above

3.Mechanical damage to fruits and vegetables by birds open the way

A. To microbial spoilage

B. To chemical spoilage

C. To spread infectious diseases

D. None of the above

4.The microbial load shed by a human being per minute is ___________

A. 103 - 104

B. 101 - 103

C. 106 - 108

D. 104 - 105

5.Spoilage in foods may be due to

A. Insects

B. Physical changes

C. Growth and activity of microorganisms

D. All of the above

6. Explain the categories of food quality changes for fresh foods
7. Discuss the systems which assure the safety and wholesomeness during food processing
8. Classify foods based on the ease of spoilage
9. List the organisms involved in the breakdown of proteins
10. With aid of diagrams, discuss the molds important to food

4.3.5.4 Tools, Equipment, Supplies and Materials

1. Labs
2. Cold chains
3. Vaccines
4. Stationery
5. Staining reagents
6. Culture systems

4.3.5.5 References

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4.3.6 Learning Outcome 5: Demonstrate the knowledge on methods of detection, identification and enumeration of food microorganism

4.3.6.1 Learning Activities

Learning activity	Special instructions
Identify and describe terminologies in basic laboratory equipment and materials as per resource materials	Identify and describe basic laboratory equipment and materials • Equipment such as incubator, autoclave, petri dishes • Materials such as different types of media and reagents
Methods of detection, identification and enumeration of microorganisms are identified and described	Perform practical to detect, identify and enumerate microorganisms Wear PPEs during the practices • Lab coat • Gloves • Closed shoes • Masks

4.3.6.2 Information Sheet

Definitions

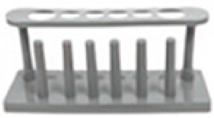
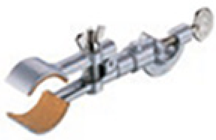
Enumeration: is counting of microorganisms present in a sample.

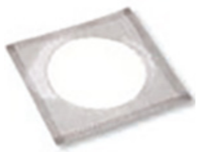
Introduction to basic laboratory equipment and materials

Laboratory equipment and materials	Use
Balance 	Used for measuring mass
Beaker 	Used to hold, mix, and heat liquids.

Beaker tongs 	Used to pick up beakers.
Bunsen burner 	Used as a heat source in the absence of flammable materials.
Buret 	Used for dispensing an accurate volume of a liquid.
Clay triangle 	Used to support a crucible during heating.
Crucible 	Used for holding chemicals during heating to very high temperatures.
Crucible tongs 	Used to hold crucibles.
Erlenmeyer Flask 	Used to hold and mix chemicals. The small neck is to facilitate mixing without spilling.
Evaporating dish 	Used to heat liquids for evaporation
Forceps 	Used to pick up or hold small objects.

Funnel		Used to transfer liquids or fine-grained materials into containers with small openings. Also used for filtration.
Graduated cylinder		Used to measure a precise volume of a liquid.
Microscope		Used to magnify specimens
Mortar and pestle		Used to crush and grind materials.
Petri dish		Used to culture cells
Pipet bulb		Used to draw liquids into a pipe
Ring clamp		Used with a ring stand to hold glassware, such as a beaker or a funnel.
Ring stand		Used to hold or clamp laboratory glassware and other equipment in place, so it does not fall down or come apart.

Stirring rod 	Used for stirring and mixing.
Test tube 	Used to hold a test tube, particularly when hot.
Test tube clamp 	Used to hold a test tube, particularly when hot.
Test tube rack 	
Thermometer 	Used to measure temperature in Celsius.
Utility clamp 	Used to secure glassware to a ring stand.
Volumetric flask 	Used to prepare solutions to an accurate volume.

Volumetric pipet 	Used to measure small amounts of liquid very accurately. Never pipet by mouth! Use pipetting aids.
Wash bottle 	Used to rinse pieces of glassware and to add small quantities of water.
Watch glass 	Used to hold solids while they are being weighed or to cover a beaker.
Wire gauze 	Used to support a container, such as a beaker, on a ring stand while it is being heated. May have a fiberglass or ceramic center.
Incubator 	Used to grow and maintain microbiological or cell cultures
Autoclave 	Used to sterilize laboratory instruments and nutrient agar

Methods of detection, identification and enumeration of microorganisms

Introduction

The detection and enumeration of pathogens in food and on food surfaces that come into contact with food are an important component of any integrate programme to ensure the safety of foods throughout the food supply chain.

Importance of detection and enumeration of microorganisms in food

- To determine the safety and quality of food
- To detect the presence of pathogens in raw and processed foods immediately

Ways to detect and enumerate microorganisms

- Testing for pathogenic bacteria
- Testing for staphylococci
- Testing for mesophilic bacteria
- Coliform test
- Total plate count

Enumeration

This is done to know the intense of presence of the spoilers in the spoiled food. It aims at detecting which type of organism is responsible for the spoilage.

This is mostly done using two important methods;

- Viable count: spread plate method
- Total count: Pour plate method

Viable count

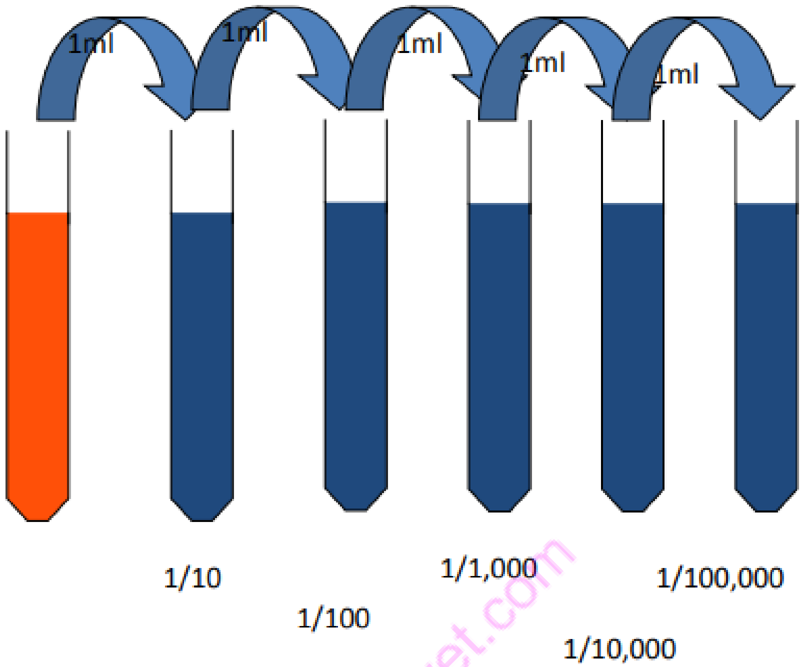
- A viable cell count allows one to identify the number of actively growing or dividing cells in a sample.
    - The plate count method or spread plate method relies on bacteria growing a colony on a nutrient medium.
    - Number of colonies can be counted.
    - Plate count agar is used for general count
    - MacConkey agar is used for Gram negative organisms.

Direct viable count:

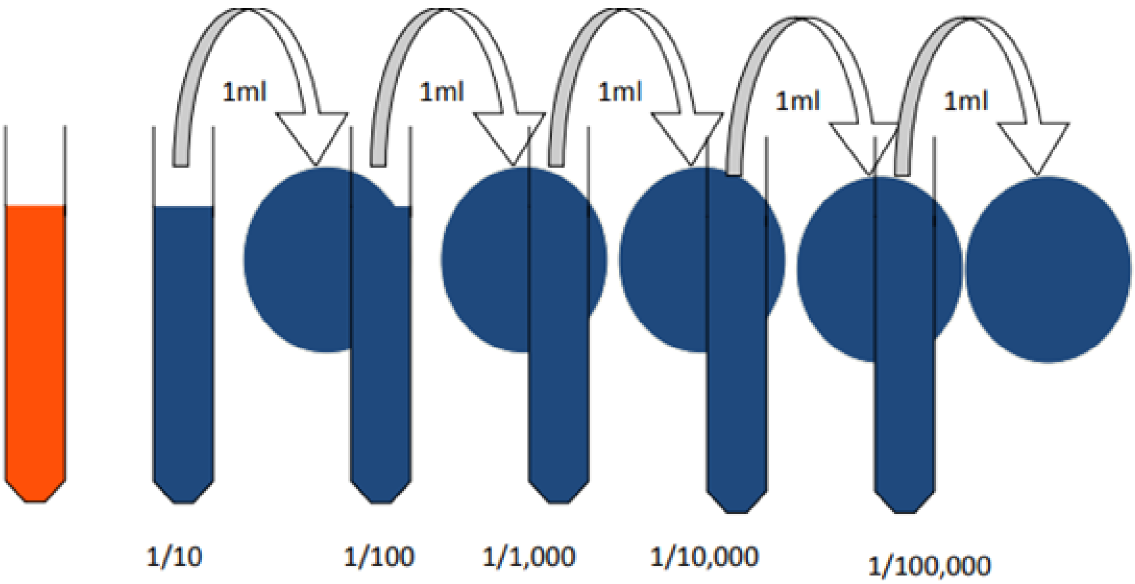
A direct viable count method involves a standard plate count, in which repeated dilutions of a sample.

- The sample is serially diluted as (1:10,1:100,1:1000 etc,) in sterile distilled water and cultivated on nutrient agar for bacteria.
- Potato dextrose agar or sabouraud's dextrose agar is used or fungal identification.

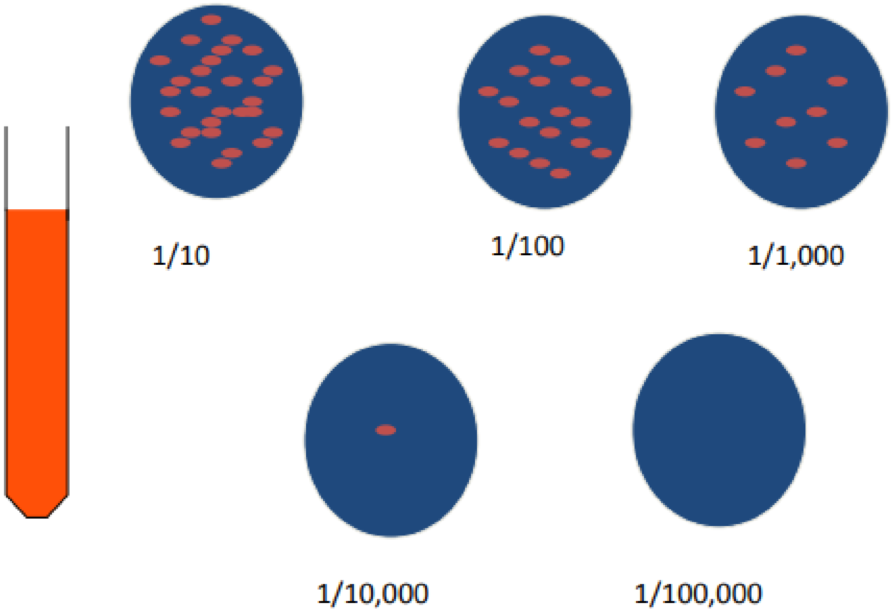
Dilution Series: dilution



Dilution series: plating



Dilution series: colony count



Total count

The initial analysis is done by mixing serial dilution of sample in liquid nutrient agar which is then poured into bottles.

↓

The bottles are then sealed and laid on their sides to produce a slopping agar surface.

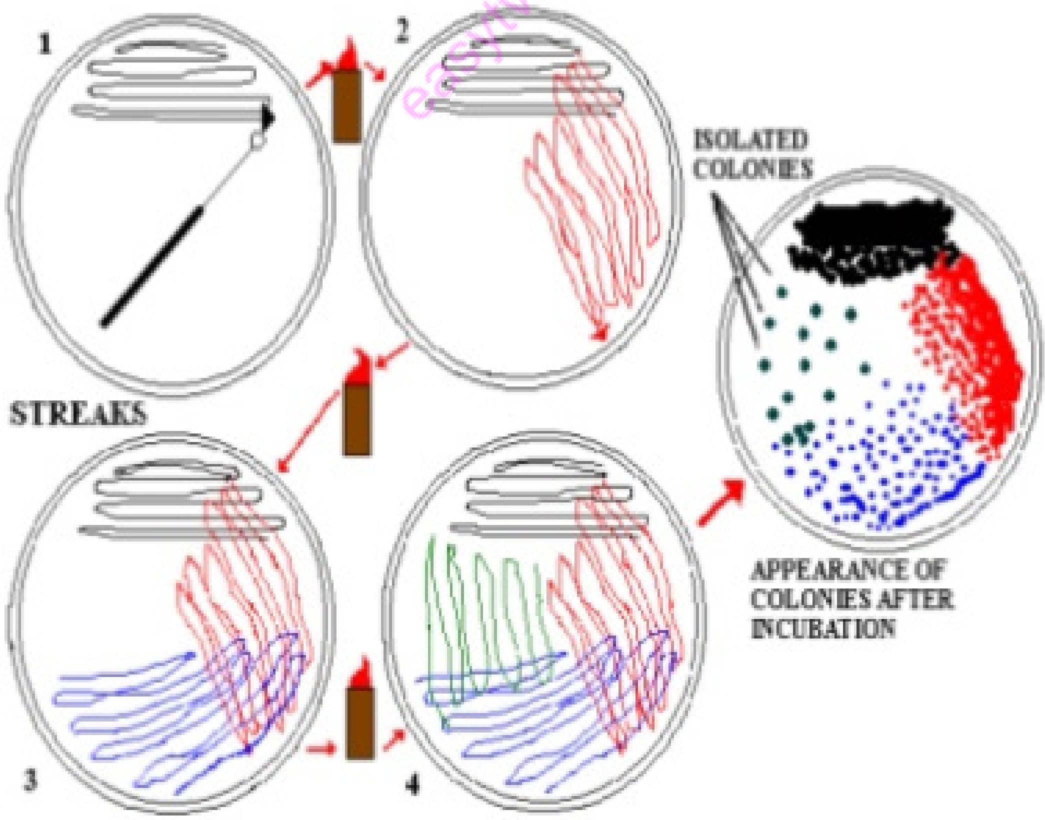
↓

The colonies are then counted by eye. The total number of colonies are said as Total Viable

Procedures involving plate counts;

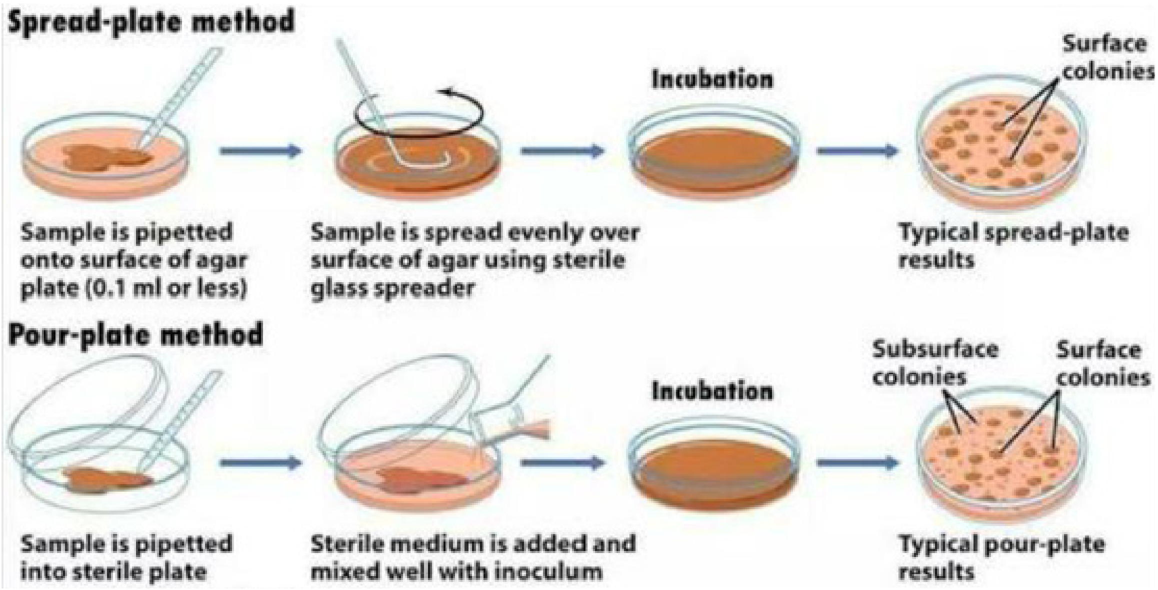
- Streak dilution plate
- Spread plate
- Pour plate

Streak dilution plate



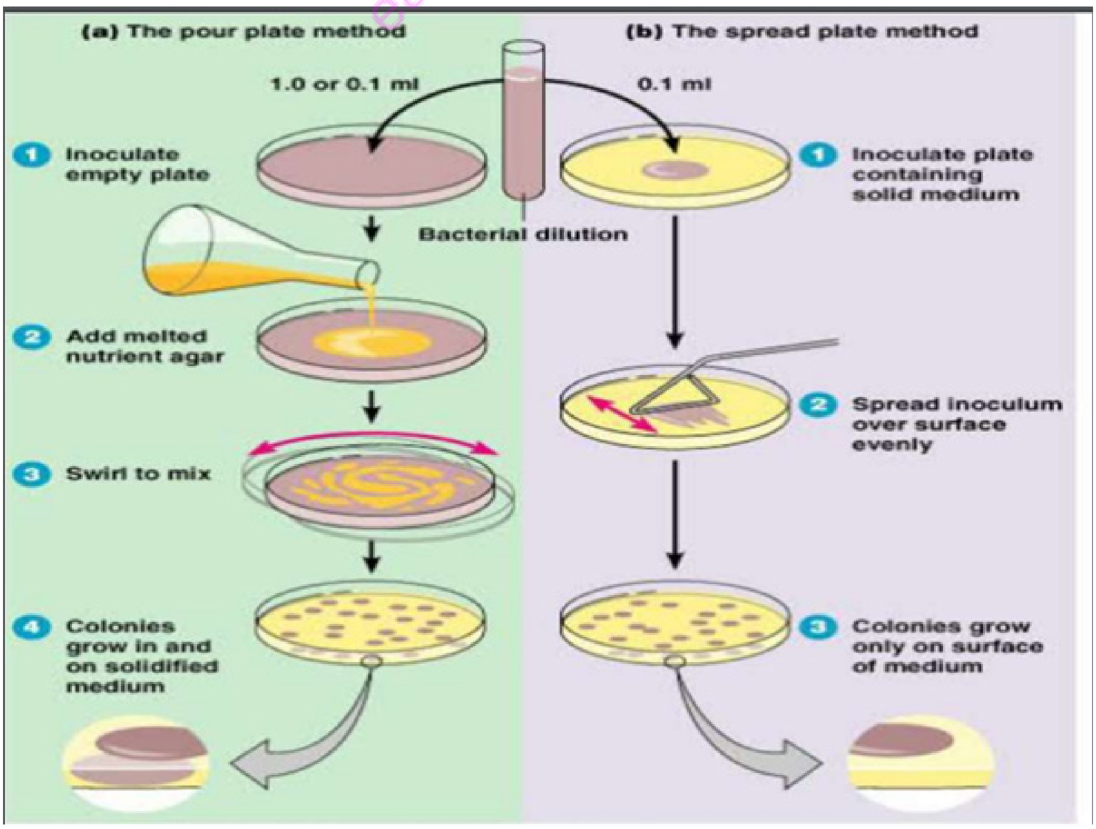
Spread plate

Method of quantifying the number of viable cells (or colony forming units) in a sample after appropriate dilution



Pour plate method

The same procedure is done for this till serial dilution. The serially diluted sample is then mixed with the molten nutrient agar, distributing the cells throughout the medium. Then poured onto the sterile petridish. Incubated under appropriate temperature and the colonies where counted.



Disadvantages

- Typical colony morphology seen in surface cultures will not be observed for those colonies that develop within the agar medium
- Some of the suspension may be left behind in the screw capped bottle

Microbial indicators assess food safety and should meet the following criteria:

i. be easily and rapidly detectable

ii. be easily distinguishable from other members of the food biota

iii. have a history of constant association with

iv. be present whenever the pathogen of concern is present

v. be an organism whose numbers ideally should correlate with those of the pathogen of concern

vi. be present only when there is a real danger of pathogen being present

vii. possess growth requirements and a growth rate equaling those of the pathogen

viii. have a die-off rate that at least parallels that of the pathogen and ideally persists slightly longer than the pathogen of concern

ix. be absent from foods that are free of the pathogen except perhaps at certain minimum numbers

Examples of organisms used as indicators

- E. coli
- Coliforms: has several strains; Citrobacter, Enterobacter, Escherichia, and Klebsiella.

Coliform test

The coliform bacteria are gram negative non-spore forming rods that occur in large numbers in human and animal feces. They are normally present on raw animal products, such as meats, milk, and eggs, and also occur naturally in soil, water, and surfaces of plants. They are heat sensitive and die rapidly during blanching or pasteurizing. Large numbers of coliforms after a heat process indicate an unacceptable degree of post-heating contamination or indicate time-temperature abuse of the food sufficient to permit growth. High coliform levels warrant investigations to determine the source of contamination or temperature mishandling.

Coliform test has been carried out to test the presence of enteropathogenic bacteria such as Salmonella and Shigella. This test normally uses coliform bacteria as indicator. As a result, testing for coliform bacteria can be a reasonable indication of whether other pathogenic bacteria are present.

The presence of Escherichia coli, member of the coliform group, in food usually indicates direct or indirect human or animal fecal contamination. Although this may be true in a broad sense, one must not assume a quantitative relationship between the numbers of E. coli and the degree of contamination with feces. E. coli grows well outside the animal body and thrives in unclean food handling equipment.

Reasons why coliforms are used as indicators for other bacteria

- They are able to survive for extensive periods of time in the environment
- Relatively easy to cultivate in the laboratory and numerous

Stages of coliform test

a) Presumptive tests

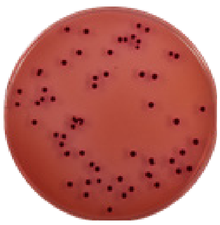
b) Confirmative tests

c) Completed tests

a) Presumptive test

Example in solid food sample using plating method;

- Add food into the petri dishes (in duplicate)
- Add molten violet red bile agar, mix then allow to harden
- Incubate the plate at 35C for 18-24 hours
- Positive result: dark red colonies with a surrounding zone of precipitated bile at least 0.5mm in diameter



b) Confirmation test

This tests should be carried out because gas formation in lactose broth is not only a characteristic for fecal Salmonella, Shigella and E. coli strains but also of non-fecal coliform like Enterobacter aerogenes and some Klebsiella species

In this second stage the presence of enteric bacteria is confirmed by re-culture of the positive result:

Positive result from plating method: Those colonies from violet red bile agar are transferred to a separate tube of brilliant green lactose bile broth and then incubated for 48 hours under 35°C before examined for the gas presence.

c) Completed test

This involves the positive tube from brilliant green. Lactose bile broth cultures are streaked and stabbed on slant of nutrient agar.

After incubation for 18-24 hours at 35°C, the slant is examined for the growth on the surface and in the stabbed portion of the slant.

Gram stain is then made from the agar slant and the positive result should show: Gram negative, non-sporing rods.

4.3.6.3 Self-Assessment

1. Define the term enumeration
2. Clay triangle is used
    A. For holding chemicals during heating to very high temperatures.
    B. To hold crucibles.
    C. To support a crucible during heating.
    D. To pick up beakers.
3. Which of the following media is used for identification of fungi?
    A. Potato dextrose agar
    B. Macconkey agar
    C. Nutrient agar
    D. Xylose Lysine Deoxycholate (XLD) agar
4. The following procedures involve plate counts except
    A. Streak dilution plate
    B. Spread plate
    C. Pour plate
    D. Serial dilution plate
5. Identify ways in which microorganisms can be detected and enumerated
6. Discuss the following methods of enumerating microorganisms

a. Viable count

b. Total count

7. Explain the procedure involving plate counts
8. Describe the characteristics of microbial indicators used to assess food safety
9. Explain the three stages of coliform tests

4.3.6.4 Tools, Equipment, Supplies and Materials

1. Equipped laboratory
2. Cold chains
3. Vaccines
4. Stationery
5. Staining reagents
6. Culture systems
7. Workplace procedure manual

4.3.6.5 References

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CHAPTER 5:

DEMONSTRATE KNOWLEDGE OF FOOD PROCESSING, SAFETY AND HYGIENE

5.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required for food processing, safety and hygiene. It is to include principles in food processing, methods of food preservation, food quality and safety-HACCP and hygiene practices in food handling.

5.2 Performance Standard

By the end of this unit of learning/competency, the trainee should apply principles of food processing and preservation in ensuring food safety as per resource materials; process and preserve different food products in line with the available resources; apply food quality, safety and hygiene practices in food handling as per the HACCP principles and resource materials.

5.3 Learning Outcomes

5.3.1 List of the Learning Outcomes

1. Identify and describe terminologies in food processing, safety and hygiene
2. Describe principles in food processing, preservation and safety
3. Demonstrate knowledge in food quality, safety and hygiene

5.3.2 Learning Outcome 1: Identify and describe terminologies in food processing, safety and hygiene

5.3.2.1 Learning Activities

Learning activity	Special instructions
Identify and describe terminologies in food processing, preservation and food safety	Define various terminologies in food processing such as • Food • Food processing • Food preservation • Food safety
Identify and describe aims and importance of food processing, preservation and safety	

5.3.2.2 Information Sheet

Definitions

Food processing is the set of methods and techniques used to transform raw ingredients into food for consumption.

Food preservation is the process of treating and handling food in such a way as to stop or greatly slow down spoilage to prevent foodborne illness and extend its shelf-life

Food safety: is defined as handling, preparing and storing food in a way to best reduce the risk of individuals becoming sick from foodborne illnesses

Food: is any nutritious substance eaten to maintain vital life processes.

FOOD PROCESSING

Food processing typically takes clean, harvested crops or slaughtered and butchered animal products and uses these to produce attractive, marketable and often long-life food products.

History of food processing

The origin of food processing goes all the way back to ancient Egypt, yet the period of those developments seems to symbolize the history of the culture of mankind. Nowadays, bread, which is characterized by its use of the fermentation action of yeast and which uses wheat flour as its raw material, is baked all over the world. The origins of beer also go back to Babylon and Egypt in the period from 3,000 to 5,000 BC.

The foundation of the modern industry was built up with the introduction of machinery and technology of new methods from Germany. Nowadays, the processed foods that are thriving in grocery shops are modern processed foods and traditional foods, but their manufacturing technology, process control and manufacturing and packaging environmental facilities have been advanced and rationalized to an incomparable extent in the last 30 years.

As a result, products with high quality and uniformity are now being manufactured. This is based on the advancement of food science, and is, moreover, due to the general introduction of hygienics, applied microbiology, mechanical engineering, chemical engineering, electronic engineering and high-polymer technology.

Importance of food processing

i) Prevent, reduce, eliminate infestation of food with microbes, insects or other vermin

ii) Prevent microbial growth or toxin production by microbes, or reduce these risks to acceptable levels

iii) Stop or slow deteriorative chemical or biochemical reactions

iv) Maintain and/or improve nutritional properties of food

v) Increase storage stability or shelf life of food as well as its supply

vi) Make food more palatable and attractive

vii) Make foods for special groups of people

viii) To save food for future use at the time of scarcity or drought etc. after suitable preservation and proper storage. Preservation of food also minimises the preparation time and energy at home.

ix) To stabilise the price of food throughout the year since seasonal food can be preserved and made available for consumption throughout the year.

Food processing methods

1) Peeling: Removal of unwanted outer layers, such as potato peeling or the skinning of peaches.

2) Chopping or slicing e.g. diced carrots.

3) Mincing and macerating: Mincing is a technique in which food ingredients are finely divided. The effect is to create a closely bonded mixture of ingredients and a soft or pasty texture

4) Liquefaction: refers to conversion of something into the liquid state, such as to produce fruit juice like mango juice

5) Fermentation: refers to the conversion of sugar to alcohol using yeast e.g. in beer breweries. Fermentation usually implies that the action of the microorganisms is desirable, and the process is used to produce alcoholic beverages such as wine, beer and cider.

6) Emulsification: an emulsion is a mixture of two immiscible liquids. One liquid (the dispersed phase) is dispersed in the other (the continuous phase). Many emulsions are

oil/water emulsions, with dietary fats being one common type of oil encountered in everyday life. Example of emulsion include butter and margarine, milk and cream.

7) Cooking, such as boiling, broiling, frying, steaming or grilling

8) Baking: the technique of prolonged cooking of food by dry heat acting by convection, and not by radiation, normally in an oven, but also in hot ashes, or on hot stones. It is primarily used for the preparation of bread, cakes, pastries, tarts, quiches and cookies.

9) Deep frying

10) Mixing

11) Addition of gas such as air entrainment for bread or gasification of soft drinks

12) Proofing

13) Spray drying

14) Pasteurization

15) Packaging: is the science, art and technology of enclosing or protecting products for distribution, storage, sale and us.

Benefits and limitations of food processing

Benefits:

1. Benefits of food processing include toxin removal, preservation, easing marketing and distribution tasks, and increasing food consistency.
2. In addition, it increases seasonal availability of many foods, enables transportation of delicate perishable foods across long distances and makes many kinds of foods safe to eat by de-activating spoilage and pathogenic microorganisms.
3. Processed foods are usually less susceptible to early spoilage than fresh foods and are better suited for long distance transportation from the source to the consumer.
4. Processing can also reduce the incidence of food borne disease.
5. Fresh materials, such as fresh produce and raw meats, are more likely to harbour pathogenic micro-organisms (e.g. Salmonella) capable of causing serious illnesses.

Limitations

1. Any processing of food can have slight effects on its nutritional density.
2. Vitamin C, for example, is destroyed by heat and therefore canned fruits have a lower content of vitamin C than fresh ones.
3. Another safety concern in food processing is the use of food additives. The health risks of any additives will vary greatly from person to person, in example sugar as an additive would be detrimental to those with diabetes.
4. Food processing is typically a mechanical process that utilizes large mixing, grinding,

chopping and emulsifying equipment in the production process. These processes inherently introduce a number of contaminate risks.

5. Food manufactures utilize industrial metal detectors to detect and reject automatically any metal fragment

Food spoilage

Spoilage is the process in which food deteriorates to the point in which it is not edible to humans or its quality of edibility becomes reduced. Various external forces are responsible for the spoilage of food. Food that is capable of spoiling is referred to as perishable food.

Reasons of food spoilage

Harvested crops decompose from the moment they are harvested due to attacks from microorganisms. These include bacteria, mould, yeast, and enzymes.

Bacteria

Various bacteria can be responsible for the spoilage of food. When bacteria breaks down the food, acids and other waste products are created in the process. While the bacteria itself may or may not be harmful, the waste products may be unpleasant to taste or may even be harmful to one's health.

Yeasts

Yeasts can be responsible for the decomposition of food with a high sugar content. The same effect is useful in the production of various types of food and beverages, such as bread, yogurt, cider, and alcoholic beverages.

Signs of food spoilage

Signs of food spoilage may include an appearance different from the food in its fresh form, such as a change in colour, a change in texture, an unpleasant odour, or an undesirable taste. The item may become softer than normal. If mould occurs, it is often visible externally on the item.

Food preservation

Food preservation is the process of treating and handling food to stop or slow down spoilage (loss of quality, edibility or nutritional value) and thus allow for longer storage. Preservation usually involves preventing the growth of bacteria, yeasts, fungi, and other micro-organisms (although some methods work by introducing benign bacteria, or fungi to the food), as well as retarding the oxidation of fats which cause rancidity. Food preservation can also include processes which inhibit visual deterioration that can occur during food preparation; such as the enzymatic browning reaction in apples after they are cut. Many processes designed to preserve food will involve a number of food preservation methods.

Preserving fruit, by turning it into jam, for example, involves boiling (to reduce the fruit's moisture content and to kill bacteria, yeasts, etc.), sugaring (to prevent their re-growth) and sealing within an airtight jar (to prevent recontamination).

There are many traditional methods of preserving food that limit the energy inputs and reduce carbon footprint. Maintaining or creating nutritional value, texture and flavour is an important aspect of food preservation, although, historically, some methods drastically altered the character of the food being preserved. In many cases these changes have now come to be seen as desirable qualities – cheese, yoghurt and pickled onions being common examples.

Preservation processes

Preservation processes include:

- Heating to kill or denature micro-organisms (e.g., boiling)
- Oxidation (e.g., use of sulfur dioxide)
- Ozonation (e.g., use of ozone [O3] or ozonated water to kill undesired microbes)
- Toxic inhibition (e.g., smoking, use of carbon dioxide, vinegar, alcohol etc.)
- Dehydration (drying)
- Osmotic inhibition (e.g., use of syrups)
- Low temperature inactivation (e.g., freezing)
- Ultra high water pressure (e.g., Fresherized®, a type of "cold" pasteurization; intense water pressure kills microbes which cause food deterioration and affect food safety)

Benefits of food processing and preservation

- Mass production of food is much cheaper overall than individual production of meals from raw ingredients.
- Reaches areas where the food item is not grown
- Easing marketing, storage and distribution tasks
- Add variety to our meals
- Increasing food consistency (season availability0
- Toxin removal
- Makes many kinds of foods safe to eat by deactivating spoilage and pathogenic microorganisms.
- Improves the quality of life for people with allergies, diabetics, and other people
- Can also add extra nutrients such as vitamins
- Processed foods are often less susceptible to early spoilage than fresh foods

Demerits of food processing and preservation

- Can lower the nutritional value of foods, and introduce hazards not encountered with naturally-occurring products
- Processed foods often have a higher ratio of calories to other essential nutrients than unprocessed foods, a phenomenon referred to as “empty calories”. So called junk food, produced to satisfy consumer demand for convenience and low cost, are most often mass produced processed food products.
- May cause adverse health effects: Preservatives such as nitrites or sulphites.
- Failures in hygiene standards in “low-level” manufacturing facilities that produce a widely-distributed basic ingredient can have serious consequences for many final products

5.3.2.3 Self-Assessment

1. Define the term food processing
2. Handling, preparing and storing food in a way to best reduce the risk of individuals becoming sick from foodborne illnesses is
   A. Food preservation
   B. Food processing
   C. Food safety
   D. Food hygiene
3. The following are preservation processes except
   A. Dehydration
   B. Osmotic inhibition
   C. Low temperature inactivation
   D. Mincing
4. Why is food preservation important?
5. Why is food processing important?
6. Discuss the merits and demerits of food processing and preservation.

5.3.2.4 Tools, Equipment, Supplies and Materials

Textbooks

Use of LCDs, video clips, charts and other teaching aids

Invitation of competent expertise

Computers with internet

Library and resource centre

Stationery

5.3.2.5 References

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5.3.3 Learning outcome 2: Describe principles in food processing, preservation and safety

5.3.3.1 Learning Activities

Learning activity	Special instructions
Identify and describe principles in food	Describe of principles of food processing and preservation
Identify and describe methods of food processing and preservation	Name and describe methods of food processing and preservation
Identify and describe effects of food processing and preservation techniques on food storage sensory and nutrition properties of food	Explain effects of food processing and preservation techniques on; • food storage • Sensory • Nutrition properties
Identify and describe traditional and modern methods in food processing and preservation for different food categories	Observe how food processing and preservation has evolved over time
Identify and describe principles in food processing and preservation as per resource materials	Observe some of the critical activities during food processing and preservation

5.3.3.2 Information Sheet

Definitions

Pasteurization: when food is heated in containers or by other method to a temperature below 100° C for a definite period of time, the process is known as pasteurization.

Gamma radiation: Use of ionizing radiation (gamma radiation) to extend shelf life or sterilize meat, seafoods, fruits, and vegetables

Sterilization: It is a process that all micro-organisms are being killed at high temperature or radiation.

Canning: a process in which over 100°C is used for killing all spoilage organisms and their spores as well as inactivating enzymes and sealing in sterile airtight containers.

Irradiation: It is the emission and propagation of energy through space or through a material medium

Food processing

As defined earlier, food processing is the conversion of agricultural product to substances which have particular textural, sensory and nutritional properties using commercially feasible methods.

There are two ain forms of processing;

i)Primary processing: conversion of raw materials to food commodities. A good example of primary processing is milling.

ii)Secondary processing: conversion of ingredients into edible products – this involves combining foods in a particular way to change properties. Baking cakes is an example of secondary processing.

Importance of food processing

- Conversion of raw food materials to edible products
- For preservation purposes
- For extension of availability and provision of accessibility
- Provision of variety and choice
- For value addition

Food processing methods that are used to preserve foods include:

- Refrigeration and freezing
- Canning
- Heating
- Irradiation
- Dehydration
- Freeze-drying
- Chilling
- Concentration
- Pickling
- Pasteurizing
- Fermentation

Principles in food processing

They principles of food processing include:

- Heat transfer

- Fluid flow
- Mass transfer
- Mixing
- Size adjustment
- Separation

Food preservation

All of the food preservation processes work by slowing down the activity and growth of disease causing bacteria, or by killing the bacteria all together. They also slow down or stop the action of enzymes which can degrade the quality of the food.

The following principles are involved in various methods;

a.Prevention or delay of microbial decomposition (control of microorganisms)

- By keeping out microorganisms (Aseptic techniques)
- By removal of microorganisms. This is done by removing air, water (moisture), filtration, lowering or increasing temperature, increasing the concentration of salt or sugar or acid in foods
- By hindering the growth and activity of microorganisms e.g. by low temperature drying, anaerobic conditions or chemicals
- By killing the microorganisms e.g. by heat or radiations

b.Prevention or delay of self-decomposition of the food (control of enzymes)

- This will involve controlling enzymes by;
    i. Inactivating endogenous enzymes
    ii. Preventing or delaying chemical Reactions in the food

c.Controlling insects, rodents, birds and other physical causes of food deterioration. This is achieved through;

- Use of suitable chemicals to kill insects or animals to prevent them from destroying food
- Storage of dried foods in dry, airtight containers to prevent insects and rodents invasion.

Methods of food processing and preservation

The basic concepts in food processing methods to prevent food spoilage are:

- thermal treatment
- water removal (in form of moisture)
- dehydration

- temperature reduction during storage
- food irradiation
- reduction of pH
- protective packaging

A. Heat treatment

This method of food processing aims at killing the microrganisms that could easily cause food spoilage. Heating also destroys or inactivate enzymes thus preventing deterioration. All types of food can be preserved for a considerable period of time by cooking. The heat treatment required depends on the kind of the target micro-organisms to be killed and the composition of the food.

Classification of heat treatments used on foods:

1) Pasteurization
2) Heat at 100°C
3) Heat > 100°C (also known as commercial sterility and can easily kill spores of C. botulinum.
4) Canning

1)Pasteurization (heating to temperature below 100°C)

In this method of preservation, foods are subjected to sufficient heat to kill most of the bacterias. The food is heated in a closed system, rapidly cooked, and then placed in covered and sealed container to prevent recontamination. The temperature used ranges from 65- 75°C.

Plate heater exchanger pasteurizer

Heat treatments that kills most but not all microorganisms.

Example: milk 63ºC, 30 mins

72ºC, 15 mins

Juice 77ºC, 30 mins

88ºC, 30 secs

There are two ways of pasteurisation:

- HTST (High temperature-short time): Food product is heated at high temperature for a short time. For example, milk is heated to 72℃ and held for 15 seconds.
- LTLH (Low temperature-long time): Food product is heated at a lower temperature for longer period of time. For example, milk is heated to 62.8℃ and held for 30 minutes.

The pasteurized products are cooled promptly after the heat treatment. This method is designed to kill only vegetative cells of pathogens, not spores.

Pasteurization is important when:

1) Heat treatment will not harm the quality of product
2) Main spoilage microbes are not very heat resistant e.g. yeast in fruit juices
3) Kill pathogens
4) Any surviving organisms will be treated with other preservative methods
5) Competing organisms are to be killed, allowing a desired fermentation

Effect of pasteurization on foods

Pasteurization is a relatively mild heat treatment and even when combined with other unit operations (for example irradiation and chilling there are only minor changes to the nutritional and sensory characteristics of most foods. However, the shelf life of pasteurized foods is usually only extended by a few days or weeks compared with many months with the more severe heat sterilization. Minimizing post processing contamination is essential to ensure an adequate shelf life.

In fruit juices, losses of vitamin C and carotene are minimized by deaeration. Changes to milk are confined to a 5% loss of serum proteins and small changes to the vitamin content

2) Heating at about 100°C(boiling)

This method of processing is sufficient to kill all microbes but not spores. Many acid foods are successfully preserved at100°C.

Methods:

• Boiled • Immersion • Baking • Simmering • Roasting

• Frying • Blanching • Exposure to flowing steam

3) Heating above 100°C (sterilization)

This method of heat treatment is mainly obtained by means of steam under. The higher the steam pressure increases the higher the temperature.

Commercial sterility: Preserving foods using minimum amount of heat necessary to kill spoilage and pathogenic microorganisms. Also include heating foods at high temperature for a short time e.g. ultra heat treatment.

All commercially sterile foods should be stored in cool, dry, place to prevent any viable thermophilic spores from germinating and cause, spoilage to the foods.

Ultra Heat Treatment: Treatment of milk by heating at 150°C by steam injection followed by 'flash evaporation' of the condensed steam and rapid coding.

Differences between pasteurization and sterilisation

	Pasteurisation	Sterilisation
Function	Partial destruction of microorganisms	Complete destruction of microorganisms
Temperature	Temperature below 100°C	Temperature 100°C and above
Advantage	Minimal damage to flavor, texture, and nutritional quality	Long shelf life. No other preservation method is necessary
Disadvantage	Short shelf life. Another preservation method must be used, such as refrigeration or freezing	Food is overcooked. Major changes in texture, flavor, and nutritional quality

4)Blanching

Briefly scald food to inactivate enzymes that cause undesirable changes.

Advantages of blanching

- Improves taste
- Increases availability of out of season foods

Disadvantages

- Storage limits
    - Fruits & veggies 1 year
    - Meat 3-6 months
    - Freezing temperatures required for storage

5) Canning

Canning (also known as hermetically sealed containers) is done in tin cans, glass containers, and aluminium and plastic pouches.

Canning process

Raw food harvested

↓

Prepare, inspect, sorting, grading

↓

Washing

↓

Filled in the can

↓

Brine added

↓

Evacuated by heating the headspace (vacuuming)

↓

Sealing

↓

Heat processing

Processed foods can be classified on the basis of extent and type of processing as follows:

1. Minimally processed foods: These are processed as little as possible in order to retain the quality of fresh foods. Generally the processes used are cleaning, trimming, shelling, cutting, slicing and storage at low i.e., refrigeration temperatures.

2. Preserved foods: The methods of preservation used do not change the character of the product substantially e.g., frozen peas and frozen vegetables, dehydrated peas, dehydrated vegetables, canned fruits and vegetables.

3. Manufactured foods: In such products, the original characteristics of the raw products are lost and some basic methods of preservation are used, often using various ingredients such as salt, sugar, oil or even chemical preservatives. Examples are pickles, jams, marmalades, squashes

4. Formulated foods: These are products prepared by mixing and processing of individual ingredients to result in relatively shelf stable food products such as bread, biscuits, ice cream, cakes.

3. Food derivatives: In industry, components of foods may be obtained from the raw product through purification, e.g., sugar from sugarcane or oil from oil seeds. In some cases, the derivative or the component may be processed further, e.g. hydrogenation.

4. Functional foods: These are foods that can have a beneficial effect on human health, e.g., probiotics, lycopene.
5. Therapeutic foods: These are used in dietary management of diseases, for example, low sodium salt, lactose–free milk for persons with lactose intolerance.

Objectives of thermal processing

a) To destroy pathogens and spoilage microorganisms

b) To destroy toxin present in foods

c) To destroy the vegetative cells and spores of yeast, bacteria and moulds

d) To destroy undesirable enzymes this can affect the quality of foods.

e) To control the growth of surviving microorganisms

f) To retain the acceptance and nutritional quality of foods

g) To reduce competition

Advantages of canning

– Increases shelf life

– Two years is considered normal shelf life

Disadvantages of canning

– Weight of product

– Requires specially treated metal cans or appropriate glass jars.

B. Temperature reduction during storage

Low temperature can lower the rate of chemical reactions and the action of enzymes. Generally, freezing can prevent the growth of most food-borne micro-organisms and the usual temperature for cold storage is 4.5-7°C.

The food industry uses a number of low temperature methods to achieve preservation of the perishable foods:

Method	Temperature range
Refrigeration	4°C to 7°C
Chilling	-2°C to 2°C
Freezing	Below 18°C

Refrigeration temperature lowers the growth rate of micro-organisms and chilling can slow down the enzymatic and microbial changes in food. For frozen food, it should be stored at or below -18°C where the enzymatic and microbial changes may be stopped or extremely slow. To extend storage life, products such as butter, cheese, and canned goods are stored in cooled warehouses.

Psychrophiles and psychrotophs are problematic when it comes to effects of low temperature. The minimum temperature at which an organism has been found to grow is -34°C (a yeast species). Growth at freezer temperatures if it occurs is extremely slow.

Effects of freezing on microorganisms

Freezing of foods can cause initial mortality immediately on freezing and depends on the species. Surviving cells die off gradually, and the rate of death is quickest at temperatures just below freezing point, with the slowest at below -20°C. All cells rarely die off. Defrosting foods must be treated as fresh products as regards microbiological activity. Endospores and toxins are not affected by low temperatures. All frozen foods should be defrosted at 4°C to reduce or prevent microbial growth. The rate of thawing also affects microbial cells – the faster they thaw, the greater the number of survivors. Repeating freezing and thawing disrupts both the food and microbial cells. It may be a hazardous procedure if sufficient time is given for growth or survivors.

C. Dehydration

This is also known as drying. The typical methods employed include sun drying, mechanical drying and freeze-drying. Certain food preparation methods of foods may have some antimicrobial effect, e.g. blanching, addition of preservatives, cooking, fat removal and addition of sugar or other solutes. The moisture contents of dried foods vary from 2% to 50%; Intermediate moisture foods from 20% to 50% or aw =0.60- 0.85. Foods are preserved by drying for a long history, especially in Chinese foods. Mushrooms, dried shrimps and salted fish are some typical examples. Both the terms “drying” and “dehydration” mean the removal of water. “Drying” usually describes the process of drying under sunshine or open air. The other term, dehydration, usually describes the removal of moisture by applying artificial heat current under controlled conditions.

The drying process per se does not kill microorganisms. Some may be killed but most may be recovered from dried foods if present prior to drying. Most bacteria and yeasts require aw > 0.90 to grow. Dried foods are not usually susceptible to spoilage. S. aureus is the most xerotolerant of the pathogens, i.e. grows in aw of 0.86. Rehydration (i.e. the addition of water or adding to other wet ingredients) enables microorganisms present to re-commence growth.

Freeze-drying has the least destructive effect on microorganisms and depends on the age of the cells. Reduction of water activity and subsequent antimicrobial effects also occur on addition of sugar or salt, but other inhibitory factors are also involved, e.g. high chlorine levels. All microbial cells require water to grow but not to survive.

Differences between dehydration and sun-drying

Sun-drying	Dehydration
Process is slow	Process is faster
Performed under open-air conditions with little hygienic control	Carried out under controlled hygienic conditions
Difficult in cloudy weather or rainy days	Does not depend on the weather
Cost-effective as no machinery and processing cost is needed	Investment on machinery and processing cost is required

Advantages of dehydration

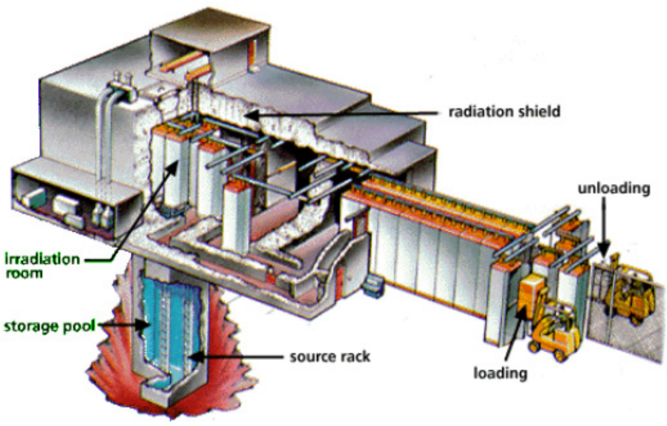
- Increases shelf life up to 2 years
- Lighter weight
- Lower volume

Disadvantages of dehydration

- Changes taste and texture of food
- Typically requires preparation to reconstitute food.

D. Food irradiation

Food absorbs and is heated up by radiant energies. Radiant energies can kill microorganisms without marked increase of temperature as well as marked changes in the nature of food. The type of radiation of primary interest in food preservation is electromagnetic. Shorter wavelengths are most damaging to microorganisms.



Food Irradiation Plant

The electromagnetic spectrum is divided into:

- Microwaves
- Ultraviolet rays
- X rays
- Gamma rays

Ionizing radiations have short wavelengths hence used in food preservation e.g. gamma rays, X rays, beta rays etc.

Gamma rays is the cheapest form of radiation for food preservation. X-rays essentially has the same character like gamma rays but produced differently.

Gamma rays possess the following properties;

- Electromagnetic radiations emitted from the excited nucleus of elements
- Cheapest form of radiation for food preservation
- Sources elements are either by-products of atomic fission or atomic waste products
- Have excellent penetration power

Ultraviolet (UV) radiation does not penetrate foods and is therefore used for surfaces of food-handling equipment.

UV light has the following characteristics;

- Powerful bactericidal agent
- Nonionizing
- Absorbed by proteins and nucleic acids, in which photochemical changes are produced that may lead to cell death (of bacteria as they produce mutations).
- Poor penetrative capacities
- May catalyze oxidative changes that lead to rancidity, discolorations, etc.
- May produce ozone when used for surface treatment of food

UV light can be used to decontaminate;

- Air (most efficient use)
- Liquids in films, e.g. water (long exposure time, expensive, complex)
- Surfaces (long exposure time, limited use)
- Packaging where heat is inappropriate, material must be transparent to UV or pack must be open
- Solid foods in very thin layers, e.g. sugar

Beta rays are a stream of electrons emitted from radioactive substances

- Cathode rays emitted from cathode of evacuated tube

X Rays: this is produced by the bombardment of heavy metal targets with high-velocity electrons within an evacuated tubes. It is essentially similar to gamma rays

Microwaves: When electrically neutral food is placed in an electromagnetic field, the charged asymmetric molecules are driven first one way and then another. Each asymmetric molecule tries to align itself with the rapidly changing alternating-current field. As the molecules oscillated about the axes while attempting to go to the proper positive and negative poles, intermolecular friction is created and manifested as a heating effect. This is microwave energy

Principles underlying the destruction of microorganisms by irradiation

1. Type of organisms: gram+ more resistant than gram-
2. Numbers of organisms: the larger the number of cells, the less effective is a given dose
3. Composition of suspending menstrum (food): those in protein rich food are more resistant
4. Presence or absence of oxygen: radiation resistance is greater in the absence of oxygen than in its presence
5. Physical state of food: resistance of dried cells higher than the moist ones
6. Age of organisms: resistance of bacteria high at lag phase, just prior to active cell division

Processing of foods for irradiation

The following steps are done prior to exposing food to ionizing radiations

- Selection of foods- for freshness and quality
- Cleaning of foods- remove debrils and dirt to ensure reduced number of microorganisms to be targeted.
- Packing: pack in containers to prevent against post-irradiation contamination
- Blanching/heat treatment: to destroy natural food enzymes which may cause undesirable post irradiation changes.

Factors affecting food irradiation

i) Types and species of microbes-Spores are generally radio resistant

ii) Number of microbes -The more cell present, the less effective a given dose of radiation

iii) Composition of medium- Cells in protein medium are more resistant

iv) Protein exerts protective effect against radiation

v) Presence or absence of oxygen -Resistance is reportedly increase when oxygen is absent

vi) Physical state of food -Dried cells are more resistant than moist cells

vii) Age of cells -Cells in lag phase are more resistant than in other phase

Advantages and disadvantages of irradiation

Advantages

i) there is little or no heating of the food and therefore negligible change to sensory characteristics

ii) heat sensitive nutrients are preserved/are not destroyed

iii) packaged and frozen foods may be treated

iv) fresh foods may be preserved in a single operation, and without the use of chemical preservatives

v) energy requirements are very low

vi) changes in nutritional value of foods are comparable with other methods of food preservation

vii) processing is automatically controlled and has low operating costs.

Disadvantages

i) the process could be used to eliminate high bacterial loads to make otherwise unacceptable foods saleable

ii) if spoilage micro-organisms are destroyed but pathogenic bacteria are not, consumers will have no indication of the unwholesomeness of a food

iii) there will be a health hazard if toxin-producing bacteria are destroyed after they have contaminated the food with toxins

iv) the possible development of resistance to radiation in micro-organisms

v) loss of nutritional value

vi) High cost

vii) inadequate analytical procedures for detecting whether foods have been irradiated

viii) public resistance due to fears of induced radioactivity or other reasons connected to concerns over the nuclear industry.

Application of irradiation

Irradiation can be used in a wide range of area in food preservation:

(i) Poultry products and seafood

(ii) Fruits

(iii) Prevention of sprouting in potatoes and onions

(iv) Delaying ripening in fruits

(v) Preservation of seafood

(vi) Prevention of insect infestation in dry foods and food products

E. Reduction of pH

To reduce the pH of a food, acids like vinegar or citric acid are used. Acids lower the pH and thus inhibit the growth of many micro-organisms. It is more effective against yeast and bacteria than moulds. About 20% vinegar (acetic acid) prevents the spoilage of most products. It is used in the preservation of pickles, sauces and chutney. Another acid, citric acid, is also used in the preservation of certain fruits and vegetables. Products of jams, jellies and squashes may contain citric acid. It lowers the pH of the food products and can prevent the growth of moulds.

Examples of acidulants used during food processing

Acid	Role(s)
Acetic	Provides flavour, decreases pH Sodium acetate is salt form present in vinegar
Benzoic	As sodium benzoate, effective antimicrobial agent Occurs naturally in cranberries
Citric	Provides flavour, decreases pH, acts as chelating and sequestering agent Occurs naturally in citrus fruits
Lactic	Provides tartness
Malic	Provides flavour Occurs naturally in apples
Phosphoric	Provides flavour and tartness in beverages Enhances juiciness in meats (as phosphate)
Propionic	As calcium propionate, effective antimicrobial agent Produced in some cheeses
Tartaric	Present in baking powder as potassium tartrate salt Occurs naturally in grapes

F. Protective packaging

This is also known as asepsis which is the absence of microorganisms. Packaging is valuable to food preservation operations because it aids in lengthening the life of food. Packaging helps maintain during storage the quality and properties of foods attained via processing. The packaging protects the food material from microbiological contaminants and other environmental factors. The package also helps prevents light-induced changes in stored food products and minimizes loss of moisture. Depending upon the intensity of lethal treatments (heat, pressure, radiation dose), processing not only affects the food material but also alters the (moisture and oxygen) barrier properties of packaging materials and possibly induces migration of polymer material into the food. Thus, careful choice of food packaging material is essential for successful food process operation. Preservation of foods in sealed containers followed by application of heat treatment. How a food is packaged also influences its shelf-life. It is also important that foods are handled properly by the consumer at home. − Check "Use By" or expiration dates. − Follow storage or preparation instructions.

Effects on nutrition properties of food

All forms of processing reduce the levels of vitamin and minerals in the foods, but some have a greater effect than others.

Vitamins are the most sensitive food components and it is these that are often lost during food processing. Minerals are less sensitive and not as badly affected by processing.

Food processes that involve heating for a long time (such as boiling to concentrate sauces, jams and chutneys) lead to high losses of the vitamins.

Direct exposure to direct sunlight during the drying process may lead to destruction of vitamin A and C in fruits and vegetables.

Effect of different types of processing in vitamin content

Form of food processing	Effect on vitamin Content
Heating for a long-time (e.g. boiling)	High vitamin loss
Blanching	Medium vitamin loss
Drying	Low loss of vitamins if not exposed to sunlight
Fermentation	Minimal loss of vitamins

Traditional methods of food processing and preservation

Drying

Drying is a very widespread method of food preservation and it involves reduction of the amount of free water in the food. Dried foods have fairly long shelf life but drying should be supplemented by other methods of preservation. Appropriate drying is applied in the drying process, the nutritional quality, colour, flavour and texture of rehydrated foods are only insignificantly less than fresh food.

The stability of a dried food during storage depends on its moisture content and the ease with which the food can pick up moisture from the air. The risk of moisture pick up is greater in regions of high humidity. Dried foods must be stored in moisture-proof packaging to prevent them absorbing water from the surrounding air.

Drying has three main purposes:

- to prevent or inhibit microorganisms and spoilage enzymes
- increase shelf-life
- to reduce the weight of food for cheaper and more convenient transport and storage

Factors that affect the rate of drying

- Temperature - of the outside air and inside the dryer
- Humidity of air
- Speed of air flow throughout the dryer
- Type of fruit or vegetable (the amount of water to be lost and the level of sugars in the fruit)
- Size of the fruit or vegetable pieces
- Loading rate of the dryer (the amount of fruit/vegetable per

The basics of drying

Drying involves removing water from the food product into the surrounding air. For effective drying, air should be hot, dry and moving. These factors are interrelated and it is important that each factor is correct: - air must be dry, so it can absorb the moisture from the fruits and vegetables - heating the air around the product causes it to dry more quickly - if the air is not moving across the food, it cannot get rid of the water vapour that it has collected. A fan or air blower is needed to keep the air circulating. In summary - when food is dried, hot dry air comes into contact with the food. The hot air absorbs water from the food and is moved away from the food. New dry air takes its place and the process continues until the food has lost all its water.

Factors affecting drying

- The composition and structure of the food has an influence on the mechanism of moisture removal. For example, the orientation of fibres in vegetables (e.g. celery) and protein strands in meat allow more rapid moisture movement along their length than across the structure.
- The amount of food placed into a drier in relation to its capacity (in a given drier, faster drying is achieved with smaller quantities of food).

Types of driers

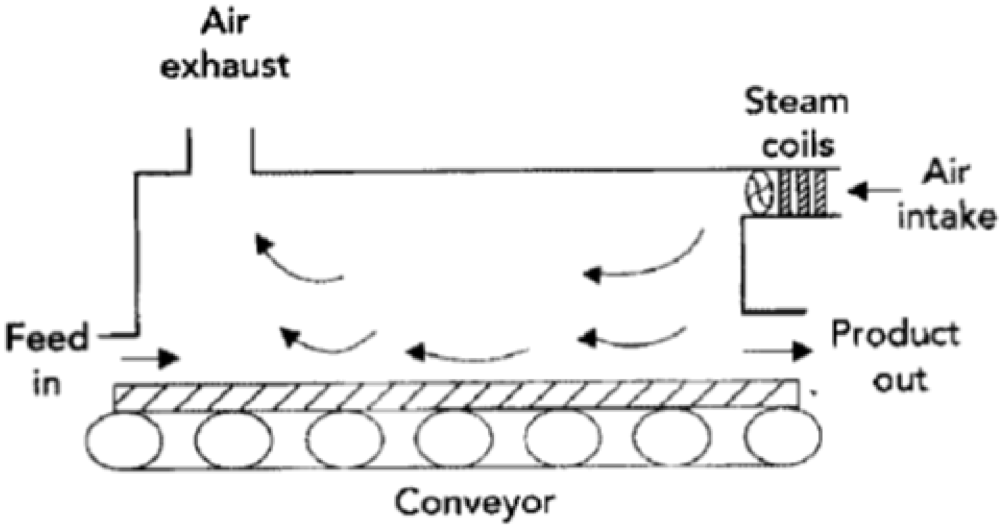
1) Hort-air driers

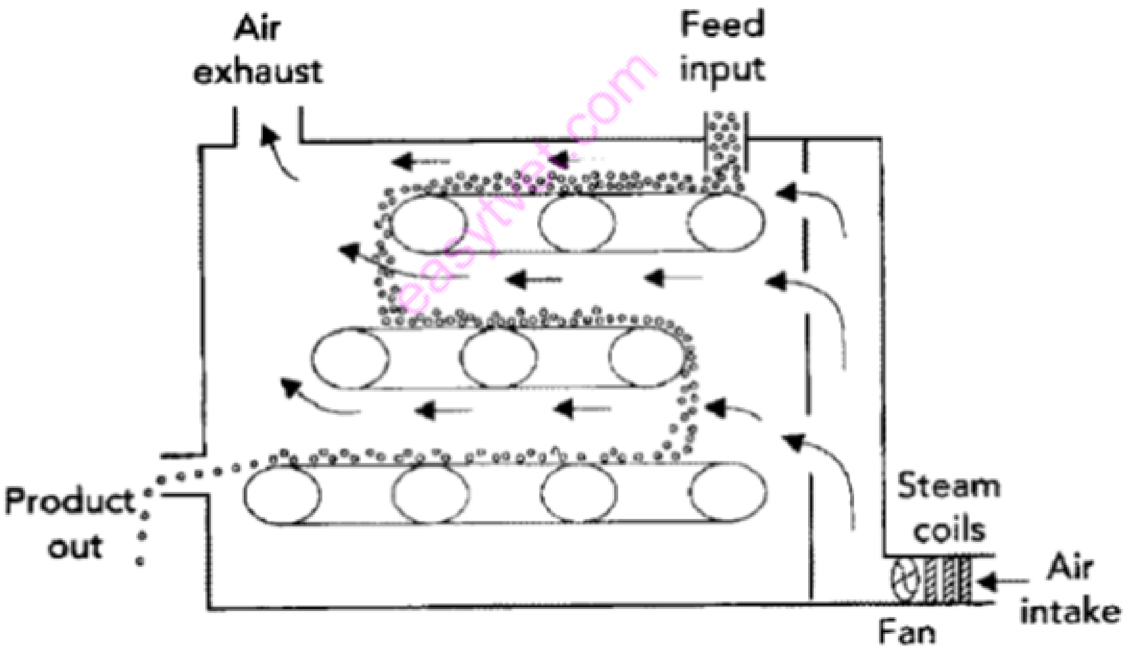
   a. Bin driers: Bin driers are large, cylindrical or rectangular containers fitted with a mesh base. Hot air passes up through a bed of food at relatively low velocities

   b. Cabinet driers (tray driers): These consist of an insulated cabinet fitted with shallow mesh or perforated trays, each of which contains a thin (2–6 cm deep) layer of food. Hot air is blown at 0.5–5ms1 through a system of ducts and baffles to promote uniform air distribution over and/or through each tray.

2) Tunnel driers: Layers of food are dried on trays, which are stacked on trucks programmed to move semi continuously through an insulated tunnel, having one or more types of air flow

3) Conveyor driers (belt driers): Continuous conveyor driers are up to 20m long and 3m wide. Food is dried on a mesh belt in beds 5–15 cm deep. The air flow is initially directed upwards through the bed of food and then downwards in later stages to prevent dried food from blowing out of the bed.





4) Fluidized-bed driers

Drying effect on foods

- All products undergo changes during drying and storage that reduce their quality compared to the fresh material and the aim of improved drying technologies is to minimize these changes while maximizing process efficiency.

•The main changes to dried foods are to the texture and loss of flavor or aroma, but changes in color and nutritional value are also significant in some foods.

Effect of drying food on its nutritional value

Large differences in reported data on the nutritional value of dried foods are due to wide variations in the preparation procedures, the drying temperature and time, and the storage conditions. In fruits and vegetables, losses during preparation usually exceed those caused by the drying operation

Vitamins have different solubilities in water and as drying proceeds, some (for example riboflavin) become supersaturated and precipitate from solution, so losses are small.

Others, for example ascorbic acid, are soluble until the moisture content of the food falls to very low levels and these react with solutes at higher rates as drying proceeds. Vitamin C is also sensitive to heat and oxidation and short drying times, low temperatures, low moisture and oxygen levels during storage are therefore necessary to avoid large losses.

Fermentation

Fermentation is the process in which chemical changes are brought about in an organic substrate through the action of enzymes elaborated by microorganisms. Any partial breakdown of carbohydrates taking place in the absence of oxygen.

It is a metabolic process that converts sugar to acids, gases or alcohol. Biochemically, fermentation is the metabolic process in which carbohydrates and related compounds are partially oxidized with the release of energy in the absence of any external electron acceptors.

Fermentation usually implies that the action of microorganisms is desirable, and the process is used to produce alcoholic beverages such as wine, beer and cider. Fermentation is also employed in the leavening of bread, and for preservation techniques to create lactic acid in sour foods such as sauerkraut, dry sausages, kimchi and yogurt, or vinegar (acetic acid) for use in pickling foods

Importance of fermentation

a) Cholesterol synthesis inhaling

b) Anticancer effects

c) Decreases cooking time hence saves energy

d) Prevention of infections

e) Increased shelf life

f) Adds microbes to the gut

g) Improves flavor of food

h) Eliminates antinutrients

i) Increases micronutrients in food e.g. vit B

j) Make food more digestible e. g in Lactose intolerance

k) Produces carbon dioxide e.g. in bread, beer, champagne

l) Reduced toxicity from some foods e.g. fermentation of cassava to make gari

Products for fermentation

- Dairy products: cheese, kefir, kumis and cultured milk products such as yoghurt
- Meat-based products: Chorizo, Salami, pepperoni
- Fish-based products: Fish sauce, shrimp paste, garum, rakfi
- Non beverage plant products
- Beverages and related products
- Grain-based products: beer, bread, rice wine, malt whisky, grain whisky
- Tea-based: Kombucha
- Fruit-based: wine, vinegar, cider, perry
- Bean-based products: soy sauce, stinky tofu, soybean paste
- Vegetable-based: kimchi and pickles

Examples of processed foods

Processed cheese

Processed cheese, process cheese, cheese slice, prepared cheese, or cheese food is a food product made from normal cheese and sometimes other unfermented dairy ingredients, plus emulsifiers, extra salt, food colourings or whey Many flavours, colours, and textures of processed cheese exist. Although processed cheese was first invented in 1911 by Walter Gerber of Thun, Switzerland, it was James L. Kraft who first applied for an American patent for his method in 1916.

Advantages:

Processed cheese has several technical advantages over unprocessed cheese, including;

- Extended shelf-life
- Resistance to separation when cooked
- Uniformity of product.

The use of emulsifiers in processed cheese results in cheese that melts smoothly when cooked. Disadvantages:

Processed cheese is often criticized for its possible health effects (associated with chemical preservatives, artificial colours/flavours, and trans-fats), inferior taste, and small range of flavors, which is far narrower than the range for unprocessed cheeses and normally very mild.

Yoghurt

Yogurt is a dairy product produced by bacterial fermentation of milk. The bacteria used to make yoghurt are known as "yoghurt cultures". Fermentation of lactose by these bacteria produces lactic acid, which acts on milk protein to give yoghurt its texture and its characteristic tang. Dairy yoghurt is produced using a culture of Lactobacillus delbrueckii subsp. bulgaricus and

Streptococcus salivarius subsp. thermophilus bacteria. In addition, Lactobacillus acidophilus, bifidobacteria and Lactobacillus casei are also sometimes added during or after culturing yoghurt. The milk is first heated to about 80 °C (176 °F) to kill any undesirable bacteria and to denature the milk proteins so that they set together rather than form curds. The milk is then cooled to about 45 °C (112 °F). The bacteria culture is added, and the temperature is maintained for 4 to 7 hours to allow fermentation.

Health benefits of fermented milks

a) Benefits to lactose-intolerant individuals

b) They lower serum cholesterol, and

c) Possess an anticancer activity.

- Probiotics
- Probiotics refers to the consumption of products that contain live organisms that are or are believed to be beneficial to the consumer. The objective here is the ingestion of the organisms, and they consist generally of various lactic acid bacteria and/or bifidobacteria.

Advantages of fermentation

– Improves taste

– Adds value to crops, such as cucumber

Disadvantages of fermentation

- It is a lengthy process in comparison to other food processing techniques.

Smoking

The addition of smoke and heat to preserve food by the action of the chemicals from the smoked wood and the partial drying of the food.

Salting

Salting or curing draws moisture from the meat through a process of osmosis. Meat is cured with salt or sugar, or a combination of the two. Nitrates and nitrites are also often used to cure meat and contribute the characteristic pink colour, as well as inhibition of Clostridium botulinum.

Sugar

Sugar is used to preserve fruits, either in syrup with fruit such as apples, pears, peaches, apricots, plums or in crystallized form where the preserved material is cooked in sugar to the point of crystallisation and the resultant product is then stored dry. This method is used for the skins of citrus fruit (candied peel), angelica and ginger.

A modification of this process produces glacé fruit such as glacé cherries where the fruit is preserved in sugar but is then extracted from the syrup and sold, the preservation being maintained by the sugar content of the fruit and the superficial coating of syrup

5.3.3.3 Self-Assessment

1. Define the following terms;

   A. Pasteurization

   B. Canning

   C. Irradiation

2. The conversion of raw materials to food commodities is known as _______________

   A. Food processing

   B. Food preservation

   C. Secondary processing

   D. Primary processing

3. _______________ is the conversion of agricultural product to substances which have particular textural, sensory and nutritional properties using commercially feasible methods.

   A. Food processing

   B. Food preservation

   C. Secondary processing

   D. Primary processing

4. _______________________ is mainly used on surfaces of food handling equipment as does not penetrate foods

   A. Ultraviolet radiation

   B. Gamma rays

   C. Beta rays

   D. X-rays

5. The following factors affect food irradiation (indicate true/false for each point)

   A. Types and species of microbes

   B. Number of microbes

   C. Composition of medium

   D. None of the above

6. Aseptic techniques involve;
    A. Removal of microorganisms
    B. Hindering the growth and activity of microorganisms
    C. Keeping out microorganisms
    D. Killing the microorganisms
7. Vinegar can be used to preserve the following except
    A. Squashes
    B. Pickles
    C. Chutney
    D. Sauces
8. Direct exposure to direct sunlight during the drying process may lead to
    A. Destruction of vitamin a and c in fruits and vegetables.
    B. Improvement of vitamin d content of the food
    C. Burning effect
    D. Loss of the original color and taste
9. Explain the two forms of food processing
10. Discuss the principles of food preservation
11. Explain the canning process
12. Discuss the principles underlying the destruction of microorganisms by irradiation
13. Discuss the importance of fermentation

5.3.3.4 Tools, Equipment, Supplies and Materials

HACCP manual

Textbooks

LCDs, video clips, charts and other teaching aids

Invitation of competent expertise

Computers with internet

Library and resource centre

Stationery

Food processing plant

Equipped laboratory

Food samples

Reagents

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5.3.4 Learning outcome 3: Demonstrate knowledge in food quality, safety and hygiene

5.3.4.1 Learning Activities

Learning activity	Special instructions
Demonstrate understanding of quality control of food and food safety during processing	Define common terms in food quality, safety and hygiene Identify the safety risk present for each food Identify foods that are at greatest risk of contamination Determine the most important qualities to control
Apply HACCP principles in food processing and preservation	Demonstrate competency in design and development of a HACCP workbook Competently fill in the HACCP workbook of a food processing plant
Identify foodborne illnesses	Identify and describe common food infections Demonstrate knowledge on the microorganisms responsible for foodborne illnesses and their prevention Classify the foodborne illnesses based on the causative agents (viral, bacterial, fungal etc) Demonstrate competency in preventing and managing foodborne illnesses
iIdentify and describe food hygiene	• Demonstrate ability to maintain sanitation • Demonstrate competency to work in a hygienic manner • Observe food, personal and kitchen hygiene during food processing
Identify and describe principles in food processing and preservation as per resource materials	Observe some of the critical activities during food processing and preservation

5.3.4.2 Information Sheet

Definitions

- Control point: Any point in a specific food system where loss of control does not lead to an unacceptable health risk
- Critical control point (CCP): Any point or procedure in a food system where control can be exercised and a hazard can be minimized or prevented
- HACCP plan: The written document that delineates the formal procedures to be followed in accordance with these general principles
- Hazard: Any biological, chemical, or physical property that may cause an unacceptable consumer health risk (unacceptable contamination, toxin levels, growth, and/or survival of undesirable organisms)
- HACCP (Hazard Analysis Critical Control Point) – A food safety system designed to keep food safe throughout its flow in an establishment.
- Hazard Analysis – The process of identifying and evaluating potential hazards associated with food in order to determine what must be done.
- Critical Limit – A set range (minimum and maximum) limit a CCP must meet in order to prevent, eliminate, or reduce the hazard to an acceptable limit.
- Monitoring – The process of analyzing whether your critical limit are
- Foodborne illness: an infection or irritation of the grastrointestinal tract caused by foods or beverages that contain harmful bacteria, parasites, viruses or chemicals.

Quality control of food and food safety during processing; from farm to fork

It is imperative for a food processor to determine what safety risk is present for each food which can be classified as follows;

a) Pathogenic microorganisms: bacteria and viruses

b) Spoilage microorganisms: fungi and bacteria

The most important qualities to control include;

i) pH

- Bacteria thrive in a pH neutral environment
- Items with pH above 8 tend to be very bitter and toxic
- Foods with pH below 6 tend to be tart or sour

ii) Temperature

- The temperature danger zone is 40-140°F; there is rapid multiplication of microorganisms
- At temperature <40°F there is very slow growth
- At temperature <28°F there is neither growth nor death

- At temperature >140°F, death of microorganisms is observed

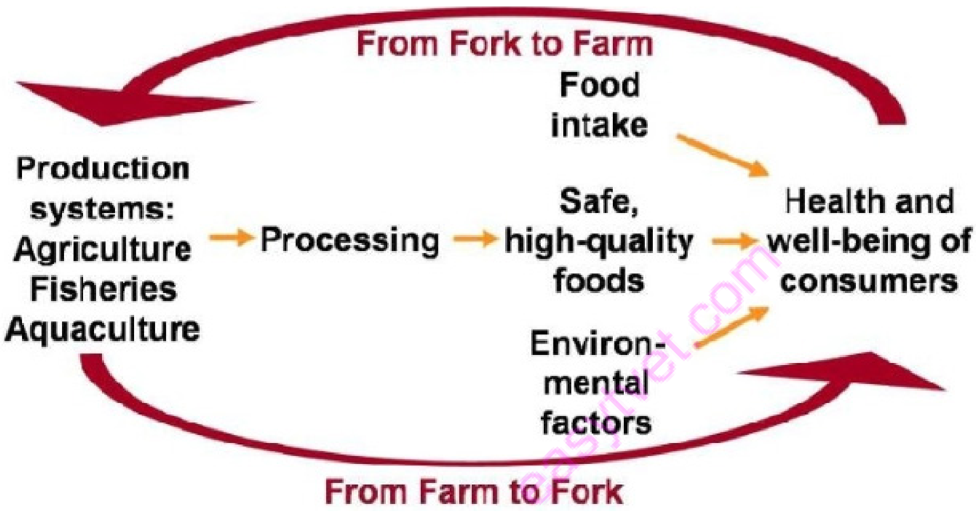
iii) Moisture content

- Bacteria need a high moisture content hence disease causing bacteria will be absent in dry foods.
- Fungi can grow in lower moisture hence causing spoilage

iv) Protein content

- Bacteria need protein but fungi rarely requires it hence most carbohydrates do not have disease causing bacteria although they may undergo spoilage

Food safety and quality are the primary aspects of food production, processing, and consumption. Decent quality and safety protocol are necessary to prevent the entire food chain from the farmers who grow it to the consumers from compromise.



If food safety lapses, this can lead to the contamination of food and people would be exposed to severe health risks.

Food quality has to do more with the taste colour, texture and nutritional value of the food we eat, and it takes professionals to come up with a standard for the food quality. Some manufacturers use panels or people such as tea tasters to monitor food quality. Over the recent years, new technological advancements allow for better enhancement of food quality.

The following are some of the approaches to safety and quality in food processing;

Facility Location And Design

To ensure food safety and quality, design and location of a food processing facility need to be taken into account. The facilities should have a firm plan, and the materials used for the internal structure should be durable, easy to clean and maintain and prevent a buildup of dirt. Also, the facility should be worker-friendly, this means that it should be safe for the staff work. Location is crucial since you want to be located near clean water to clean the firm, windy areas might not be suitable for a food manufacturer since wind brings a lot of dust in the facility.

Pest Control

Pest control plays a crucial role in food safety. Cockroaches and flies are among the troublesome insects which can help spread disease and eventually lead to the development of food-borne illnesses. Stored product insects are also destructive as they can damage and contaminate food during transport and storage. Other pests that cause damage are rodents such as rats, and these can destroy the building fixtures and machinery as well as spreading deadly diseases.

The best way to take care of the pest problem is to Investing in a pest control monitoring and detection system. This system will help prevent pests from entering a food processing facility, and assist in the compliance of food safety guidelines.

Waste Management

An appropriate waste removal and storage procedure should be provided, and this is purposefully to ensure that proper food safety practices are followed. Waste management is a crucial factor in food processing since any contact to of waste to the food could lead to contamination or significant callbacks. The waste disposal should be managed following set regulations to prevent accumulation, the risk of contamination and the attraction of pests.

Machinery and Production Line Design

A facility's production line should have a layout that allows easy maintenance and cleaning of machinery and surrounds. The plan should also be able to prevent contamination of the food products and ingredients during the production process.

The food processing machines should have a design that complies with food safety regulations. The regulations are aimed to avoid poor designs. Sometimes poor designs can lead to food materials building up in hidden places which are difficult to clean making rot and contamination inevitable. There are set standards for machinery design so that each machine performs at a high standard of hygiene.

There are principles which assist when coming up with a design for processing machinery. These principles are used to address the issue of poor design and come up with one that meets all standards, and they are as follows:

1. Cleanable to a microbiological level.
2. Made of compatible materials.
3. Accessible for inspection, maintenance, cleaning, and sanitation.
4. No product or liquid collection.
5. Hollow areas hermetically sealed.
6. No niches.
7. Sanitary operational performance.
8. Hygienic design of maintenance enclosures.
9. Hygienic compatibility with other plant systems.
10. Validate cleaning and sanitizing protocols.

Cleaning

Institute proper cleaning and disinfecting programs. A cleaning schedule will help ensure food safety complies. Also to prevent foodborne illnesses from breaking out, the correct hygiene standards should be met.

Microorganisms can cause food poisoning in the processing facility and the best way to avoid this is through the use of disinfectants. The food preparation areas should be properly disinfected, also utensils and machinery used within food processing cycle should be adequately cleaned as well. Microbes will not contaminate food products created if surfaces are always clean.

Keeping track with the correct cleaning schedule will also reduce the risk as well as preventing pests from coming into the facility and getting into contact with food.

Maintenance

To ensure the production of safe foods and that everything runs smoothly and correctly, a proactive maintenance measure for premises and food processing machinery should be established. Some researchers claim that failure to ensure equipment is properly maintained under the correct sanitary conditions has caused some foodborne illnesses outbreaks. Machines performances can be affected by pests such as rats and mice which gnaw at the power cables. They also contaminate components which have direct contact with the food products. This is why maintenance is crucial for the normal functioning of a food processing facility.

Personal Hygiene

Food safety requirements can be met by installing the correct facilities for staff to ensure proper personal hygiene is met. This will help reduce the spread of bacteria since they can quickly be spread through biological and physical contamination.

To reduce the risk of contamination staff should ensure they follow effective hand washing techniques, try to minimize direct hand contact with raw food. They should also ensure that they use gloves safely and dispose of them properly.

Staff Training

Staff should be educated on how to follow food safety practices, and this will help reduce the risk of food contamination in the processing zone. Regulations dictate that food handlers are supervised and trained in food handling practices suitable in their fields.

Food safety and quality is a global concern that affects the world’s population. Ensuring safety and quality will lead to reduced food wastage, hunger and starvation in the world as well as providing quality foods to everyone’s tables.

Principles of HACCP

Principle 1: conduct hazard analysis:

Assess the hazards and risks associated with the growing, harvesting, raw materials, ingredients, processing, manufacturing, distribution, marketing, preparation, and consumption of the food in question.

The process of conducting a hazard analysis involves two stages:

i) Hazard identification — During this "brainstorming session" stage, the HACCP team reviews the ingredients used in the product, the activities conducted at each step and the equipment used, the final product and its method of storage and distribution, and the intended use and consumers. Based on this review, the team develops a list of potential biological, chemical or physical hazards which may be introduced, increased or controlled at each step in the production process.

ii) Hazard evaluation — during this stage, the HACCP team evaluates the severity and likelihood of each potential hazard occurring and decides which ones must be addressed in the HACCP plan. (Such considerations do not include common dietary choices which lie outside of HACCP.)

After completing the hazard analysis, the hazards associated with each step in the production of the food should be listed along with any measures that are used to control the hazards. The term "control measure" is used because not all hazards can be prevented, but virtually all can be controlled.

Principle 2: Determine CCP(s):

A critical control point is defined as a step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. The potential hazards that are reasonably likely to cause illness or injury in the absence of their control must be addressed in determining CCPs. The principle seeks to minimize and/or to control the hazard. It focuses on;

- Heat process steps where time-temperature relations must be maintained to destroy given pathogens
- Freezing and time to freezing before pathogens can multiply
- The maintenance of pH of a food product at a level that prevents growth of pathogens
- Employee hygiene

One strategy to facilitate the identification of each CCP is the use of a CCP decision tree. (Keep in mind that a decision tree is merely a tool; it is not a mandatory element of HACCP, nor is it a substitute for expert knowledge).

Examples of CCPs may include:

- Chilling
- Thermal processing
- Product formulation control
- Testing ingredients for chemical residues
- Testing product for metal contaminants

CCPs must be carefully developed and documented. In addition, they must be used only for purposes of product safety. Different facilities preparing similar food items can differ in the hazards identified and the steps which are CCPs. This can be due to differences in each facility's layout, equipment, selection of ingredients, processes employed, etc.

Principle 3: Establish Critical Limits for each CCP identified

A critical limit is a maximum and/or minimum value to which a biological, chemical or physical parameter must be controlled at a CCP to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard. This could mean keeping refrigeration temperatures within a certain specific and narrow range or making sure that a certain minimum destructive temperature is achieved and maintained long enough to effect pathogen destruction. A critical limit is used to distinguish between safe and unsafe operating conditions at a CCP.

Each CCP will have one or more control measures to assure that the identified hazards are prevented, eliminated or reduced to acceptable levels. Each control measure has one or more associated critical limits.

Critical limits may be based upon factors such as:

- Temperature
- Time
- Physical dimensions
- Humidity
- Moisture level
- Water activity
- pH
- Titratable acidity
- Salt concentration
- Available chlorine
- Viscosity
- Preservatives
- Sensory information such as aroma and visual appearance

Critical limits must be scientifically based. For each CCP, there is at least one criterion for food safety that is to be met. The critical limits and criteria for food safety may be derived from sources such as regulatory standards and guidelines, literature surveys, experimental results and experts.

Principle 4: Establish Procedures to Monitor each CCP

The monitoring of a CCP involves the scheduled testing or observation of a CCP and its limits; monitoring results must be documented. If, for example, the temperature for a certain process step should not exceed 400C, a chart recorder may be installed.

Microbial analyses are not used to monitor since too much time is required to obtain results. Physical and chemical parameters such as time, pH, temperature, and water activity (^) can be quickly determined and results obtained immediately.

Monitoring serves three main purposes:

a. It facilitates tracking of the operation. If monitoring indicates that there is a trend towards loss of control, then action can be taken to bring the process back into control before a deviation from a critical limit occurs.

b. It is used to determine when there is loss of control and a deviation occurs at a CCP (i.e., exceeding or not meeting a critical limit). When a deviation occurs, an appropriate corrective action must be taken.

c. It provides written documentation for use in verification.

When it is not possible to monitor a CCP on a continuous basis, it is necessary to establish a monitoring frequency and procedure that will be reliable enough to indicate that the CCP is under control, such as statistically designed data collection or sampling systems.

Principle 5: Establish Corrective Actions

Corrective actions to be taken when deviations occur in CCP monitoring should be established. This because there is no system which is perfect and when preventative measures fail, corrective actions must come into play so as to prevent potential hazards from reaching the consumers.

- The actions taken must eliminate the hazard that was created by deviation from the plan. If a product is involved that may be unsafe as a result of the deviation, it must be removed.
- Although the actions taken may vary widely, in general they must be shown to bring the CCP under control.

Corrective actions should:

- Determine and correct the cause of non-compliance
- Determine the disposition of non-compliant product
- Record the corrective actions that have been taken

Principle 6: Establish Procedures for Verification

Verification refers to the activities, other than monitoring, that influence the validity of the HACCP plan and also confirms that the processes are being implemented as per the plan.

Establish procedures for verification that the HACCP system is working correctly.

Verification consists of methods, procedures, and tests used to determine that the system is in compliance with the plan. An effective HACCP system requires little end-product testing, since sufficient validated safeguards are built in early in the process. Therefore, rather than relying on end-product testing, firms should rely on frequent reviews of their HACCP plan, verification that the HACCP plan is being correctly followed, and review of CCP monitoring and corrective action records.

Verification confirms that all hazards were identified in the HACCP plan when it was developed, and verification measures may include compliance with a set of established microbiological criteria when established.

The following information is needed to validate a HACCP plan:

i) Scientific studies

ii) Expert advice

iii) In-plant observations, measurements and evaluations

Principle 7: Establish Effective Recordkeeping Systems

An effective recordkeeping systems should be established to document the HACCP plan. The HACCP plan must be on file at the food establishment and must be made available to official inspectors upon request. Forms for recording and documenting the system may be developed, or standard forms may be used with necessary modifications.

Typically, these may be forms that are completed on a regular basis and filed away. The forms should provide documentation for all ingredients, processing steps, packaging, storage, and distribution.

Generally, the records maintained for the HACCP System should include the following:

1. A summary of the hazard analysis, including the rationale for determining hazards and control measures

2. The HACCP Plan

- Listing of the HACCP team and assigned responsibilities
- Description of the food, its distribution, intended use and consumer
- Verified flow diagram
- HACCP Plan Summary Table that includes information for:
    - o Steps in the process that are CCPs
    - o The hazard(s) of concern
    - o Critical limits
    - o Monitoring
    - o Correction actions

- o Verification procedures and schedule
- o Record-keeping procedures

Developing HACCP plan

Step 1: Assembling the HACCP team

The team should be made up of individuals, from engineering, production, quality assurance, food microbiology & sanitation departments, who have specific knowledge and expertise about the product and process. External experts can also be added into the team so as to help weigh in on potential chemical, biological and/or physical hazards.

Step 2: Description of the product

It is the responsibility of the HACCP team to provide the general description of the food, ingredients used and processing methods followed. They should also determine the method of distributing the product and the state of food during circulation e.g. refrigerated, frozen or at ambient temperature

Step 3: Identification of the product's customer and intended use

The targeted users of the product may be the general public or specific population group e.g the infants, geriatrics, pregnant and lactating mothers etc

Step 4: construction of flow diagram describing the production process

All the steps involved should be stated in clarity and simplicity. The diagram can be a block-type design — it should does not need to be as complex as engineering drawings. Also, including a simple schematic of the facility can be useful for understanding product and process flow.

Step 5: On-site confirmation of flow diagram

The HACCP team should perform an on-site review of the operation to verify the accuracy and completeness of the flow diagram, and modifications should be made to the diagram as needed. After these first five preliminary tasks have been completed, the following seven principles of HACCP are applied.

The next steps will then be the seven principles of HACCP in their correct order.

Implementation and management of HACCP plan

The commitment of the management is very critical to the successful implementation of a HACCP plan. A plan describing the individuals' roles and responsibilities for developing, implementing and maintaining HACCP system should also play a key role in the implementation of a HACCP system. Once this is in place, the individuals involved should be well trained on the implementation so they understand what is expected of each one of them.

Maintaining an effective HACCP system depends largely on regularly scheduled verification activities. The HACCP plan should be updated and revised as needed.

Download a sample HACCP manual here

https://myhaccp.food.gov.uk/help/guidance/resources

Food borne illnesses

Food borne illnesses are also known as food poisoning

There are 3 main Causes of Food Borne Illnesses:

1. Cross-Contamination
2. Time-Temperature Abuse
3. Poor Personal Hygiene

1. Cross contamination

Cross contamination occurs when microorganisms are transferred from one surface or food to another. The microorganism can transfer from:

Hand to food: When food is contaminated during handling; preparation, storage, service. It occurs mostly because of poor food handling practices such as not washing hands.

When to wash hands

When to wash hands

Before:

- Beginning food preparation
- Putting on disposable gloves
- Serving customers
- Handling a baby

After:

- Arriving at work and after break
- Using the restroom, washing sinks
- Eating, drinking, smoking, chewing tobacco and gums
- Using the telephone
- Using handkerchief or tissue
- Using handkerchief or tissue
- Handling inventory
- Handling raw foods
- Touching or scratching a part of the body
- Coughing, sneezing

- Handling garbage
- Touching dirty surfaces

Food to food: When harmful organisms from one food contaminate other foods

Preventing food to food contamination

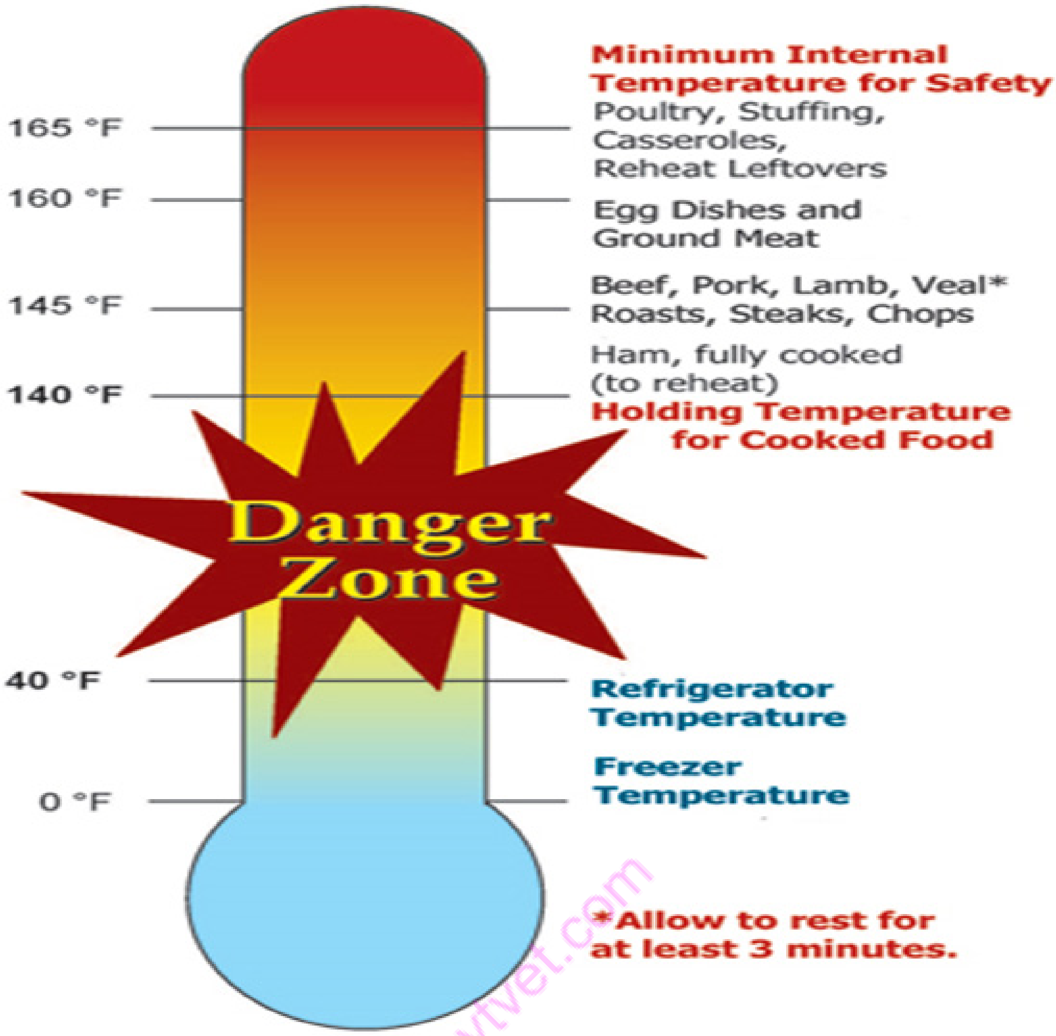
- Always keep raw foods separate from ready-to-eat foods
- In the refrigerator, ready to eat foods must be stored above raw food
- Don’t mix left over foods with fresh foods
- Wash fruits & veg. in running water
- Do not let raw meat and raw vegetables be prepared on the same surface at the same time
- Prepare ready to eat foods first- then raw foods
- Prepare raw and ready to eat foods in separate areas of the kitchen

Equipment to food: when equipment harbors contaminants and they get into food

- Use separate cutting boards for different foods (meat-veg)
- Prepare raw foods in separate area from fresh and ready to eat foods
- Clean & sanitize equipment, work surfaces & utensils after preparing each foods
- Use specific containers for various food products.
- Make sure cloth and paper towel used for wiping spills are not used for any other purposes

2.Time-Temperature abuse

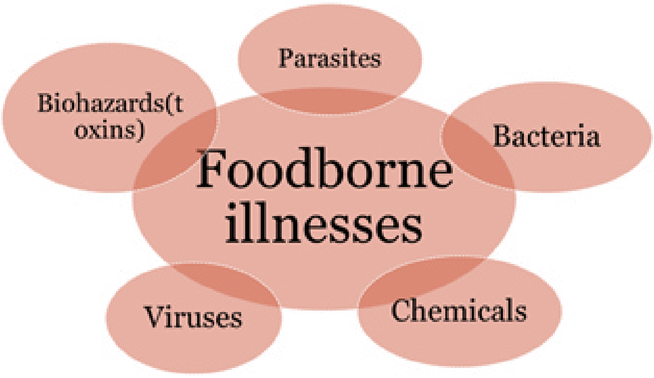
Happens when food is exposed to Temperature Danger Zone (40ºF -140ºF) for more than 4 hrs. It’s the temperature range in which food-borne bacteria(e.g E.coli, salmonella) can grow to dangerous levels and can cause illness



3. *Poor personal hygiene*

Factors contributing to outbreaks of food poisoning:

- Storage at ambient temperature
- Inappropriate cooling
- Contaminated processed food
- Undercooking
- Contaminated canned food
- Inappropriate thawing
- Cross contamination
- Infected food handlers



Common causes of foodborne illnesses

Classification of food borne illnesses

- Food-borne infections – Where the disease is produced by living organisms such as certain bacteria, parasites, viruses,etc entering the body through consumption of food that contains living disease-causing microorganisms.
- Food Intoxication – caused by eating food that contains a harmful chemical or toxin produced by bacteria or other source. It is also where the disease is produced by substances called toxins or poisonous agents in the food before consumption.
- Toxin-mediated infection - caused by eating a food that contains harmful microorganisms that will produce a toxin once inside a human body.

Types of food-borne illnesses caused by bacteria

Bacteria are classified as "spore forming" and "non spore forming". Spores enable cells to survive environmental stress such as cooking, Freezing, high salt condition, drying and high acid condition.

1. Botulism

It is caused by a bacteria known as clostridium botulinum, an anaerobic and spore forming bacteria. This organism produce a neurotoxin, deadly biological toxin to man. Spore forming bacteria are found in foods that are grown in soil and animal products.

Type of illness: Bacterial intoxication

Symptoms: Dizziness, double vision, difficulty in breathing and swallowing

Onset time: 12-36 hrs.

Food Sources: Improperly canned foods, vacuum packed, Refrigerated foods

Prevention: Discard bulging cans ,

Do not use home canned foods

Do not mix and store oil and garlic

Saute onion as needed

Don't store left over potatoes in a foil

2. Campylobacteriosis

It is caused by campylobacter Jejuni bacteria. This bacteria requires a very strict amount of air for growth (microaephilic).

Type of Illness: bacterial infection

Symptoms: watery, bloody diarrhoea, fever, nausea, vomiting, abdominal pain, headache, muscle pain

Onset time: 7-10 days

Food Sources: Unpasteurized milk, raw poultry, beef faecal contaminated water

Preventive measures:

- Personal hygiene,
- Follow hand washing guidelines
- Avoid cross contamination
- Cook all meat
- Maintain good pest control
- Use pasteurized dairy products
- Use safe water

3. E. Coli Infection

This food infection is caused by Escherichia coli, a facultative anaerobic bacteria which produces shiga toxin, a poisonous substance.

Type of Illness: Bacterial Infection

Onset time: 3-8 days

Symptoms: Bloody diarrhoea followed by kidney failure

Haemolytic Uremic Syndrome

Food Sources: undercooked ground beef, unpasteurized apple juice, undercooked fruits & vegetables, raw milk, dairy products

Prevention

- Good personal hygiene
- Avoid cross contamination
- Cook all poultry, meat carefully

- Use pasteurized milk and dairy products
- Wash all fresh fruits & vegetables in a clean running water

4. Listeriosis

This foodborne illness is caused by a facultative anaerobic bacteria known as Listeria Monocytogenes. This bacteria has the ability to survive in high salt foods, and can grow in refrigerated temperature.

Type of Illness: Bacterial Infection

Onset time: 3- 7 days

Symptoms: headache, stiff neck, confusion, loss of balance, convulsion, dangerous for pregnant women (may result to premature delivery, fetal death)

Food Sources

- raw milk, meat
- refrigerated ready to eat foods
- processed foods (hotdogs, deli meats, luncheon meats)
- soft cheeses

Prevention

- Good personal hygiene
- Avoid cross contamination
- cook all meat, poultry carefully
- Use pasteurized milk, milk products
- Wash all fruits & vegetables in a clean running water
- Clean & sanitized utensils & equipment

5. Perfringens foodborne illness

This infection is caused by a microaerophilic bacteria known as Clostridium perfringens.

Type of Illness: Bacterial toxin mediated infection

Onset time: (8- 22 hrs.)

Symptoms: Severe abdominal cramps; severe diarrhoea

Food Sources

- cafeteria germs
- spices, gravy
- improperly cooled foods
- foods not cooked to the right temperature

Prevention

- Good personal hygiene
- Avoid cross contamination
- Cook all meat carefully

6. Salmonellosis

This food infection is caused by a facultative anaerobic bacteria called salmonella bacteria. It is mostly brought about by faecal contamination.

Type of Illness: Bacterial infection

Symptoms: stomach cramps, diarrhoea, head ache, nausea, fever, vomiting

Type of Illness: Bacterial infection

Symptoms: stomach cramps, diarrhea, head ache, nausea, fever, vomiting

Food Sources

- contaminated by soil, insects, intestinal waste of animals
- raw meat, fish, eggs,
- raw salad dressing, cake mixes, sliced fruits & vegetables
- dried gelatin, peanut butter

Prevention

- Good personal hygiene
- Avoid cross contamination
- Cook all meat carefully

7. Shigellosis

It is a food infection caused by shigella bacteria, a facultative anaerobic bacetria. It mainly comes from human intestines, polluted water, spread by flies and food handlers.

Type of Illness: Bacterial infection

Symptoms

Diarrhea,fever,Abdominalcramps,dehydration

Food Sources: foods that are prepared by human contacts e.g. salads, ready to eat meats

pasta salads, lettuce, moist foods

Prevention

- Good personal hygiene
- Avoid cross contamination

- Use clean water
- control flies
- cook foods properly

8. Staphylococcal illness

This foodborne illness is caused by facultative anaerobic bacteria called staphylococcus aureus. It can grow in cooked or safe foods that are recontaminated. It is commonly found in human skin, hands, hair, nose and throat.

The interesting thing about this illness is that the carriers are both healthy and unhealthy people. It can grow in high salt or high sugar, and lower water capacity.

Type of Illness: Bacterial intoxication

Symptoms: nausea, vomiting,

- Abdominal cramps, headaches
- Food sources
- Foods that are prepared by human contacts
- Left overs, meat,
- Eggs, egg products,
- Potato salad, salad dressings

Prevention

- Good hygiene
- Avoid cross contamination
- Cover a burn or cut wounds
- Wear a disposable gloves when preparing foods
- Cook foods thoroughly

Food hygiene

The food safety and hygiene rules and regulations cover three main areas;

- Personal hygiene
- Kitchen hygiene
- Food handling

Personal hygiene

- Clean and cover cuts and wounds

- Never use bare hands when handling ready to eat foods
- Disposable gloves should be used once
- Take a bath everyday
- Wear appropriate attire
- Observe proper hand washing procedures at all times
- Use a handkerchief to blow the nose, while sneezing e.t.c
- Hair should be kept short and clean

Kitchen hygiene

- There should be nothing in the kitchen to attract pests. Spilt food should be cleaned immediately.
- All equipment and utensils should be cleaned and stored in a clean area
- Work surfaces should be cleaned every day. The floor should be cleaned as soon as spills occur.
- Cloths such as dishcloths and tea towels should be washed daily because dirty clothes are prone to harbouring infectious microorganisms
- Use kitchen bins to dispose of kitchen waste.
- Kitchen bins should be kept outside the kitchen and stored away from the window leading to the kitchen.
- Bins should have tightly closing lids. They should also be easy to clean and maintain

Processing room

- Keep the building clean and tidy at all times.
- Do not let animals into the room.
- Keep out insects and pests.
- Toilets must be in a separate room.
- Store the raw materials in a separate room or cupboard.
- Keep the cleaning materials in a separate room or cupboard.
- Store the finished products in a separate room.
- The store room must be in a cool dry place away from the direct sunlight.
- Only use clean water to wash equipment.

Food hygiene

- Personal hygiene guidelines should be followed
- Always avoid handling food directly if possible, especially cooked food.
- Keep food covered to prevent contamination
- Utensils and equipment should always be kept clean
- Ensure to cook food thoroughly
- Refrain from wearing jewellery, make up, and nail polish
- Hot foods should be eaten while hot
- If a food is eaten cold, it should be cooled as fast as possible and refrigerated within 90 minutes.
- Cold foods should be kept below 5◦C in a refrigerator.
- Cooked food should not be stored too long; up to 3 days in a refrigerator. For longer storage, food should be frozen.
- Avoid reheating food by preparing food that is just enough for a meal.

Plant design and surface layout

Plant design is defined as the overall design of a processing plant. Several stages are involved in designing which may include identification and selection of the product to be processed feasibility analysis and appraisal, design, economic evaluation, design report preparation, procurement of materials, installation and commissioning.

Plant design specifies;

- Equipment to be used
- Performance requirements for the equipment
- The placement of equipment, storage space, shop facilities, office spaces, and site plans etc.
- Required instrumentation and controls, and process monitoring and control interconnections
- Utility and waste treatment requirements, connections and facilities
- The rationale for site selection
- The basis for selecting and sizing critical pieces of equipment

Factors to consider when planning a food plant design and layout.

1. Product flow: – consider if the plant processing with the available equipment will need a linear flow or otherwise

2. Equipment spacing: – ensure that the equipment is properly laid out in the facility to leave adequate room for personnel movement
3. Space for maintenance operations: – ensure that all the equipment has at least 75 cm clearance from the nearest wall to facilitate movement and manipulation during maintenance operations. The doors should open freely
4. Orient the equipment in the plant to facilitate suitable product flow
5. Process parameters (or indicators) should be visible and accessible to facilitate quick implementation of corrective mechanisms
6. Properly place all the operating control panels within reach and properly labelled
7. Consider all other safety concerns within the plant.

Plant layout

Plant layout refers to an optimum arrangement of different facilities including human resource, plant and machinery, material. It is very difficult to change a layout once implemented and the cost of doing so would be very high.

The problem of plant layout should be seen in relation to overall plant design which includes many other functions such as product design, sales planning, selection of the production process, plant size, plant location, building, diversification etc. The layout problem occurs because of many developments including:

- Change in product design
- Introduction of new product
- Obsolescence of facilities
- Changes in demand
- Market changes
- Competitive cost reduction
- Frequent accidents
- Adoption of new safety standards
- Decision to build a new plant

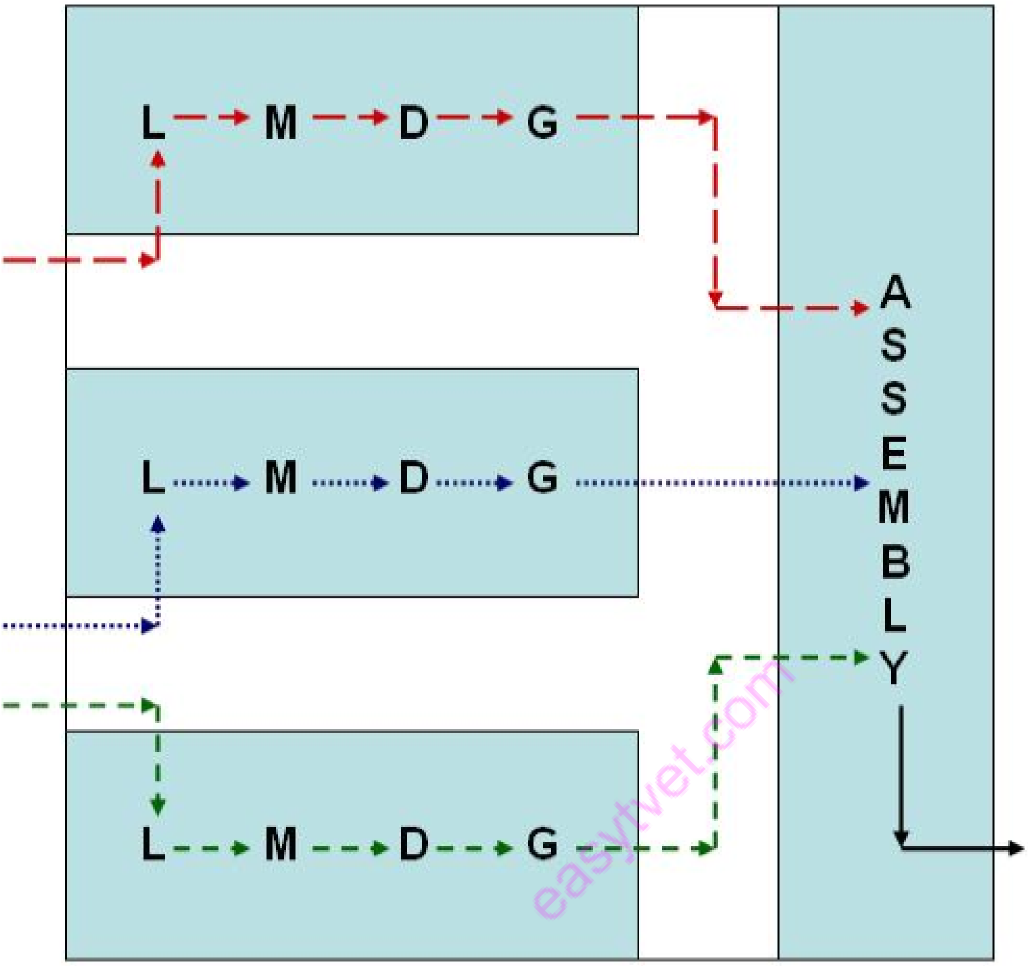
Types of layouts

Depending upon the focus of layout design, the basic types of the layouts are:

1. Product or line layout
2. Process or functional layout
3. Cellular or group layout
4. 'Fixed Position' Layout

Product or line layout

Product focused systems, whereby only one product is produced in a given area, would best fit this type of layout. Work stations are organised in the sequence of appearance in the production process.



Product or line layout

The decision to organize the facilities on a product or line basis is dependent upon a number of factors and has many consequences which should be carefully weighed. Following conditions favor decision to go for a product- focused layout.

- High volume of production for adequate equipment utilization
- Standardization of product
- Reasonably stable product
- demand Uninterrupted supply of material

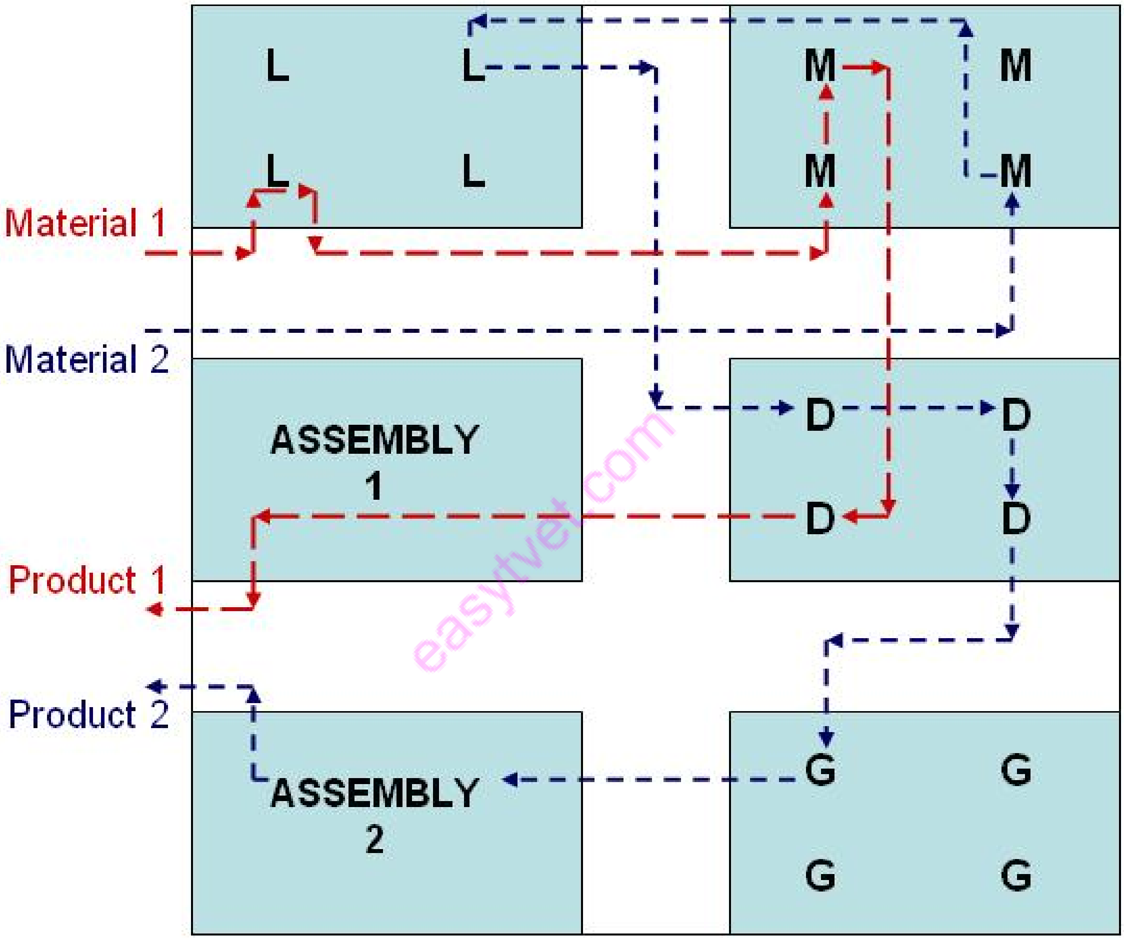
Some of the major advantages of this type of layout are:

- Reduction in material handing
- Less work-in-process

- Better utilization and specialization of labor
- Reduced congestion and smooth flow
- Effective supervision and control

Process or functional layout

It is a layout that is designed for process focused system whereby the processingunits are organized by functions. It is more applicable in a plant where there are low volumes of production of unstandardized products. It is cost effective when flexibility is the basic system requirement.

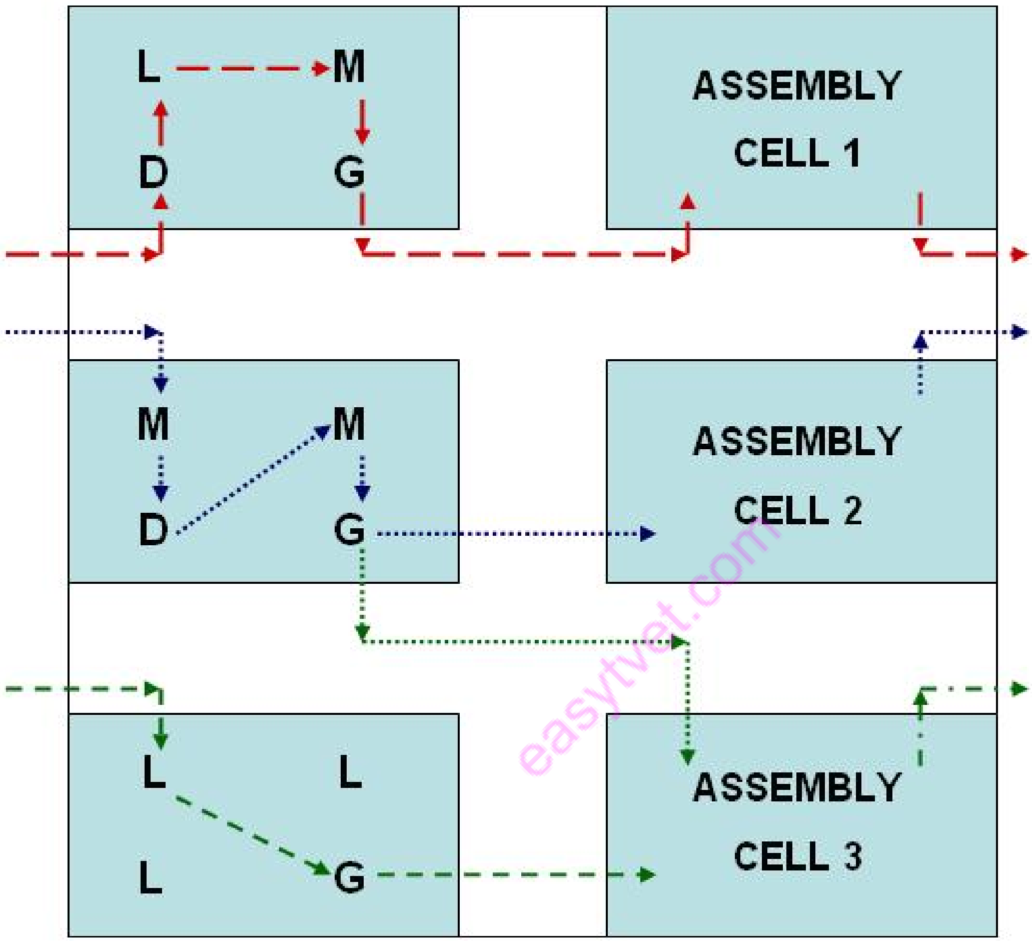


Advantages of a process layout

- Better equipment utilization
- Higher flexibility
- Greater incentive to individual worker
- More continuity of production in unforeseen conditions like breakdown, shortages, absenteeism etc.

Cellular or group layout

t is a special type of functional layout in which the facilities are clubbed together into cells. This is suitable for systems designed to use the concepts, principles and approach of group technology. Such a layout offers the advantages of mass production with high degree of flexibility. We can employ high degree of automation even if the number of products is more with flexible requirements. In such a system the facilities are grouped into cells which are able to perform similar type of function for a group of products.



Cellular or group layout

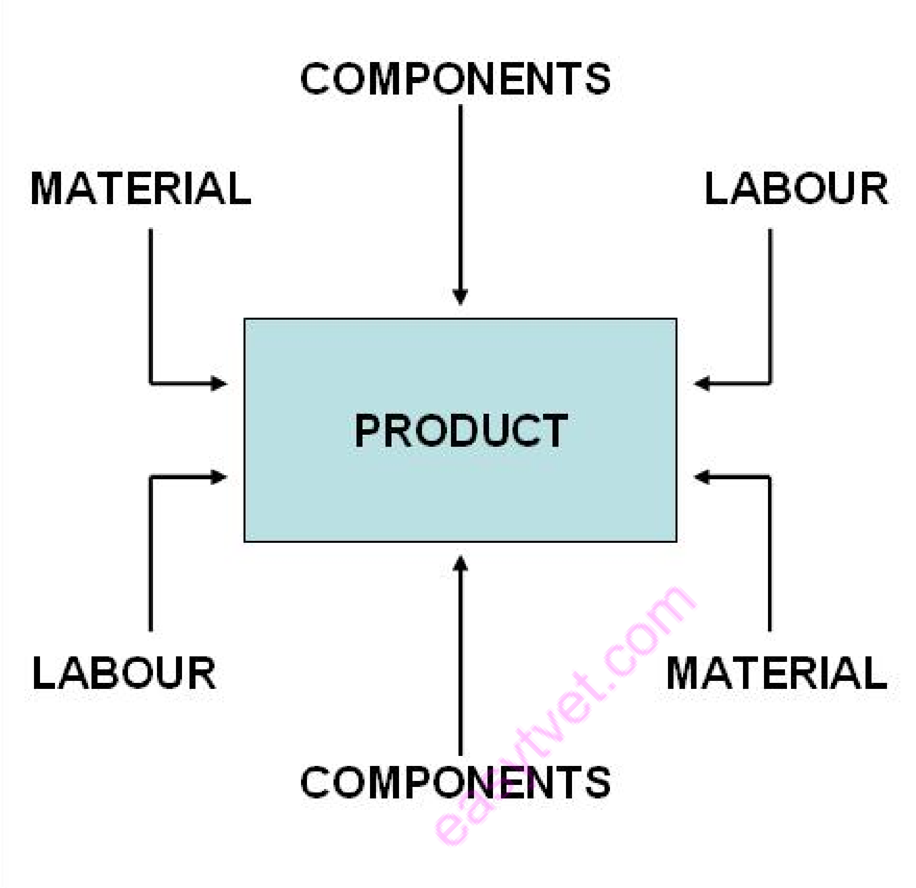
Advantages

- Each cell manufactures products belonging to a single family.
- Cells are autonomous manufacturing units which can produce finished parts.
- Commonly applied to machined parts.
- Often single operators supervising CNC machines in a cell, with robots for materials handling.
- Productivity and quality maximised. Throughput times and work in progress kept to a minimum.
- Flexible.

- Suited to products in batches and where design changes often occur.

Fixed position layout

This is a suitable layout for plant that produces single, large, high cost components or products. The product is usually static hence labour, tools and equipment come to the work site.



Fixed position layout

Food premises and equipment hygiene

Food premises are classified depending on:

Whether commercial or welfare:

- Commercial - purpose generating profit.
- Welfare – put up of taking care of the well-being of customer.

Market served (whether general or restricted):

- General market - market which is open to everyone
- Restricted market- it serves specific group of people.

Ownership: who owns the establishment?

- privately owned

- Public or government owned.

Whether catering is the major or minor activity:

- Commercial : catering is the main activity
- Welfare: catering is not always available to public and catering is secondary to main business.

Operational Requirements

Inspection of food facilities is carried out by public health officials who certify that a facility has met food safety and hygiene requirements.

Key elements assessed include:

- Design and layout of premises,
- Handwashing facilities and toilets,
- Transport,
- Equipment,
- ventilation,
- personal hygiene,
- water supply,
- waste management e.T.C

Sanitation and waste management

Sanitation refers to the provision of facilities (latrines and toilets) and services for the safe disposal of human urine and faeces, the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal. It is primarily concerned with liquid waste.

Globally, insufficient sanitation is a key cause of disease and improving sanitation is known to have a significant beneficial impact on health both in households and across communities.

Waste management: the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker.

Although sanitation and waste management address different issues using different techniques, they have a number of features in common. For example, they both:

- Deal with wastes
- Are concerned with safeguarding human health and preventing disease
- Cause major problems if not done correctly
- Help to reduce environmental pollution (introduction into the environment of substances liable to cause harm)
- Need to be paid for by the users, the city authorities or the government

Types of liquid and solid waste

Waste: a substance/object which is disposed of or is intended to be disposed of by the provisions of national law.

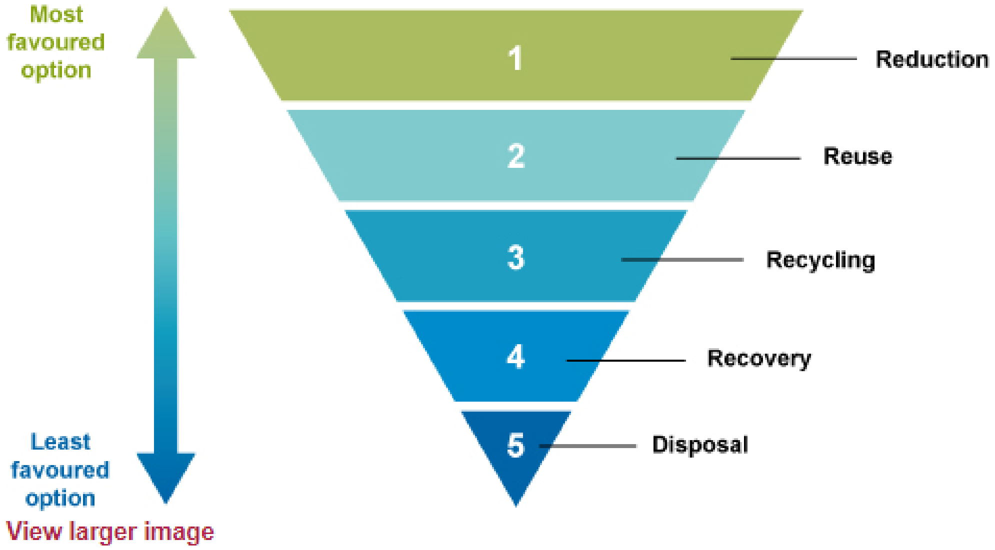
Liquid wastes include;

- blackwater- waste water that contains human waste and urine
- greywater- waste water from human washing and bathing, kitchen sinks, clothes washing etc
- stormwater - wastewater that flows on the surface of the land to join streams. Note that this is considered as wastewater because it contains many different contaminants.
- Sewage is a combination of wastewater coming from any of the above sources and flows in underground sewers or open ditches.
- Excreta is a combination of urine and faeces.

Solid wastes include:

- Residential waste: from households and residential areas. This is sometimes called household waste. Garbage, rubbish, trash and refuse are other terms for residential waste.
- Commercial waste: from businesses such as food and drink establishments, shops, etc.
- Industrial waste: from various types of industrial processes, e.g. food processing, paper manufacture, manufacture of chemicals and metal processing.
- Institutional waste: from public and government institutions, e.g. offices, religious institutions, schools, universities, etc. This is similar to residential and commercial waste in composition.
- Municipal waste (or municipal solid waste) covers all the above wastes produced in an urban area. It is similar in composition to residential waste but excludes some industrial wastes.
- Healthcare waste: any solid waste produced in hospitals, clinics, health posts and other health facilities.
- Agricultural waste: waste that comes from farming.
- Waste from open areas: street sweepings, contents of roadside dustbins, ditches and other public places.
- Construction and demolitionwaste: from various types of building and demolition activities in urban areas.
- Electronic and electrical waste (e-waste): wastes generated from used electronic devices and household appliances.

The waste hierarchy



The waste hierarchy

5.3.4.3 Self-Assessment

1. Define the following terms
   A. Food borne illness
   B. Critical control point
   C. Hazard
2. The following are types of potential food hazards except
   A. Biological Hazards
   B. Radioactive Hazards
   C. Chemical Hazards
   D. Physical Hazards
3. Indicate if the following statements about determination of critical control point are true or false
   A. It focuses on heat process steps where time-temperature relations must be maintained to destroy given pathogens
   B. It overlooks freezing and time to freezing before pathogens can multiply
   C. It focuses on the maintenance of ph of a food product at a level that prevents growth of pathogens
   D. It does not focus on employee hygiene

4. Clostridium botulinum produces _______________ a deadly biological toxin to man
   A. Aflatoxin
   B. Mycotoxin
   C. Neurotoxin
   D. Nutratoxin
5. Differentiate between sanitation and waste management
6. Discuss the various types of plant layout for a food processing plant
7. Why is design important for a food processing plant
8. Illustrate the different designs of processing plant layout
9. Discuss the principles of HACCP
10. Describe the steps followed when developing HACCP plan
11. Discuss the causes, symptoms and preventive measures for the following foodborne diseases
    A. Listeriosis
    B. Campylobacteriosis
    C. Salmonellosis
    D. Botulism

5.3.4.4 Materials

HACCP manual/workbook

Textbooks

LCDs, video clips, charts and other teaching aids

Invitation of competent expertise

Computers with internet

Library and resource centre

Stationery

Food processing plant

Equipped laboratory

Food samples

Reagents

5.3.4.5 References

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CHAPTER 6:

APPLY NUTRITION BIOCHEMICAL TECHNIQUES

6.1 Introduction of the Unit of Learning

This unit specifies the competencies required to apply biochemical techniques. It involves demonstrating the knowledge of macromolecules and their metabolism, enzymes, molecular genetics and biochemistry of macronutrients.

6.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to apply their understanding of macromolecules and their metabolism in metabolic disorders based on the specific macromolecule; demonstrate knowledge of enzymes and hormones based on I.B.U.N; and, describe the nature of chemical constituents of living matter, and their transformation in biological systems based on workplace procedures.

6.3 Learning Outcomes

6.3.1 List of the Learning Outcomes

i) Demonstrate the knowledge of macromolecules and their metabolism

ii) Demonstrate the knowledge of enzymes and hormones

iii) Demonstrate the knowledge of molecular genetics

iv) Demonstrate the knowledge of biochemistry of macronutrient

6.3.2 Learning outcome 1: Demonstrate the knowledge of macromolecules and their metabolism

6.3.2.1 Learning Activities

Learning Activity	Specific instructions
Identify the types of macro molecules.	• Define the term biochemistry • Illustrate the basic structure of a living cell • identify four main types of macro molecules
Illustrate the hierarchy of molecular organization of cells.	• Describe the hierarchy of molecular organization of cells
Describe the structure of the cell and how it is organized to conduct its characteristic chemical functions.	• Identify various cell organelles and explain the function of each.

6.3.2.2 Information Sheet

Definitions

Biochemistry: The study of the transformation chemical substances and vital processes occurring in living organisms.

Application: Nutrition & Preventive medicine – understanding proper nutrition is based on biochemistry also referred to as the chemistry of life

Life is structured in levels beginning with the atom, element, then molecule, from distinct cell up to living organism i.e. the human.

Atom: the smallest object that retains properties of an element. The simplest atom is hydrogen which consists of one proton

Element: a substance consisting of atoms which has the same number of protons

Molecule: Two or more atoms that are chemically combined

Compound: a substance formed by reaction of two or more chemical elements. The elements in a compound are present in fixed ratios. e.g. H2O

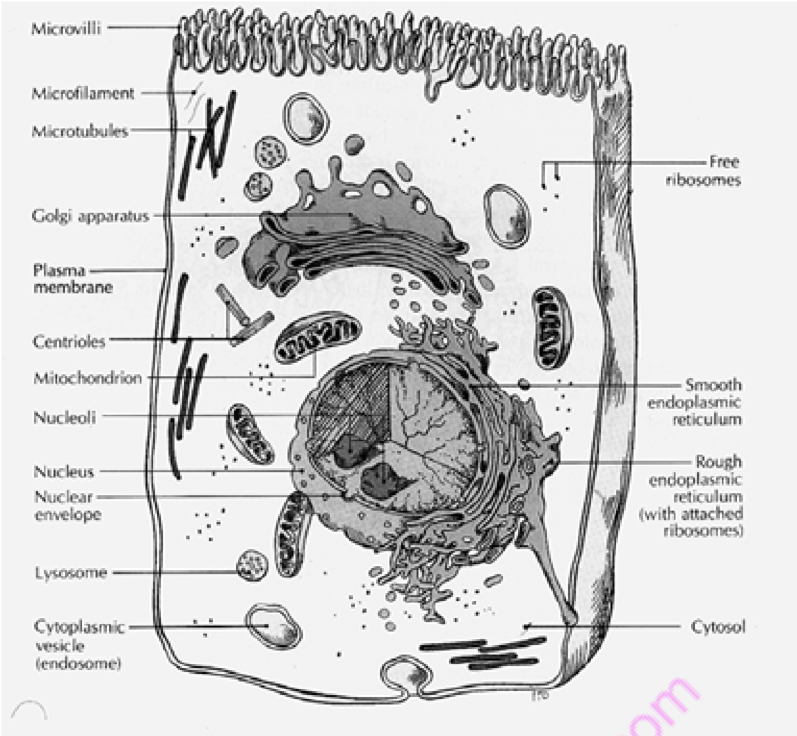
Chemical bonds – Forces by which atoms or ions are bound in a molecule

Cell, structure, function

A cell is the smallest operative unit of a living organism which executes the basic functions of life. The mass and vigor of a cell is defined by its genes, including Its nourishment by the biomolecules and their eventual excretion.

Cellular transport is mediated by transport mechanisms such as diffusion, active transport ingestion, and cellular phagocytosis and pinocytosis

All chemical processes required by the living organism take place at cellular level.



Function of cell organelles

Cell membrane: The plasma membrane is the unit membrane at the cell surface. It defines the boundaries of the cell,

Ribosomes: assemble amino acids into proteins specified by the code in the process of protein synthesis.

Endoplasmic reticulum: The ER exists in two types that is the smooth ER synthesizes steroids and other lipids, Detoxifies alcohol and other drugs, Manufactures all of the membranes of the cell, Whereas, the rough ER which produces the phosphoslipids and proteins of the plasma membrane, and synthesizes proteins that are either packaged in other organelles such as lysosomes or secreted from the cell.

Golgi complex The Golgi complex receives the newly synthesized proteins from the rough ER.It sorts them, cuts and splices some of them, adds carbohydrate moieties to some, and finally packages the proteins in membrane-bounded Golgi vesicles.

Nucleus: it is the control centre of the cell, contains genetic material for the cell, it dictates what the cell is going to do and how it is going to do it.

https://www.youtube.com/watch?v=URUJD5NEXC8&t=70s (Cell Structure and functions video)

Types of macromolecules

a. Water: Substances required for the cells existence are dissolved or suspended in water

b. Carbohydrates: Carbohydrates are the most abundant biomolecules in nature e.g. sugar & starch, Oxidation of carbohydrates is the central energy-yielding pathway – storage & transport of energy e.g. starch & Glycogen

c. Proteins – these are chains of amino-acids joined together by peptide bonds in a linear sequence specified by DNA including enzymes which are proteins that are specialized to catalyse a specific metabolic reactions.

d. Lipids are heterogeneous water insoluble biomolecules that have high solubility in organic solvents but insoluble in polar solvents

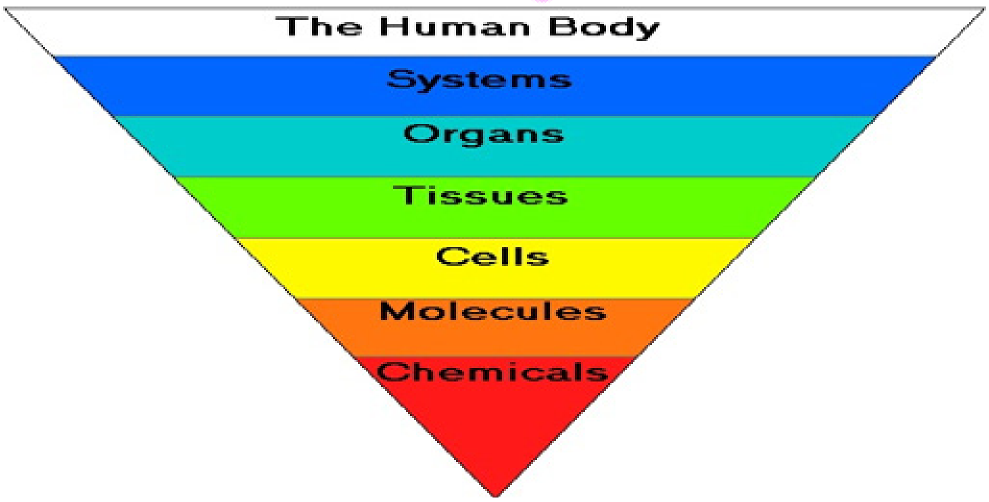
e. Nucleic acids (Ribonucleic acid – RNA & Deoxyribonucleic acid – DNA)

f. Vitamins and minerals- these are organic substances that cannot be synthesized by an organism but are essential for maintenance of normal metabolism and they must be included in the diet hence they must be supplied in the diet, they are required in very small amounts hence they are referred to as micronutrient

g. Hormones: chemical messengers transported by the bloodstream that stimulate responses in another tissue or organ, often far away.

Hierarchy of molecular organization of cells

The hierarchy of molecular organization is organized from the smallest to the most complex as illustrated below:



6.3.2.3 Self-Assessment

1. Describe the hierarchy of the molecular organization
2. Draw an outline of the eukaryotic cell
3 Describe the functions of five organelles of the eukaryotic cell
4. The following are the functions of Golgi complex which one is not.
   A. Receives the newly synthesized proteins
   B. Sorts, cuts and splices some synthesised proteins ,
   C. Control centre of the cell
   D. Adds carbohydrate moieties to some synthesized proteins
5. The ability of the cell membrane to act as a selective barrier depends upon
   A. The lipid composition of the membrane
   B. The pores which allows small molecules
   C. The special mediated transport systems
   D. All the above
6. The power house of the cell is
   A. Nucleus
   B. Cell membrane
   C. Mitochondria
   D. Lysosomes

6.3.2.4 Tools, Equipment, Supplies and Materials

- Anatomical model
- Projector
- Video
- Laboratory
- Microscope
- Stationery

6.3.2.5 References

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6.3.3 Learning Outcome 2: Demonstrate the knowledge of enzymes and hormones

6.3.3.1 Learning Activities

Learning activity	Special instructions
Describe the structure of enzymes Outline the relationship among holoenzymes, apoenzymes and cofactors.	Define the term enzymes and the describe process of enzyme catalysis Demonstrate ability to biochemical reactions which micro and macro molecules undergo within the organisms Using a diagram illustrate the structure of enzymes Describe the relationship holoenzymes, apoenzymes and cofactors
Outline the general mechanisms by which enzymes catalyze reactions as per the type of macro molecule	Explain general mechanisms by which enzymes catalyze reactions
Classify Enzymes as per the I.B.U.N Identify properties of enzymes as per the workplace procedures Discuss the Isoenzymes and zymogens based on workplace procedures Relate Enzymes to their chemical applications based on workplace procedures	Classify the enzymes according to IBUN Discuss properties of enzymes Clearly distinguish between Isoenzymes and zymogens
Functions of hormones, their secretion modes and endocrine disorders are identified and described as per resource materials.	Discuss the functions of hormones Describe the Secretion mode of action and regulation of hormones Explain the various forms of Endocrine disorders

6.3.3.2 Information Sheet

Key terminologies

Enzymes: They are protein specialized to catalyze a specific metabolic reactions.

Intracellular enzymes- Enzymes used in the cells that synthesize them

Extracellular enzymes-Enzymes which are produced by other cells and are secreted to other parts of the body e.g. digestive system.

Zymogen: An enzyme which is secreted in an inactive form and ultimately activated by an agent secreted by another cell e.g. trypsinogen which is activated by enterokinase to give active trypsin. Zymogen secretion may be a protective mechanism against membrane lysis by these enzymes.

Zyamase: an extracellular enzymes which is secreted ready for action e.g amylase

Substrate: the substance on which the enzyme acts.

Allosteric enzymes: These are regulatory enzymes

Allosteric site: The site other than the catalytic site where the modulator of effector molecule bind to achieve regulation.

Active site: The region of an enzyme surface that binds the substrate molecule and transforms it.

Structure of the enzymes

Holoenzyme. A complete, catalytically active enzyme together with its bound coenzyme and/or metal ions.

Apoenzyme or Apoprotein: The protein part of such an enzyme is called the Co-factor is the non-protein chemical molecule(s) which is bound either loosely or tightly to an apoenzyme. Co-factors are of two types: Inorganic and organic cofactors; e.g Hexokinase requires an inorganic co-factor (Mg^{2+})

Co-factors: These are also sub-classified into two categories Prosthetic group and Coenzymes

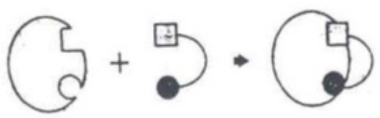
Co-enzymes: A coenzyme is loosely bound organic co-factor. E.g. vitamins & NAD^+

Prosthetic group: A prosthetic group is a tightly bound organic co-factor e.g. Flavins, heme groups and biotin.

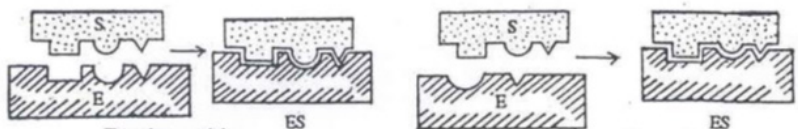
Mechanism of Action of Enzymes

a) Emil Fischer's model Lock and Key model 1890

Lock and Key model of enzyme action implies that the active site of the enzyme is complementary in shape to that of its substrate, i.e. the shape of the enzyme molecule and the substrate molecule should fit each other like a lock and Key. See illustration below



Template or lock-and-key model



Template model

Induced fit model

b) Induced fit Model by KoshLand

In 1958, Daniel Koshland, postulated another model; which implies that the shapes & the active sites of enzymes are complementary to that of the substrate only after the substrate is bound.

Classification of Enzymes

Class	Type of reaction catalysed	Examples
Oxidoreductases	Transfer of electrons (hydride ions or H atoms)	Dehydrogenases, pyruvate dehydrogenase
Transferases	Group transfer reactions	Transaminases e.g Alanine aminotransferase
Hydrolases	Hydrolysis reactions (transfer of functional groups to water)	Peptidase, Esterases and Amidases
Lyases	Addition of groups to double bonds, or formation of double bonds by removal of groups	Decarboylases
Isomerases	Transfer of groups within molecules to yield isomeric forms	Epimerases and racemases
Ligases	Formation of C--C, C--S, C--O, and C--N bonds by condensation reactions coupled to ATP cleavage	COA Ligases

The international agreement, has adopted a system for naming and classifying enzymes. This system divides enzymes into six classes as shown above, each with subclasses, based on the type of reaction catalyzed .Each enzyme is assigned a four-part classification number and a systematic name, which identifies the reaction it catalyzes. As an example, the formal systematic name of the enzyme catalyzing the reaction

ATP + D-glucose = ADP + D-glucose 6-phosphate is ATP: glucose phosphotransferase, which indicates that it catalyzes the transfer of a phosphoryl group from ATP to glucose.

Its Enzyme Commission number (E.C.number) is 2.7.1.1.

- The first number (2) denotes the class name (transferase);
- The second number (7), the subclass (phosphotransferase);
- The third number (1), a phosphotransferase with a hydroxyl group as acceptor.
- The fourth number (1), D-glucose as the phosphoryl group acceptor.

Note: For many enzymes, a trivial name is more commonly used in this case hexokinase

Properties of Enzymes

- The active site of an enzyme is the region that binds substrates, co-factors and prosthetic groups and contains residue that helps to hold the substrate.
- Active sites generally occupy less than 5% of the total surface area of enzyme.
- Active site has a specific shape due to tertiary structure of protein.
- A change in the shape of protein affects the shape of active site and function of the enzyme.

Enzyme Specificity

Enzymes are specific for their substrate and reactions they catalyse. The ability of an enzyme on specific reaction and essentially no others is one of the most significant properties of enzymes. We have several types of enzyme specificity:

Chemical Specificity:-

Group Specificity:-refers to enzymes that act on a number of structurally related compounds from the same homologous series often at different rates, e.g. Hexokinase which assists in the transfer of a phosphate from ATP

Absolute specificity: - this means one enzyme catalyzes or acts on only one substrate. For example: Urease catalyzes hydrolysis of urea but not thiourea.

Stereo specificity- these are enzymes that have the capacity to discriminate stereoisomers of a specific substrate this applies to substrates that exist in two stereo chemical forms chemically identical but with different arrangement of atoms in 3D space For example: arginase catalyzes the hydrolysis of L-arginine but not D-arginine. Maltase catalyzes the hydrolysis of α- but not β –glycosides.

Bond Specificity Enzymes that are specific for a bond or linkage such as ester, peptide or glycosidic belong to this group Examples, Esterases- acts on ester bonds, Peptidases-acts on peptide bonds and Glycosidases- acts on glycosidic bonds

Iso-enzymes: these are multiple forms of an enzyme that differ from each other in their substrate affinity the maximum activity or in regulatory properties. They occur in a number of different forms having the same catalytic activity and they differ from each other chemically E.g The four forms of hexokinase found in mammalian tissues are but one example of a common biological situation: the same reaction catalyzed by two or more different molecular forms of an enzyme.

Enzymes Inhibition

a) Reversible or Irreversible Inhibition

Enzyme inhibitors are molecular agents that interfere with catalysis, slowing or halting enzymatic reactions. Enzymes catalyze virtually all cellular processes, so it should not be surprising that enzyme inhibitors are among the most important pharmaceutical agents known. For example, aspirin (acetylsalicylate) inhibits the enzyme that catalyzes the first step in the synthesis of prostaglandins, compounds involved in many processes, including some that produce pain. The study of enzyme inhibitors also has provided valuable information about enzyme mechanisms and has helped define some metabolic pathways. There are two broad classes of enzyme inhibitors: reversible and irreversible

Reversible Inhibition One common type of reversible inhibition is called competitive. A competitive inhibitor competes with the substrate for the active site of an enzyme. While the inhibitor occupies the active site it prevents binding of the substrate to the enzyme. Many competitive inhibitors are compounds that resemble the substrate and combine with the enzyme to form an EI complex, but without leading to catalysis.

Irreversible Inhibition

The irreversible inhibitors are those that bind covalently with or destroy a functional group on an enzyme that is essential for the enzyme's activity, or those that form a particularly stable non-covalent association. Formation of a covalent link between an irreversible inhibitor and an enzyme is common. Irreversible inhibitors are another useful tool for studying reaction mechanisms. Amino acids with key catalytic functions in the active site can sometimes be identified by determining which residue is covalently linked to an inhibitor after the enzyme is inactivated. A special class of irreversible inhibitors is the suicide inactivators.

These compounds are relatively unreactive until they bind to the active site of a specific enzyme. A suicide inactivator undergoes the first few chemical steps of the normal enzymatic reaction, but instead of being transformed into the normal product

HORMONES

Definition

Hormones chemical messengers transported by the bloodstream that stimulate responses in another tissue or organ, often far away

Secretion and Functions of hormones

Anterior Pituitary Hormones

Anterior lobe of the pituitary synthesizes and secretes six principal hormones, two gonadotropin hormones that target gonads

1) FSH (follicle stimulating hormone) stimulates secretion of ovarian sex hormones, development of ovarian follicles and sperm production

2) LH (luteinizing hormone) stimulates ovulation, stimulates corpus luteum to secrete progesterone and stimulates testes to secrete testosterone

3) TSH (thyroid stimulating hormone) stimulates secretion of thyroid hormone

4) ACTH (adrenocorticotropic hormone) stimulates adrenal cortex to secrete glucocorticoids

5) PRL (prolactin): after birth stimulates mammary glands to synthesize milk, enhances secretion of testosterone by testes

6) GH (growth hormone) stimulates mitosis and cellular differentiation

Posterior Pituitary Hormones

They are produced in hypothalamus, transported to posterior lobe and released hormones when hypothalamic neurons are stimulated

ADH (antidiuretic hormone) - increases water retention, thus prevents dehydration

OT (oxytocin)released during sexual arousal and orgasm, promotes feelings of sexual satisfaction and emotional bonding between partners, stimulates labor contractions during childbirth, stimulates flow of milk during lactation, promotes emotional bonding between mother and infant,

Growth Hormone has widespread effects on the body tissues ,especially cartilage, bone, muscle, and fat induces liver to produce growth stimulants i.e. insulin-like growth factors (IGF-I or IGF-II), stimulate target cells in diverse tissues, protein synthesis increases , lipid metabolism increases, provides energy for growing tissues, carbohydrate metabolism, makes glucose available for glycogen synthesis and storage and electrolyte balance bone growth, thickening, and remodeling influenced, especially during childhood and adolescence secretion high during first two hours of sleep.

The growth hormones can peak in response to vigorous exercise and GH levels decline gradually with age, lack of protein synthesis contributes to aging of tissues and wrinkling of the skin.

Parathyroid hormone (PTH) is secreted by the Parathyroid hormone it increases blood Ca^{2+} levels, promotes synthesis of calcitriol, increases absorption of Ca^{2+} , decreases urinary excretion, increases bone resorption, when stimulated, releases catecholamines (epinephrine and norepinephrine) and a trace of dopamine directly into the bloodstream, effect is longer lasting than neurotransmitters, increases alertness and prepares body for physical activity –,mobilize high energy fuels, lactate, fatty acids, and glucose, increases blood pressure, heart rate, blood flow to muscles, pulmonary air flow and metabolic rate, decreases digestion and urine production

Mineralocorticoids; regulate electrolyte balance. Aldosterone stimulates Na^+ retention and K^+ excretion, water is retained with sodium by osmosis, so blood volume and blood pressure are maintained

Glucocorticoids; regulate metabolism of glucose and other fuels, especially cortisol, stimulates release of fuels into blood, helps body adapt to stress and repair tissues, anti-inflammatory effect can become immune suppression in long-term use

Sex steroids: - Androgens – sets libido; large role in prenatal male development, Estradiol – small quantity, but important after menopause for sustaining adult bone mass

Insulin secreted by B or beta (β) cells, secreted during and after meal when glucose and amino acid blood levels are rising, stimulates cells to absorb these nutrients and store or metabolize them lowering blood glucose levels, promotes synthesis of glycogen, fat, and protein, suppresses use of already-stored fuels

Functions of estradiol and progesterone, development of female reproductive system and physique including adolescent bone growth, regulate menstrual cycle, sustain pregnancy and prepares the mammary glands for lactation.

Mode of action and regulation of hormones

The hormones are classified into

a) Hydrophobic hormones are usually steroid hormones penetrate plasma membrane and enter nucleus. They act directly on the genes, estrogen, progesterone, thyroid hormone act on nuclear receptors they take several hours to days to show effect due to delay for protein synthesis

b) Hydrophilic Hormones: they are usually protein of peptide hormones they cannot penetrate target cell and so must stimulate indirectly most cells sensitive to more than one hormone and exhibit interactive effects.

Synergistic effects -multiple hormones act together for greater effect e.g FSH and testosterone for sperm production

Permissive effects- one hormone enhances the target organ's response to a second later hormone, estrogen prepares uterus for action of progesterone

Antagonistic effects -One hormone opposes the action of another for instance insulin lowers blood glucose and glucagon raises it. Hormone signals must be turned off when they have served their purpose. Most hormones are taken up and degraded by liver and kidney and excreted in bile or urine

Metabolic clearance rate (MCR) - this is defined as the rate of hormone removal from the blood

Endocrine disorders:

These are caused by variations in hormone concentration and target cell sensitivity have noticeable effects on body.

Hyposecretion – this occurs when there is inadequate hormone release, tumor or lesion destroys gland or interferes with its ability to receive signals from another gland, head trauma affects pituitary gland's ability to secrete ADH For instance in diabetes insipidus - chronic polyuria, autoantibodies fail to distinguish gland from foreign matter

Hypersecretion this occurs when there is excessive hormone release, tumors or autoimmune disorder, pheochromocytoma, tumor of adrenal medulla secretes excessive epinephrine and norepinephrine, toxic goiter (Graves disease) Autoantibodies mimic effect of TSH on the thyroid causing thyroid hypersecretion

Diabetes Mellitus occurs when cells cannot absorb glucose, must rely on fat and proteins for energy needs , weight loss and weakness, fat catabolism increases free fatty acids and ketones in blood.

It is characterised by ketonuria which promotes osmotic diuresis, loss of $Na+$ and $K+$, irregular heartbeat, and neurological issues, ketoacidosis occurs as ketones decrease blood pH deep, gasping breathing and diabetic coma are terminal result. If it is chronic pathology (chronic hyperglycemia) it will lead to neuropathy and cardiovascular damage from atherosclerosis and microvascular disease, arterial damage in retina and kidneys (common in type I), atherosclerosis leads to heart failure (common in type II). Diabetic neuropathy – nerve damage from impoverished blood flow can lead to erectile dysfunction, incontinence, poor wound healing, and loss of sensation from area.

6.3.3.3 Self-Assessment

1. Clearly distinguish between the lock and Key hypothesis and the induced fit hypotheses for enzyme action
2. Describe three areas of application of enzymes
3. Steroid hormones are synthesized from
   A. Adenine
   B. Protein
   C. Vitamin
   D. Cholesterol
4. All the following hormones promote hyperglycemia except
   A. Epinephrine
   B. Norepinephrine
   C. Insulin
   D. Glucagon
5. State whether the following statements are TRUE or False
   A. Zyamase an extracellular enzymes which is secreted ready for action e.g. amylase
   B. Substrate is the substance on which the enzyme acts.
   C. Allosteric enzymes are enzymes produced by other cells
   D. Allosteric site is the region of an enzyme surface that binds the substrate molecule and transforms it.
6. Explain the mode of action of steroid hormones
7. Explain the mode of action of adrenalin hormones
8. Discuss three properties of enzymes
9. What do you understand by the following endocrine disorders
   a. Hyposecretion
   b. Hypersecretion

6.3.3.4 Tools, Equipment, Supplies and Materials

- Anatomical model
- Video
- Stationery
- Projector
- Laboratory

6.3.3.5 References

Murray, R. K., Granner, D. K. and Mayes, P. A., (2000). Harper'sm Biochemistry (25th edition). McGraw-HillPress, New York.

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Harwood, R., (2002). Biochemistry Cambridge University Press,Cambridge.

6.3.4 Learning Outcome 3: Demonstrate the knowledge of molecular genetics

6.3.4.1 Learning Activities

Learning Activity	Specific instructions
Identify and classify Nucleic acids. Identify Heterocyclic bases present in nucleic acid.	Discuss the Structural elements of chromosomes Classify the Nucleic acids Identify the heterocyclic bases present in nucleic acid
Identify the pentose sugars in nucleic acid as per the molecular structure Describe the Structures and functions of DNA and RNA.	Using illustrations explin the Structures and functions of DNA and RNA Identify the Pentose sugars in nucleic acid
Describe the process of DNA replication described Describe the process of DNA transcription described	Describe the process of DNA replication Explain the process of DNA transcription
Describe the process of protein synthesis process.	Discuss the process of Protein synthesis
Describe Point mutation Outline the Chromosomes and chromosome pathology.	Define Point mutation explain Chromosomes and chromosome pathology

6.3.4.2 Information Sheet

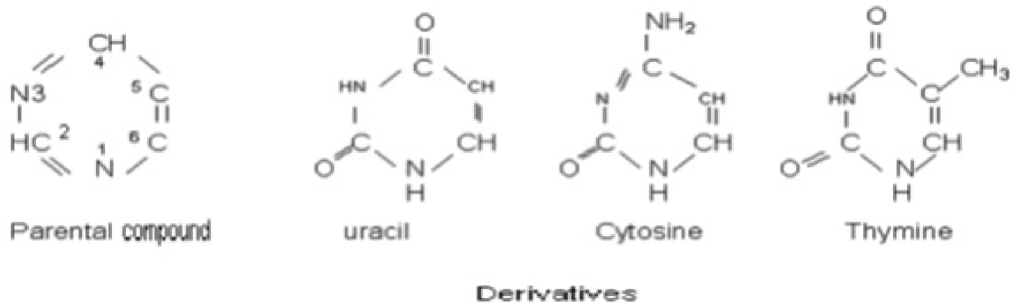
Definitions

Nucleic acid: these are non-protein nitrogenous substances madeup of monomeric unit called a nucleotide they are present in nucleus and Mitochondria. They exist in two basic structural forms, deoxyribonucleic acid (DNA) made up of deoxyribonucleotide and ribonucleic acid (RNA) and in RNA Ribonucleotide

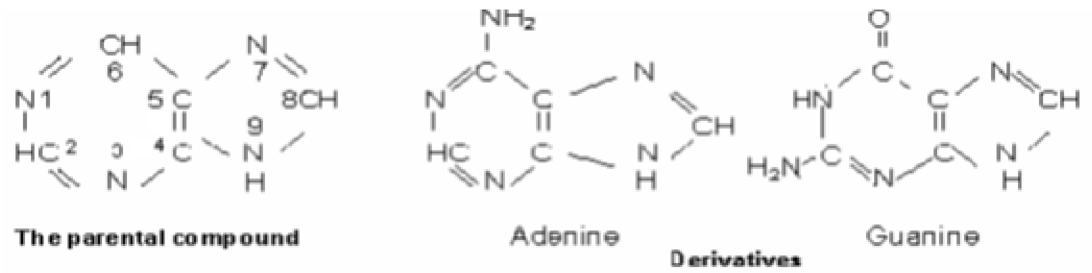
THE STRUCTURE OF DNA

Each deoxyribonucleotide is composed of deoxyribonucleoside an iinorganic phosphate group. Each deoxyribonucleoside is composed of nitrogen bases and a sugar deoxyribose. The nitrogenous bases are usually either purines or pyrimidines.

Pyrimidines bases



Purines bases

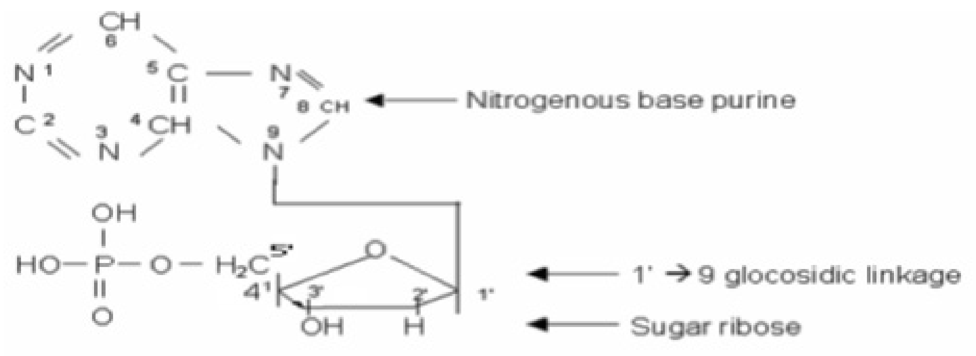


DNA and RNA are polymers of deoxyribonucleotides attached to each other by phosphodiester linkages.Heterocyclicbases.

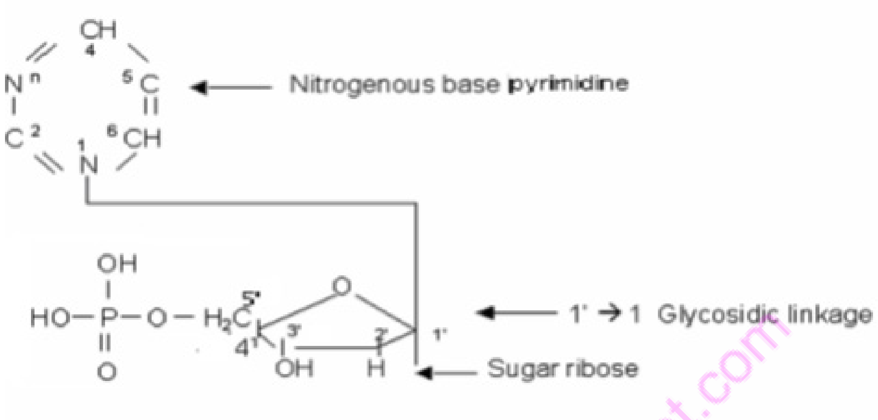
Nomenclature of Nucleic acids

Base	Nucleoside	Nucleotide	Nucleic acid
Purines Adenine	Adenosine Deoxyadenosine	Adenylate Deoxyadenylate	RNA DNA
Guanine	Guanosine Deoxyguanosine	Guanylate Deoxyguanylate	RNA DNA
Pyrimidines Cytosine	Cytidine Cytidylate	Deoxycytidine Deoxycytidylate	DNA
Thymine	Thymidine or deoxythymidine	Thymidylate or deoxythymidylate	DNA
Uracil	Uridine	Uridylate	RNA

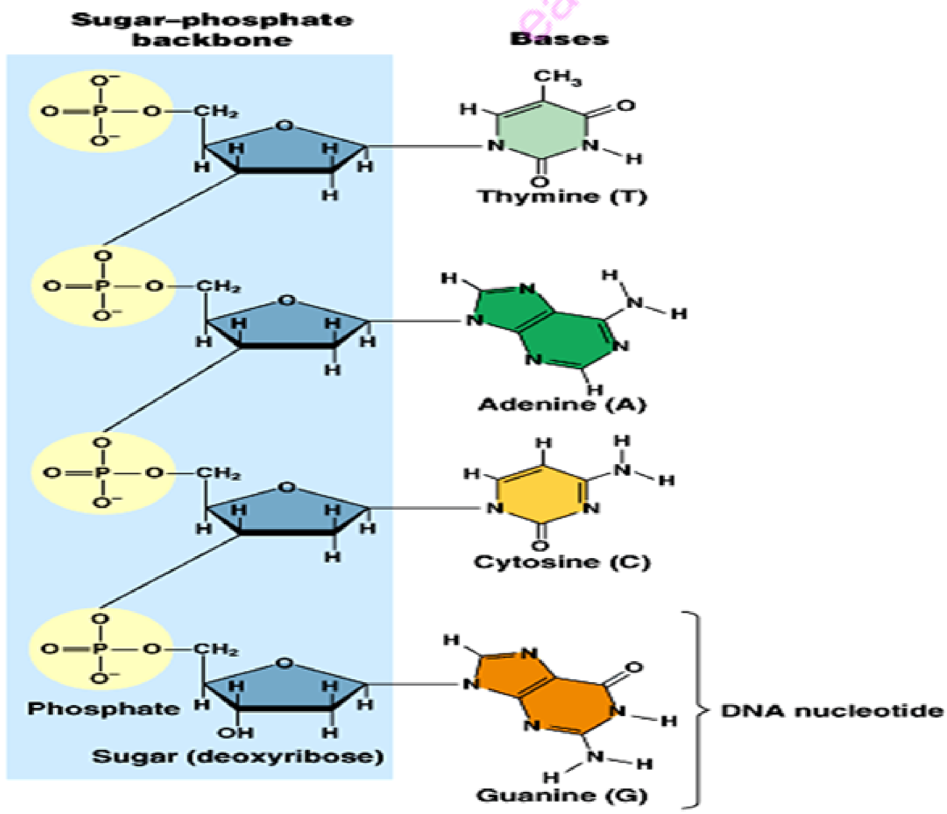
The structure below is a purine deoxyribonucleotide (DNA)



The structure below is a pyrimidine deoxyribonucleotide (RNA)



Primary structure of DNA



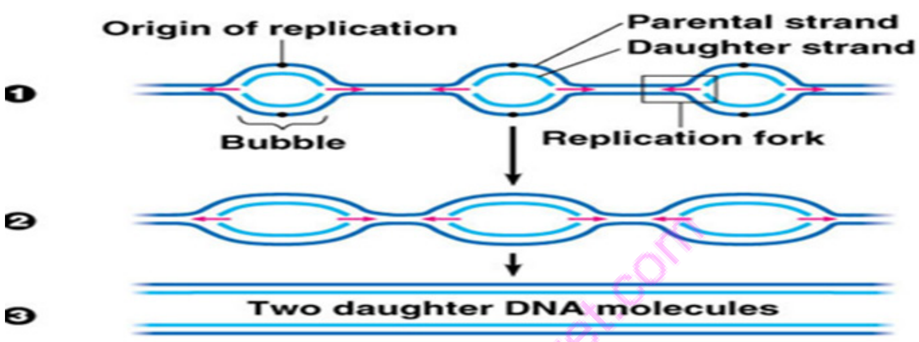
DNA REPLICATION

Synthesis of DNA is called replication. DNA replication starts at the early stage of cell division.

It is the way in which the genetic information can pass from parental cell to daughter cell. As stated before, the double helical structure of DNA depends on the base complementarity. Also this complementarity represents the fundamental basis for the formation of new DNA strands from the parent DNA strand in a semi conservative manner. In this process, two daughter DNA's are produced, each has one parent strand and newly synthesized strand.

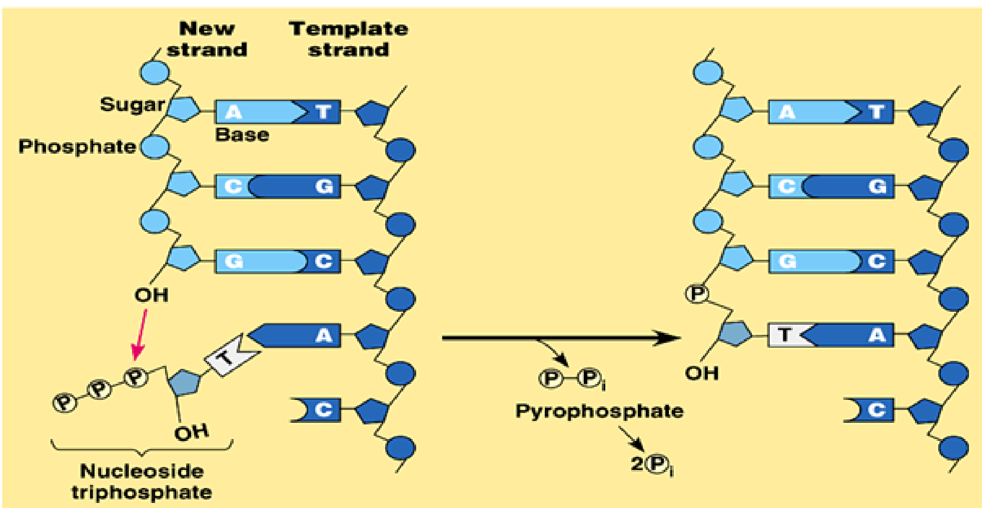
Steps of Replication

Origin of DNA - Replication starts at particular DNA sequence called origin. Origin is rich in TA-T sequence.



(a) In eukaryotes, DNA replication begins at many sites along the giant DNA molecule of each chromosome.

In eukaryotic cells origin is at many sites. To start DNA replication origin is recognized by special protein called DNA. Gyrase is a protein which recognizes DNA origin with the help of DNA protein. The main function of gyrase is to put the negative super twist on double helix of DNA. But the two strands of DNA can be separated by special protein Helicase.

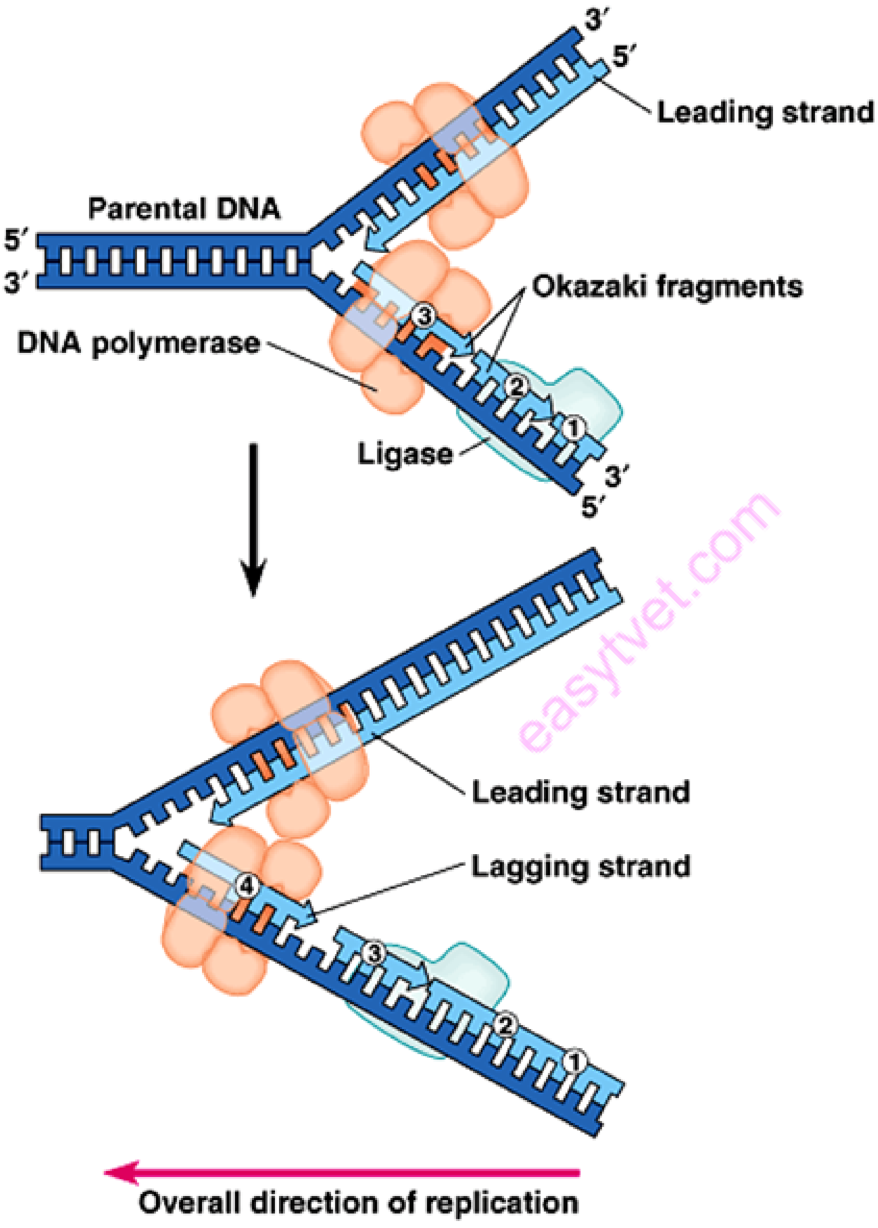


Helicase melts the hydrogen bond of the two strands of DNA. To prevent the recoiling back to the double helix single strand binding protein (SSB) plays the role.

SSB binds to the single stranded DNA and thus protects the single strand from rejoining.

Due to complimentary base paring – one strand of DNA determines the sequence of the other strand. Therefore, each strand of double stranded DNA acts as a template.

The double helix first unwinds – controlled by enzymes –and uses new nucleotides that are free in the nucleus to copy a complimentary strand off the original DNA strand



Enzymes involved in DNA replication & replication

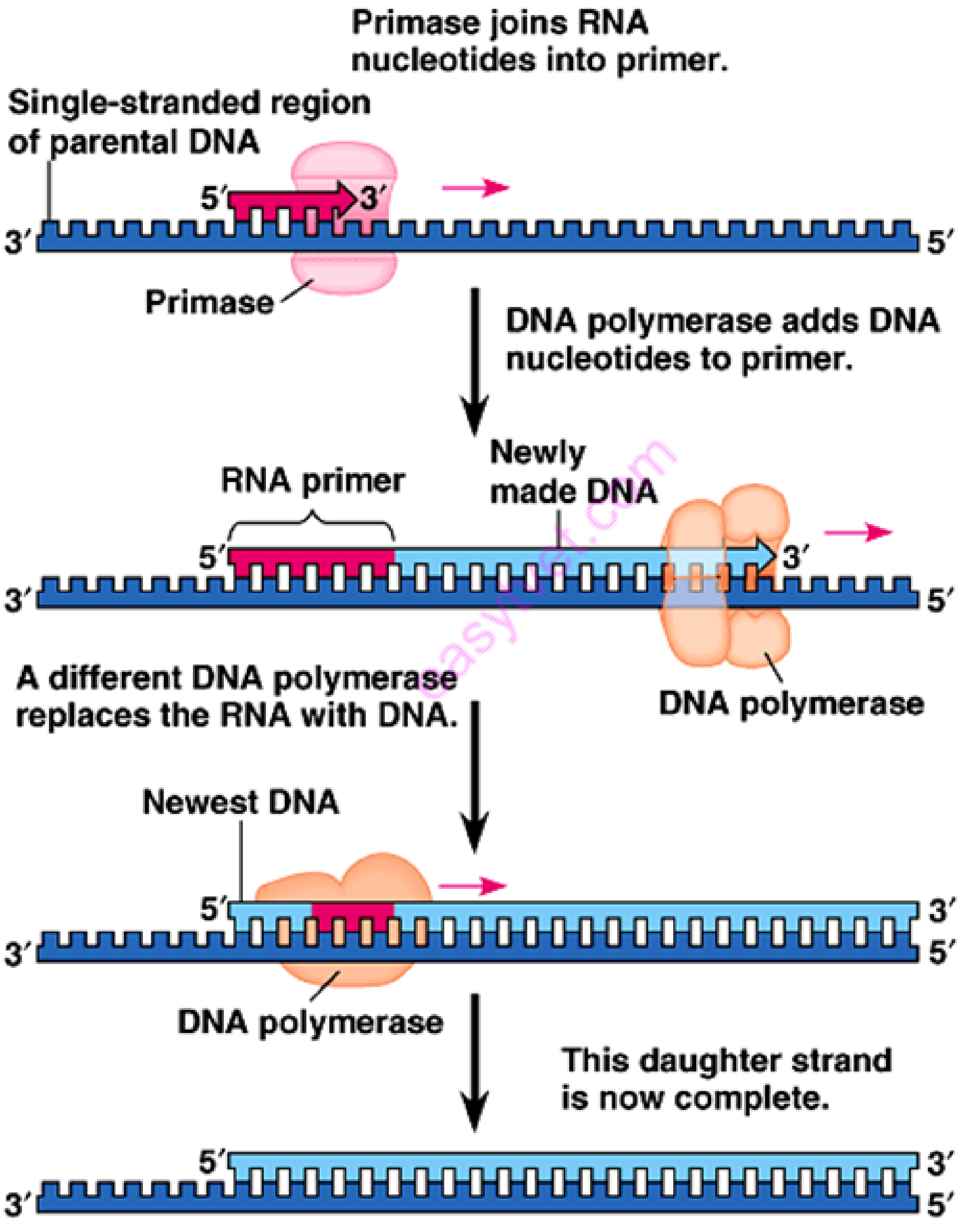
Helicase enzyme will always unwind the original double helix strand.

DNA polymerase-is a single-strand binding protein keeps helix apart so replication can start

Primase is used to prime an area to start replication except it that it adds RNA nucleotides at first

Polymerase to join individual nucleotides (dehydration synthesis).

Ligases is useful in joining of the short segments,



6.3.4.3 Self-Assessment

1. Distinguish between RNA and DNA
2. Outline the process of Protein synthesis
3. Explain the process of DNA replication
4. Which one of the following is not a component of deoxy- ribonucleotide
   A. Inorganic phosphate group
   B. Fatty acid group
   C. Nitrogen bases
   D. Sugar deoxyribose
5. A nucleoside consists of
   A. Nitrogenous base
   B. Purine or pyrimidine base + sugar
   C. Purine or pyrimidine base + phosphorous
   D. Purine + pyrimidine base + sugar +phosphorous
6. A nucleotide consists of
   A. A nitrogenous base like choline
   B. Purine + pyrimidine base + sugar + phosphorous
   C. Purine or pyrimidine base + sugar
   D. Purine or pyrimidine base + phosphorous
7. A purine nucleotide is
   A. AMP
   B. UMP
   C. CMP
   D. TMP
8. A pyrimidine nucleotide is
   A. GMP
   B. AMP
   C. CMP
   D. IMP

6.3.4.4 Tools, Equipment, Supplies and Materials

- Anatomical model
- Projector
- Video
- Laboratory
- Microscope
- Stationery

6.3.4.5 References

Nelson, D.L. and Cox, M.M., (2000). Principles of Biochemistry (3rd edition). W. H. Freeman, London.

Harwood, R., (2002). Biochemistry Cambridge University Press, Cambridge.

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6.3.5 Learning Outcome 4: Demonstrate the knowledge of biochemistry of macronutrient

6.3.5.1 Learning Activities

Learning Activity	Specific instructions
Identify and describe the terminologies in biochemistry of macronutrients ,	Demonstrate the ability to define of terms in biochemistry of macronutrients
Describe the Biochemistry of carbohydrates	Explain the structure, properties and classification of carbohydrates, Discuss the various froms of carbohydrate metabolism, Calculate the net energy output in the energy path ways Identify and explain metabolic disorders of carbohydrate metabolism
Describe the Biochemistry of proteins as per resource materials	Explain the structure, properties and classification of aminoacids and proteins Discuss the various froms of aminoacids and proteins, Calculate the net energy output in the energy path ways Identify and explain metabolic disorders of protein metabolism
Describe the Biochemistry of lipids is as per resource materials	Explain the structure, properties and classification of lipids, Discuss the various froms of lipid metabolism, Calculate the net energy output in the energy path ways Identify and explain metabolic disorders of lipids metabolism

6.3.5.2 Information Sheet

Definitions

- Metabolism is the totality of an organism's chemical reactions
- Anabolic pathways consume energy to build complex molecules from simpler ones. The synthesis of protein from amino acids is an example of anabolism
- Catabolic pathways release energy by breaking down complex molecules into simpler compounds. Cellular respiration, the breakdown of glucose in the presence of oxygen, is an example of a pathway of catabolism
- Anabolism(Synthesis) + Catabolism (Degradation)= Metabolism.

Biochemistry of carbohydrates;

Structure, properties and classification of carbohydrates,

Carbohydrates have a general formula CnH_20n where n>or =3. They are also referred to as polyhydroxy aldehydes and ketones. The simplest carbohyrate has $C_3H_60_3$

Functions of Carbohydrates

1. Carbohydrates are a source of energy for the cells in the form of glucose
2. Another role is Energy storage in the form of glycogen and starch
3. They are also a source of carbon ,pyruvate is used to make aminoacids such as Ile, Leu, Val, Ala
4. Carbohydrates are also a protective an structural component in connective tissue in the form of chitin and cellulose.
5. Carbohydrates also critical in Recognition and Signaling in that Antibodieshave carbohydrate moieties in the form of glycoproteins and glycolipids

Classes of carbohydrates

The carbohydrates are classified into three categories

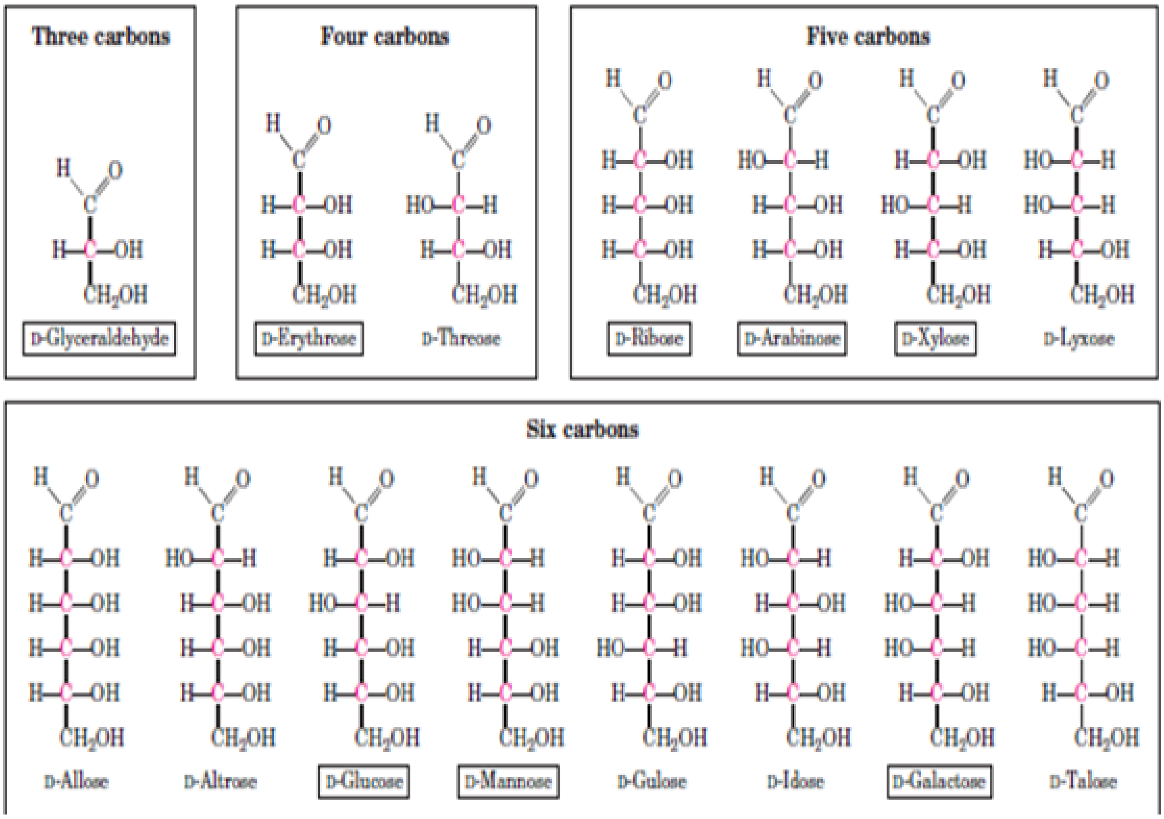
1. Monosaccharides.
2. Disaccharides when few(3-10) oligosaccharides are joined they are referred to as oligosaccharides
3. Polysaccharides E.g. starch, cellulose, glycogen)

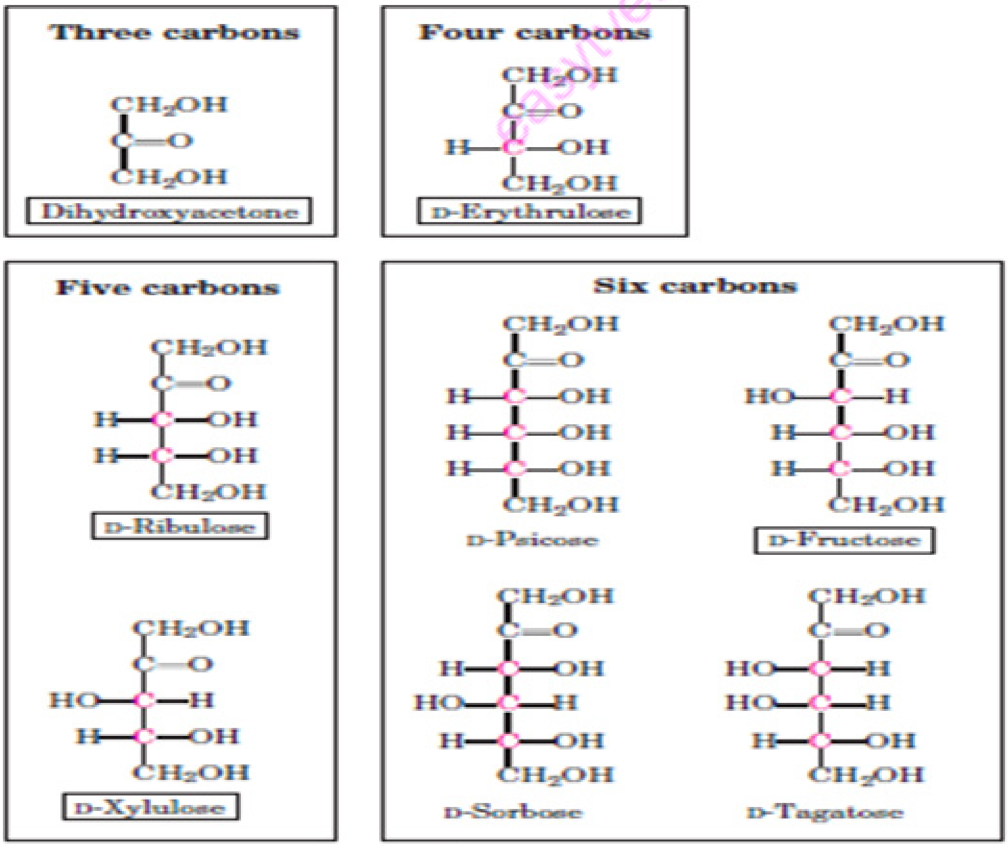
Monosaccharides are further classified based on

- The number of carbon atoms present in their structure

The monosaccharides that contain from three carbon atoms are referred to as trioses while those with four, five, six and seven these sugars are called tetroses, pentoses, hexoses and heptoses respectively

They are classified based on the functional group either aldehydes or ketones monosaccharides that have ketone functional group are referred to as ketoses whereas those with an aldehyde functional group are referred to as aldoses. The table below shows the various aldoses and Ketoses respectively classified according to number of carbon atoms.


Three carbons
D-Glyceraldehyde
Four carbons
D-Erythrose
D-Threose
Five carbons
D-Ribose
D-Arabinose
D-Xylose
D-Lyxose
Six carbons
D-Allose
D-Altrose
D-Glucose
D-Mannose
D-Gulose
D-Idose
D-Galactose
D-Talose


Three carbons
Dihydroxyacetone
Four carbons
D-Erythrulose
Five carbons
D-Ribulose
D-Xylulose
Six carbons
D-Psicose
D-Fructose
D-Sorbose
D-Tagatose

D-Ketoses

Properties of monosaccharides

i. Colourless crystalline solids

ii. Freely soluble in water but not in non –polar solvents

iii. The majority of the monosaccharides are sweet-tasting

iv. Cyclization of Monosaccharide -In solution, monosaccharides are cyclic this mainly relates to the pentoses and hexoses hence the sugars are represented using the **Haworth Projection Formula**.

Asymmetric Center and Stereoisomerism-All the monosaccharides except dihydroxyacetone contain one or more asymmetric or chiral carbon atoms and thus occur in optically active isomeric forms. Monosaccharides with n number of asymmetric centers will have (2n) isomeric forms. (n= number of asymmetric carbon atoms). carbohydrate metabolism

***Asymmetric/chiral carbon** is a carbon that has four different groups or atoms attached to it and having optical activity in solution.*

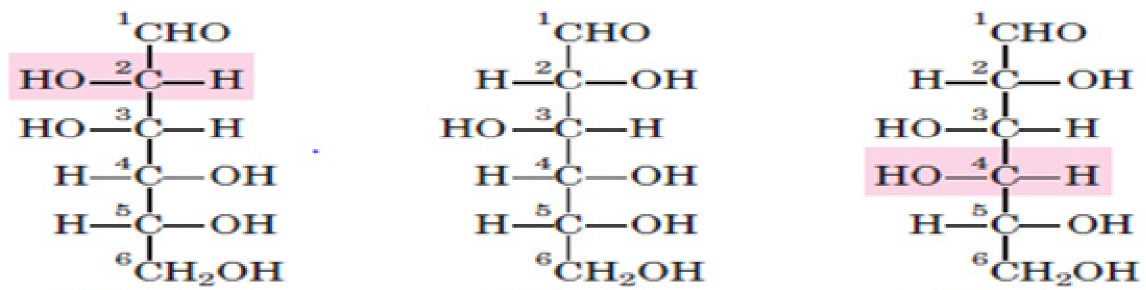
Optical Activity

The presence of asymmetric carbon atom causes optical activity. When a beam of planepolarized light is passed through a solution of carbohydrate it will rotate the light either to right or to left. Depending on the rotation, molecules are called dextrorotatory (+) (d) or levorotatory (-)

(l). Thus, D- glucose is dextrorotatory but D- fructose is levorotatory. When equal amounts of D and L isomers are present, the resulting mixture has no optical activity, since the activities of each isomer cancel one another. Such a mixture is called racemic or DL mixture.

Epimers

When sugars are different from one another, only in configuration with regard to a single carbon atom (around one carbon atom) they are called epimers of each other. For example glucose and mannose are epimers. They differ only in configuration around C2. Mannose and Galactose are epimers of Glucose.See diagram below:



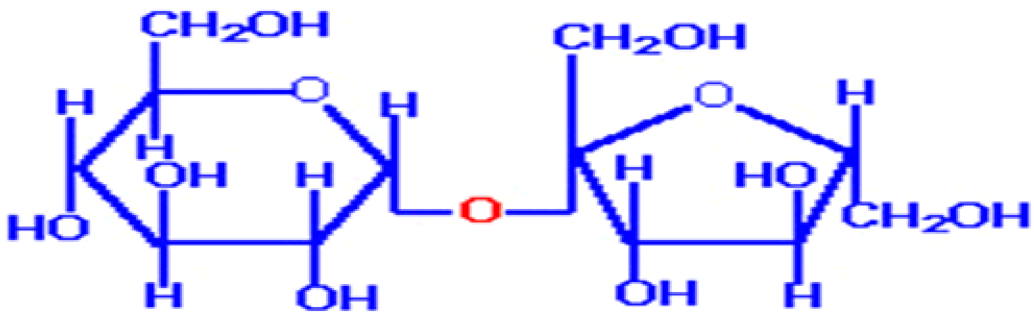
D-Mannose (epimer at C-2) D-Glucose D-Galactose (epimer at C-4)

FIGURE 7–4 Epimers. D-Glucose and two of its epimers are shown as projection formulas. Each epimer differs from D-glucose in the configuration at one chiral center (shaded red).

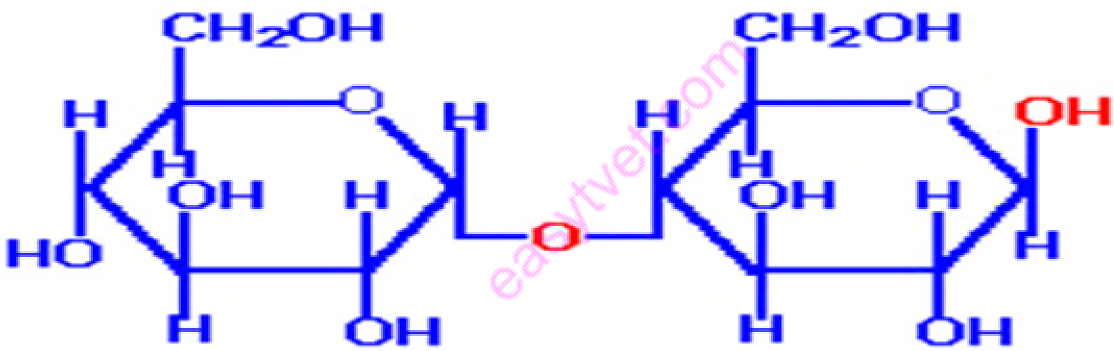
Disaccharides

When two monosaccharides are covalently bonded together by glycosidic linkages a disaccharide is formed. Biologically important disaccharides are

1) ***Sucrose***. Sucrose is a disaccharide of α- D- glucose and β-D-fructose. It is obtained from cane sugar. It is also present in various fruits



2) ***Maltose***-Maltose is the major degradative product of Starch and is hydrolysed by maltase, It has a α- (1, 4) glycosidic bond.



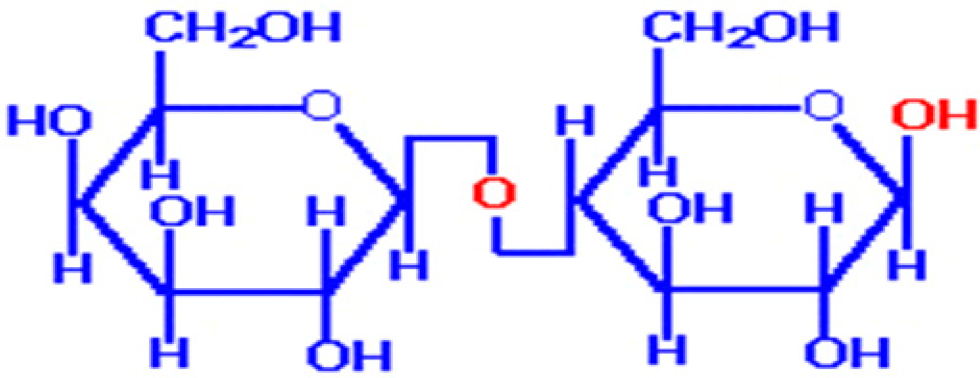
3) ***Lactose***.

Lactose is a disaccharide of β-D galactose and β-D- glucose which are linked by β-(1,4) glycosidic linkage. Lactose is a disaccharide of β-D galactose and β-D- glucose which are linked by β-(1,4) glycosidic linkage.deficiency in enzyme lactase. Causes an accumulation of Lactose accumulates in small intestine

Degraded by intestinal bacteria producing CO2, hydrogen gas, and organic acids o Presence of excess undigested lactose is harmful as well

Both cause symptoms: Bloating Nausea Cramping Diarrhoea Treatment:

- o Avoid products containing lactose (dairy products)
- o Use commercial products to hydrolyze lactose before consumption
- o Add enzyme called β-galactosidase (e.g. lactaid milk)



Polysaccharides

Most of the carbohydrates found in nature occur in the form of high molecular polymers called polysaccharides.There are two types of polysaccharides.

These are:

- Homopolysaccharides that contain only one type of monosaccharide building blocks.
- Heteropolysaccharides, which contain two or more different kinds monosaccharide building blocks. Homopolysaccharides: Example of Homopolysaccharides: Starch, glycogen, Cellulose and dextrins.

Starch

It is one of the most important storage polysaccharide in plant cells. It is especially abundant in tubers, such as potatoes and in seeds such as cereals.

Starch consists of two polymeric units made of glucose called Amylose and Amylopectin but they differ in molecular architecture.

Amylose is un-branched with 250 to 300 D-Glucose units linked by α-(1, 4) linkages Amylopectin consists of long branched glucose residue (units) with higher molecular weight.

The inner part of glucose units in amylopectin are joined by α-(1, 4) glycosidic linkage as in amylose, but the branch points of amylopectin are α- (1,6) linkages. The branch points repeat about every 20 to 30 (1-4) linkages

Glycogen

Glycogen is the main storage polysaccharide of animal cells (Animal starch). It is present in liver and in skeletal muscle.

- Like amylopectin glycogen is a branched polysaccharide of D-glucose units in α - (1, 4) linkages, but it is highly branched.
- The branches are formed by α - (1, 6) glycosidic linkage that occurs after every 8 -12 residues. Therefore liver cell can store glycogen within a small space. Multiple terminals of branch points release many glucose units in short time.

Cellulose

Cellulose is the most abundant structural polysaccharide in plants. It is fibrous, tough, water insoluble. Cellulose is a linear unbranched homopolysaccharide of 10,000 or more D- glucose units connected by β-(1, 4) glycosidic bonds. Humans cannot use cellulose because they lack of enzyme (cellulase) to hydrolyze the β-(1-4) linkages.

Dextrins

These are highly branched homopolymers of glucose units with α-(1, 6), α-(1, 4) and α-(1, 3) linkages. Since they do not easily go out of vascular compartment they are used for intravenous infusion as plasma volume expander in the treatment of hypovolumic shock.

Hetero polysaccharides

These are polysaccharides containing more than one type of sugar residues for example Hyaluronic acid, Heparin and chondroitin sulphate. They belong to a family called Glycosaminoglycans, (GAGs or mucopolysaccharides)

They are long, usually un-branched, composed of a repeating disaccharide units. They are negatively charged hetero-polysaccharide chains (polyanions). The amino sugar is either D-glucosamine or D-galactosamine in which the amino group is usually acetylated, thus eliminating its positive charges. The amino sugar may also be sulfated on carbon 4, 6, or on a monoacetylated nitrogen. The acidic sugar is either D-glucuronic acid or its carbon 6 epimer, L-uronic acid.

GAGS are an essential components of the extra cellular matrix, GAG's play an important role in mediating cell-cell interactions. Ground substance is a part of connective tissue, which is a gel like substance containing water, salt, proteins and polysaccharides. An example of specialized ground substance is the synovial fluid, which serves as a lubricant in joints, and tendon sheaths.

Heparin: contains a repeating unit of D-glucuronic and D-gluconsamine, with sulfate groups on some of the hydroxyl and amino-groups an important anticoagulant, prevents the clotting of blood by inhiginting the conversion of prothrombin to throbin. Thrombin is an enzyme that acts on the conversion of plasma fibrinogen into the fibrin. It is found in mast cells in lung, liver skin and intestinal mucosa.

Digestion of Carbohydrates

Dietary carbohydrates principally consist of the polysaccharides: starch and glycogen. It also contains disaccharides: sucrose, lactose, maltose and in small amounts monosaccharides like fructose and pentoses. Liquid food materials like milk, soup, fruit juice escape digestion in mouth as they are swallowed, but solid foodstuffs are masticated thoroughly before they are swallowed.

1. Digestion in Mouth

Digestion of carbohydrates starts at the mouth, where they come in contact with saliva during mastication. Saliva contains a carbohydrate splitting enzyme called salivary amylase (ptyalin).

Action of ptyalin (salivary amylase)

It is α - amylase, requires Cl^- ion for activation and optimum pH 6-7. The enzyme hydrolyzes α-(1, 4) glycosidic linkage at random, from molecules like starch, glycogen and dextrins, producing smaller molecules maltose, glucose and disaccharides maltotriose. Ptyalin action stops in stomach when pH falls to 3.0

Starch or glycogen

2. Digestion in Stomach

No carbohydrate splitting enzymes are available in gastric juice. HCl may hydrolyze some dietary sucrose to equal amounts of glucose and fructose.

3. Digestion in Duodenum

Food reaches the duodenum from stomach where it meets the pancreatic juice. Pancreatic juice contains a carbohydrate-splitting enzyme pancreatic amylase.

Action of pancreatic Amylase

It is also an α - amylase, optimum pH 7.1. Like ptyalin it also requires Cl^- for activity. The enzyme hydrolyzes α-(1, 4) glycosidic linkage situated well inside polysaccharide molecule. Other criteria and end products of action are similar of ptyalin.

4. Digestion in Small Intestine

Action of Intestinal Juice

a. pancreatic amylase:

It hydrolyzes terminal α-(1,4) glycosidic linkage in polysaccharides and Oligosaccharide molecules liberating free glucose molecules.

b. Lactase

It is a β- glycosidase, its pH range is 5.4 to 6.0. Lactose is hydrolyzed to glucose and galactose.

Lactose Intolerance

Lactose is hydrolyzed to galactose and glucose by lactase in humans (by β- Galactosidase in bacteria).Some adults do not have lactase. Such adults cannot digest the sugar. It remains in the intestines and gets fermented by the bacteria. The condition is called as Lactose intolerance. Such patients suffer from watery diarrhea, abnormal intestinal flow and chloeic pain. They are advised to avoid the consumption of Lactose containing foods like Milk.

C. Maltase

The enzyme hydrolyzes the α -(1,4) glycosidic linkage between glucose units in maltose molecule liberating two glucose molecules. Its pH range is 5.8 to 6.2.

D. Sucrase

PH ranges 5.0 to 7.0. It hydrolyzes sucrose molecule to form glucose and fructose.

Mechanism of Absorption

Two mechanisms are involved:

i. Simple Diffusion

ii. Active Transport Mechanisms

Glucose metabolic pathways

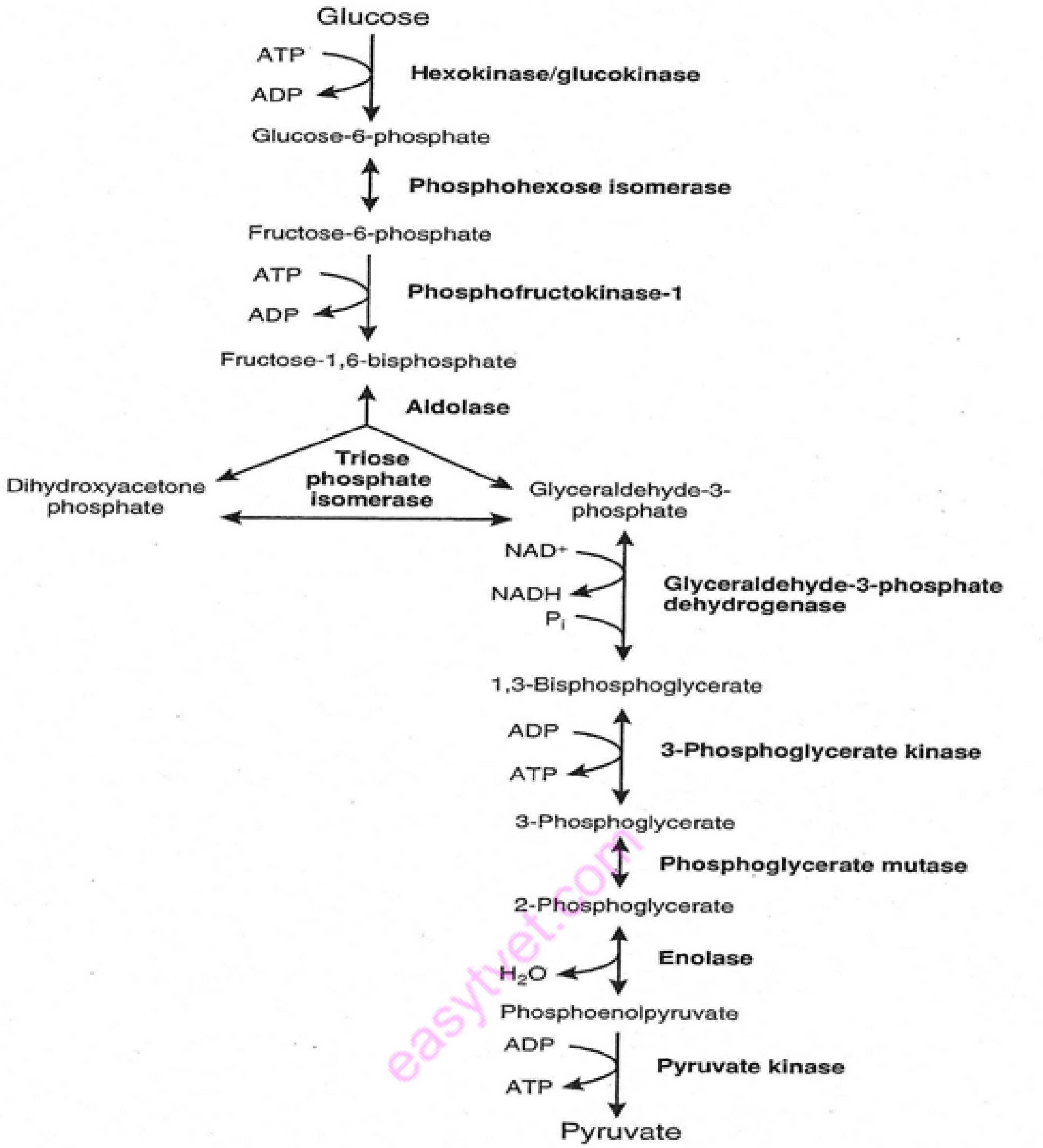
They are a major function of carbohydrate in metabolism is to serve as fuel and get oxidised to provide energy for other metabolic processes, metabolic intermediates are used for various biosynthetic reactions. For this purpose, carbohydrate is utilized by the cells mainly in the form of glucose. A major part of dietary glucose is converted to glycogen for storage in liver. Glucose is degraded in the cell by way of a series of phosphorylated intermediates mainly via three metabolic pathways for immediate source of energy

1. ATP generation- glycolysis, TCA cycle, oxidative phosphorylation
2. Glycogenesis, glycogenolysis, gluconeogenesis
3. Pentose phosphate pathway
4. Precursor for triacylglycerol synthesis (adipose tissue)

Glycolysis

It is defined as the Oxidation of glucose to pyruvate. Glycolysis occurs virtually in all tissues.

- Erythrocytes and nervous tissues derive the energy mainly from glycolysis
- This pathway is unique because it can proceed in both aerobic (presence of O_2) and anaerobic (absence of O_2) conditions. All the enzymes of glycolysis are found in the cytoplasm of the cell



Reactions of glycolytic pathway

Series of reactions of glycolytic pathway, which degrades glucose/ glycogen to pyruvate/ lactate, are discussed below. For discussion and proper understanding, the various reactions can be arbitrarily divided in to four stages.

Stage I

This is preparatory stage, before the glucose molecule can be split; the rather asymmetric glucose molecule is converted to almost symmetrical form fructose 1, 6 bisphosphate in the presence of ATP.

1. Uptake of Glucose by Cells and its phosphorylation

Glucose is freely permeable to Liver cells. In Intestinal mucosa and kidney tubules, glucose is taken up by 'active' transport. In other tissues, like skeletal muscle, cardiac muscle, diaphragm, adipose tissue etc. Insulin facilitates the uptake of glucose. Glucose is then phosphorylated to form glucose – 6- Phosphate. The reaction is catalyzed by the specific enzyme glucokinase in liver cells and by nonspecific Hexokinase in liver and extrahepatic tissues.

• ATP acts as phosphate donor in the presence of Mg .One high energy PO4 bond is utilized and

ADP is produced. The reaction is accompanied by considerable loss of free energy as heat, and hence under physiological conditions is regarded as irreversible.

• Glucose 6 phosphate formed is an important compound at the junction of several metabolic pathways like glycolysis, glycogenesis, glycogenolysis, glyconeogenesis,

Hexosemonophosphate Shunt, uronic acid partway. Thus is a "committed step" in metabolic pathways.

2. Conversion of G- 6- phosphate to Fructose6-phosphate

Glucose6 phosphate after formation is converted to fructose 6-p by phospho- hexose isomerase, which involves an aldose- ketose isomerization. The enzyme can act only on α - anomer of Glucose 6 phosphate.

3. Conversion of Fructose 6phosphate to Fructose 1, 6 bisphosphate

The above reaction is followed by another phosphorylation. Fructose-6-p is phosphorylated with ATP at 1- position catalyzed by the enzyme phospho- fructokinase-1 to produce the symmetrical molecule fructose –1, 6 bis phosphate.

Note: reaction one is irreversible and one ATP is utilized for phosphorylation of glucose at position 6. Phosphofructokinase I is the key enzyme in glycolysis that regulates the pathway. The enzyme is inducible, as well as allosterically modified

Phosphofructokinase II is an enzyme which catalyzes the reaction to form fructose-2 6-bis phosphate. Fructose-6-phosphate + ATP Fructose-2, 6-bisphosphate + ADP

Energetics

Note that in this stage glucose oxidation does not yield any useful energy rather there is expenditure of 2 ATP molecules for two phosphorylations (-2 ATP). Phospho- hexose isomerase

Stage II

Here,Fructose, 1, 6- bisphosphate is split by the enzyme aldolase into two molecules of triose phosphates, an Aldotriose, glyceraldehyde3 phosphate and a Ketotriose, Dihydroxy acetone phosphate.

Note: The reaction is reversible. Both triose phosphates are interconvertable D- glyceradehyde-3 –phosphate

Stage III

This is the energy- yielding reaction. Reactions of this type in which an aldehyde group is oxidized to an acid are accompanied by liberation of large amounts of potentially useful energy.

This stage consists of the following two reactions:

1. Oxidation of Glyceraldehyde 3phosphate to 1,3 bis phosphoglycerate

Glycolysis proceeds by the oxidation of glyceraldehde-3-phosphate, to form1,3-bis phosphoglycerate. Dihydroxyacetone phosphate also forms 1, 3 - bisphosphoglycerate via glyceraldehydes-3-phosphate shuttle.The enzyme responsible is Glyceraldehyde 3 phosphate dehydrogenase, which is NAD+ dependant.

In first reaction of this stage- NADH produced will be oxidized in electron transport chain to produce 3 ATP in presence of O2. Since two molecules of triose phosphate are formed per molecule of glucose oxidized, 2 NADH will produce 6 ATP. Phosphotriose isomerase Dihydroxy acetone-p +6ATP

2. The second reaction will produce one ATP. Two molecules of substrate will produce ATP.

Net gain at this stage per molecule of glucose oxidized= + 8ATP

Stage IV

This is the recovery of the PO4 group form 3- phosphoglycerate. The two molecules of 3-

phosphoglycerate the end- product of the previous stage, still retains the PO4 group originally derived from ATP in stage 1. Body wants to recover the two ATP spent in first stage for two phosphorylation reactions. This is achieved by following three reactions:

1. Conversion of 3- phosphoglycerate to 2- Phosphoglycerate

   3-Phosphoglycerate formed by the above reaction is converted to 2-phosphoglycerate, catalyzed by the enzyme phosphoglycerate mutase. It is likely that 2,3 bisphosphoglycerate is an intermediate in the reaction and probably acts catalytically.

2. Conversion of 2-phosphoglycerate to Phosphoenol pyruvate

   The reaction is catalyzed by the enzyme enolase, the enzyme requires the presence of either Mg2+ or Mn2+ for activity.

3. Conversion of phosphoenol pyruvate to pyruvate

   Phosphoenol pyruvate is converted to 'Enol' pyruvate, the reaction is catalyzed by the enzyme pyruvate kinase. The Reaction is irreversible. ATP is formed at the substrate level without electron transport chain. This is another example of substrate level phosphorylation in glycolytic pathway "Enol" pyruvate is converted to ' Keto' pyruvate spontaneously.

Significance of lactate formation:

Under anaerobic conditions NADH is re oxidized via lactate formation. This allows glycolysis to proceed in the absence of oxygen. The process generates enough NAD for another cycle of glycolysis.

B. Clinical Importance

Tissues that function under hypoxic conditions will produce lactic acid from glucose oxidation. Produces local acidosis. If lactate production is more it can produce metabolic acidosis. Vigorously contracting skeletal muscle will produce lactic acid.

Note: Whether O2 is present or not, glycolysis in erythrocytes always terminated in to pyruvate and lactate.

Glycogen metabolism

Glycogen is the major storage form of carbohydrate in animals .It is mainly stored in liver and muscles through glycogenesis and is mobilized as glucose whenever body tissues require through Glycogenolysis.

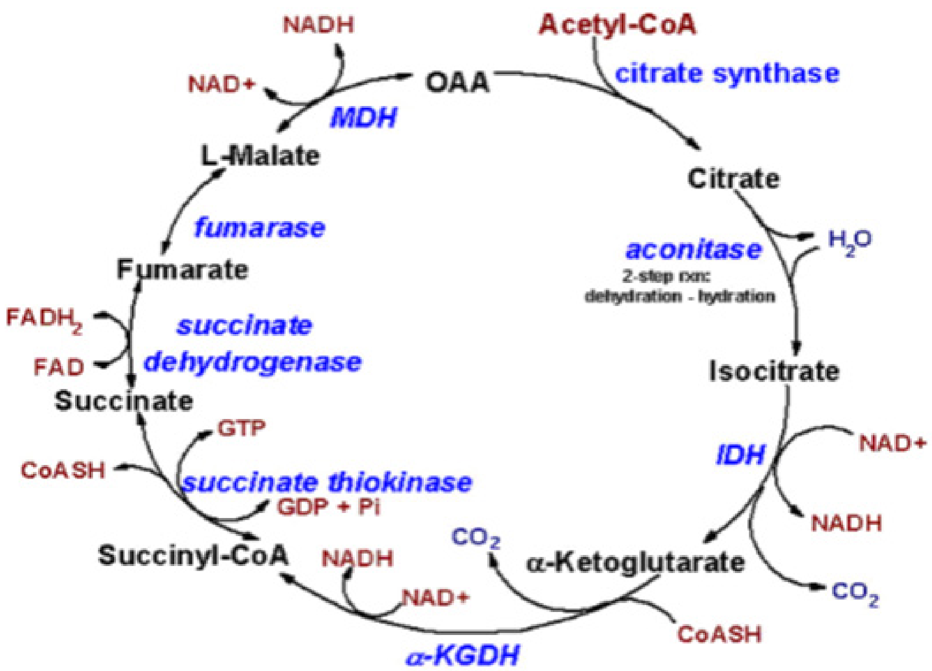
Gluconeogenesis

Gluconeogenesis is the synthesis of glucose from non-carbohydrate sources, such as lactate, amino acids, and glycerol. Several of the reactions that convert pyruvate into glucose are common to glycolysis. Gluconeogenesis, however, requires four new reactions to bypass the essential irreversibility of three reactions in glycolysis.

The major raw materials for gluconeogenesis by the liver are lactate and alanine produced from pyruvate by active skeletal muscle. The formation of lactate during intense muscular activity buys time and shifts part of the metabolic burden from muscle to the liver.

KREB'S CYCLE

Also called-tricarboxylic acid cycle (TCA) or Citric acid cycle. Final common pathway for complete exudation of carbohydrates, fatty acids and many amino acids. Common pathway for catabolism of acetyl COA ,a common intermediate of different catabolic pathways



Biochemistry of lipids

Lipids comprise very heterogeneous group of compounds which are insoluble in water but soluble in non-polar organic solvents such us benzene, chloroform, and ether. They are present in all living organisms. The group includes fats, oils, waxes and related compounds.

General Functions of Lipids

i. They make food palatable

ii. They also dissolve the vitamins, which are fat-soluble and assist their digestion.

iii. They are efficient energy sources.

iv. Serve as thermal insulators.

v. They are structural components of the cell membrane.

vi. Serve as precursors for hormones (steroid hormones).

Classification: - The lipids are classified in to three main categories i.r the Simple Lipids, complex Lipids and the derived lipids.

Simple lipids:- these are esters of fatty acids with different alcohols.

Fats and oils:- These are esters of fatty acids with glycerol.

Waxes:- Esters of fatty acids with high molecular weight monohydric alcohols

Complex lipids:- Esters of fatty acids and alcohols together with some other head groups. Phospholipids:- Esters of the above type containing phosphoric acid residue. Whre they contain an alcohol glycerol they are referred to as Glycerophospholipids:- and Sphingophospholipids where the alcohol is sphingosine. Glycolipids are lipids containing fatty acid, sphingosine and carbohydrate residues. Others Include sulfolipids, amino lipids and lipoproteins, which are modified forms of lipids.

Derived lipids: include the hydrolytic products of the simple and complex lipids. Eg. Fatty acids, cholesterol etc. The simplest naturally occurring lipids are triacylglycerols formed by esterification of fatty acids with glycerol. Biological membranes are made up of phospholipids, glycolipids and proteoglycans.

FATTY ACIDS

Fatty acids are building block of most lipids, made of long chain organic acids having one polar.

carboxyl group (head) and a non-polar hydrocarbon chain (tail). The hydrocarbon chain makes them water insoluble. They are not found free in nature but found as esterified forms. Most naturally occurring fatty acids have got even number of carbons.

They may be classified into saturated or unsaturated, with one or more double bonds.

There are two systems of numbering the carbon atoms in a fatty acid. Numbering starts from carboxyl carbon. The last carbon is the "n" carbon. The second carbon is the "α"and the third the "β" Carbon. The last carbon atom is omega.

E.g.:- CH_3 $(CH_2)_7$ CH_2CH_2 $(CH_2)_7$ COOH stearic acid (saturated fatty acid)

E.g.:- CH_3 $(CH_2)_7$ CH=CH $(CH_2)_7$ COOH oleic acid (Unsaturated fatty acid)

Fatty acids can be represented as shown below where the delta indicates the position of the double bond and the next number shows the number of carbon atoms and the last number indicates the number of double bonds. In a different way the position of the double bond(s) can be indicated as shown in the second expression without the delta. C18:1, Δ9 or 18:1(9)

C18 indicates 18 carbons, 1 indicates the number of double bonds, delta 9(Δ9) indicates the position of double bond between 9th and 10th carbon atoms.

Double bonds in naturally occurring fatty acids are in the cis- configuration and saturated fatty acids

PUFA (Polyunsaturated fatty acids): They have two or more double bonds .they are called as

Essential Fatty Acids (EFAS) because they are required in the body and cannot be synthesized. So they need to be include in the diet.

18 Linoleic acid 18: 2; 9 (12)

18 Linolenic acid 18: 2; 9 (12, 15)

These two are called essential fatty acids. 20 Arachidonic acid 20: 4; (5, 8, 11, 14)

Arachidonic acid is semi essential fatty acid because it can be synthesized from the above two essential fatty acids.

TRIACYLGLYCEROLS

These are esters of fatty acids with the alcohol glycerol, which are storage forms of lipids. Triacylglycerols or also called as triacylglycerides, exist as simple or mixed types depending on the type of fatty acids that form esters with the glycerol. Both saturated and/or unsaturated fatty acids can form the ester linkage with the backbone alcohol. Eg. Tripalmitate,

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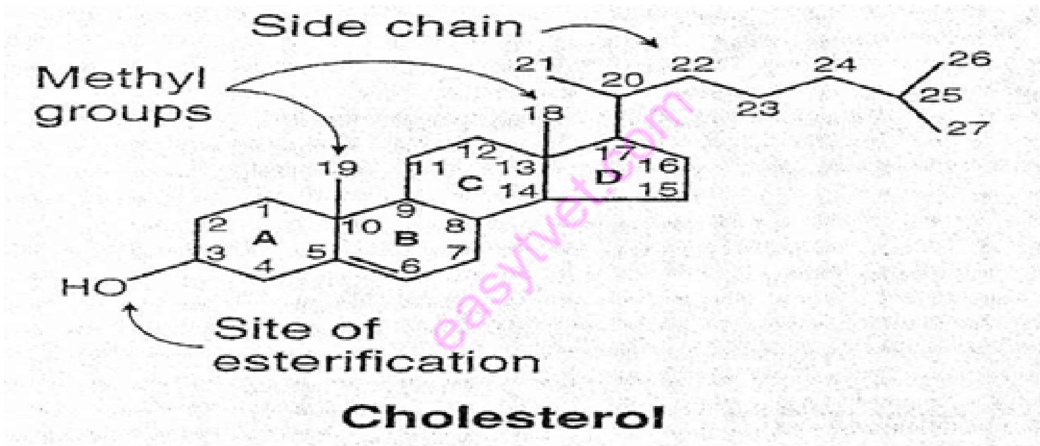
Gangliosides: These are glycolipids most of which are complex containing oligomers of sugars on head groups. One unit shall definitely be N-acetyl neuraminic acid (sialic acid) 6% of grey brain matter is ganglioside.

Cerebrosides:- These are glycolipids which have no phosphate group but neutral head group and contain one or two sugar groups usually glucose or Galactose

Derived Lipids

Compounds containing 27 carbon cyclopentanoperhydrophenanthrene structures with four rings labeled A to D. Steroids are complex fat-soluble molecules, which are present in the plasma lipoproteins and outer cell membrane. Cholesterol is one of the most significant derived lipid that is grouped as a steroid.



Cholesterol is important in many ways:

1. For the synthesis of vitamin D3
2. For the synthesis of bile salts that are important in lipid digestion and absorption.
3. For the synthesis of steroid hormones that are biologically important like the sex hormones estrogen and progesterone.
4. As a structural material in biological membranes.
5. As a component of lipoproteins as transport forms of lipid based energy

Digestion and Absorption of Lipids

Diet contains triglycerides, cholesterol and its ester, phospholipids, fattyacids etc.Mouth and gastric juice has got lipase. It can hydrolyse fats without emulsification with bile salts.Milk fat and butter fat is digested by the enzyme. Major part of fats are digested by pancreatic lipase. It acts on emulsified lipids only. The products are monoglyceride and 2 fatty acids.

Monoglyceride is further hydrolyzed by another lipase. Thus 3 fatty acids and one glycerol molecule is produced from the digestion of dietary triglyceride

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Major part of fats is digested by pancreatic lipase. It acts on emulsified lipids only. The products are monoglyceride and 2 fatty acids. Monoglyceride is further hydrolyzed by another lipase. Thus 3 fatty acids and one glycerol molecule is produced from the digestion of dietary triglyceride. Cholesterol esterase hydrolyses cholesterol ester to free cholesterol and one fatty acid. The digested products are water soluble but some are insoluble. Glycerol, short chain fatty acids enter portal blood directly. Cholesterol, long chain fatty acids are esterified and absorbed in form of micelles .Bile salts are required for the process. Impaired secretion of lipases from the pancreas and bile salts from liver results in failure in fat absorption and causes steatorrea Absorption products of lipid digestion are absorbed from micelles. The micelles, through the intestinal lumen move to the brush border of the mucosal cells where they are absorbed into the intestinal epithelium. The tri-acyl-glycerols play an important role in furnishing energy in animals. They have the highest energy content over 9kcal/mole. They provide more than half the energy need of some organs like the brain, liver, heart and resting skeletal muscle.

Mobilization of Fatty Acids from Adipocytes

When the energy supply from diet is limited, the body responds to this deficiency through hormonal signals transmitted to the adipose tissue by release of glucagon, epinephrine, or

adrenocorticotropic hormone. The hormones bind to the plasma membranes of adipocyte cells and stimulate synthesis of cyclicAMP (cAMP). The cAMP activates a protein kinase that phosphorylates and in turn activates hormone-sensitive triacylglycerol lipases (see the mechanism action of Hormones).

These lipases hydrolyze the triacylglycerols at position 1 or 3 to produce diacylglycerols (DAG) and fatty acid, which is the rate limiting step in the hydrolysis. The diacylglycerol lipases hydrolyze the DAG to monoacylglycerols (MAG) and a fatty acid. Finally MAG lipases hydrolyze MAG to fatty acid and glycerol. The free fatty acids (FFA) produced by lipolysis move through the plasma membranes of the adipose cells and endothelial cells of blood capillaries by simple diffusion and bind to albumin in the blood plasma, which are transported to peripheral tissues. The glycerol produced is taken up by liver, phosphorylated and oxidized to dihydroxyacetone phosphate, which is isomerised to glyceraldehydes-3-phosphate, an intermediate of both glycolysis and gluconeogenesis. Therefore, the glycerol is either converted to glucose (gluconeogenesis) or to pyruvate (glycolysis).

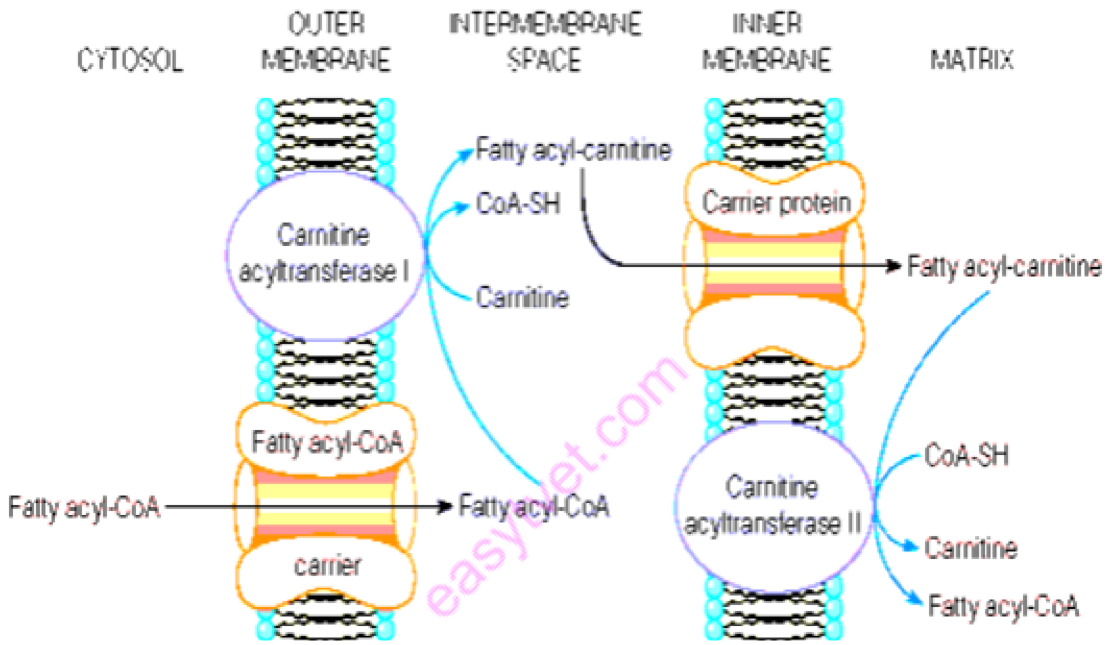
Transport of Fatty Acids to the Mitochondria

The fatty acids transported to the different tissue cells must first be activated or primed by reaction with Coenzyme A at the expense of ATP. The reaction is catalyzed by AcylCoA synthetase or also called thiokinase, found in the cytosol and mitochondria of cells. The pyrophosphate generated from ATP favors more Acyl CoA formation by further hydrolysis.

Inorder to undergo β-oxidation, the fatty acids must enter the mitochondria. But they cannot easily cross it as such by passive diffusion. There are two fatty acid sources those coming from absorption of FFA and those from hydrolysis of triacylglycerols from adipose tissue. The transport of acyl derivatives across the mitochondrial membrane needs three acyltransferases (shuttles).Specific for short chain acyl groups, does not require carnitine

Specific for the long chain acyl groups. The shuttles for long chain acyl groups are

carnitine acyltransferase I and II. Therefore, long chain acyl groups cross the mitochondrial membrane in combination with carnitine.

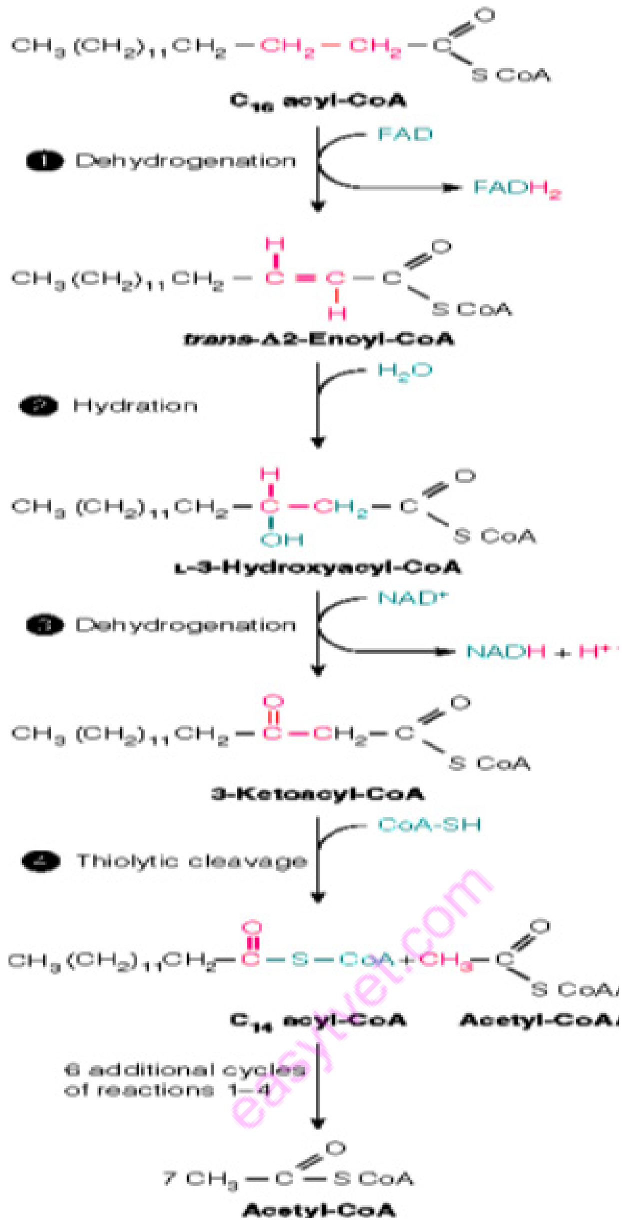


β-oxidation of Fatty Acids

The successive oxidative removal of two carbons in the form of acetyl–CoA beginning from the carboxyl end is called β-oxidation.It requires a set of enzymes. The oxidation is so called because the β carbon is oxidized during the oxidation process. It takes place in the matrix of mitochondria. Energy needs of tissues are met by the oxidation of free fatty acids, released by adipose tissue. Fatty acids are activated with the help of thiokinase, prior to transport to mitochondria. Overall activation of fatty acid requires hydrolysis of two phosphodiester bonds.

1. Acyl CoA dehydrogenase converts acyl CoA to acyl trans enoyl CoA
2. Hydratase converts it to 3-hydroxy acyl CoA.
3. Hydroxy acyl CoA dehydrogenase converts it to 3keto acyl CoA.
4. It is further converted to acyl CoA and acetyl CoA.by Thiolase

The cycle is repeated 7 times for palmitic acid for complete oxidation.



The FADH2 and NADH +H+ join the electron transport chain as high energy electron carriers. The latter donates its reducing equivalents (hydrogens) to NADH dehydrogenase to produce 3ATP per pair of electrons and the former produces only 2ATPS.

Complete oxidation of fatty acid can be divided in to two stages.

A. Formation of acetyl CoA.

B. Oxidation of acetyl CoA to CO2, water via TCA cycle.

Stochiometry of the reaction:

Palmitoyl CoA + 7FAD + 7 NAD +7CoA = 8 Acetyl CoA+7FADH2 +7 NADHH.

Energetics of palmitate oxidation:

Reduced equivalents enter ETC and produce energy rich phosphate bonds. Acetyl CoA release energy through TCA cycle.

Oxidation of Unsaturated Fatty Acids

The oxidation of unsaturated fatty acids requires two additional enzymes called isomerase and

reductase. Most naturally occurring unsaturated fatty acids are in cis- configuration, which are not suitable for the action of enoyl-CoA hydratases and hence they must be changed to their trans isomer by an isomerase. The rest of the enzymes are needed for the oxidation in addition to these two for the oxidation are the same.

Oxidation of Fatty Acids with Odd Number of Carbons

Ruminant animals can oxidize them by B- oxidation producing acetylCoAs until a three carbon propionylCoA residue is left.The acetylCoAs produced are funneled to the Krebs cycle but the propionylCoA produced is converted to succinylCoA by three enzymatic steps. SuccinoyCoA is an intermediate in the Kreb's cycle and it can be metabolized.

The metabolism of Ketone Bodies

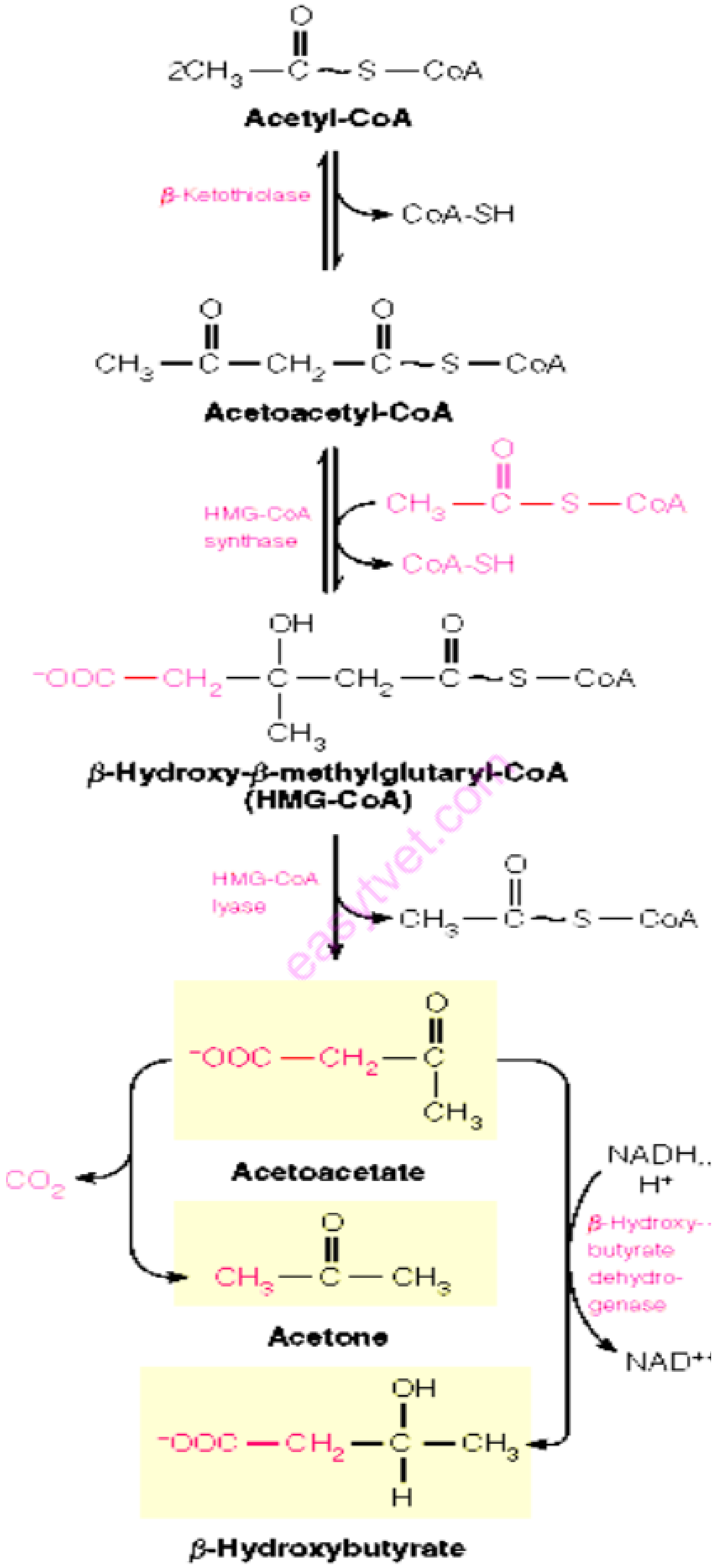
When the level of acetyl CoA from β-oxidation increases in excess of that required for entry into the citric acid cycle, it undergoes ketogenesis in the mitochondria of liver (ketone body synthesis). The three compounds viz., acetoacetate, β-hydroxybutyrate, and acetone are collectively known as ketone bodies. The synthesis of ketone bodies takes place during severe starvation or severe diabetes mellitus. During such conditions, the body totally depends on the metabolism of stored triacylglycerols to fulfill its energy demand.

In the synthesis, two molecules of acetyl CoA condense together to form acetoacetyl CoA, a reaction catalyzed by thoilase. Another molecule of acetyl CoA reacts with the acetoacetyl CoA to form 3-Hydroxy-3-methyl glutaryl CoA (HMGCoA). This step is the rate limiting step and the reaction is catalyzed by HMGCoA synthase enzyme. Note that this compound is also an intermediate in the synthesis of cholesterol in the liver cell cytosol but the mitochondrial HMGCoA goes to ketone body synthesis. The HMGCoA formed in the hepatocytes mitochondria by the action of the enzyme HMGCoA lyase is changed to acetoacetate.

The acetoacetate, when its concentration is very high in blood is spontaneously decarboxylated to acetone. Acteoacetate can be converted to β-hydroxy butyrate by a dehydrogenase enzyme.

It is a reversible reaction.

The odor of acetone may be detected in the breath of a person who has a high level of acetoacetate, like diabetic patients. During starvation and severe diabetes mellitus peripheral tissues fully depend on ketone bodies. Even tissues like the heart and brain depend mainly on ketone bodies during such conditions to meet their energy demand.


Acetyl-CoA
β-Ketothiolase
CoA-SH
Acetoacetyl-CoA
HMG-CoA
synthase
CoA-SH
β-Hydroxy-β-methylglutaryl-CoA
(HMG-CoA)
HMG-CoA
lyase
Acetoacetate
CO2
Acetone
NADH,
H+
β-Hydroxy-
butyrate
dehydro-
genase
NAD+
β-Hydroxybutyrate

Lipoproteins

Plasma lipids contain triacylglycerols, cholesterol and other polar lipids.Lipids combined with apolipoproteins to form Lipoproteins. Based on their density they are classified into four subgroups:

Chylomicrons:

These are derived from intestinal absorption of triacylglycerols and other lipids and have a very short lifespan. They have the least density and richly consist TAG. Chylomicrons transport dietary triacylglycerols and cholesterol from the intestine to the liver for metabolism.

VLDL (very low density lipoproteins):

These are synthesized in the liver and used to transport triacylglycerols from the liver to extrahepatic tissues.

LDL (Low density lipoproteins):

These are produced from the final stage in the catabolism of VLDL. They transport cholesterol synthesized in the liver to peripheral tissues. LDL is metabolized via the LDL receptor Approximately 30% of the LDL is degraded in extra hepatic tissues, rest is degraded in liver.

HDL (High Density Lipoproteins):

HDL has the highest density in this group since it contains more protein and cholesterol than triacylglycerols. It transports excess cholesterol from peripheral tissues to the liver for degradation and removal. Therefore, HDL cholesterol is good cholesterol but LDL cholesterol is called bad cholesterol.High concentration of circulating VLDL,LDL are indicative of possible atherosclerosis .Elevated HDL is a good sign which indicates less chances of atherosclerosis. There is a proven correlation between the incidence of coronary heart disease and low level of HDL. The higher the ratio of HDL/LDL,the less the chances of CHD.

Lipids and Membranes

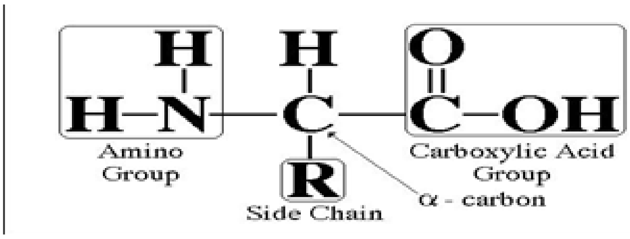
Membranes are important biological structures, which are indispensable for life. Membranes give cells their individuality by separating them from their surrounding and they are highly selective and semi permeable containing specific gates, pumps, and channels. Membranes control the flow information between cells and their environment since they contain specific receptor molecules in the form of glycoproteins.

Biochemistry of proteins

There are approximately 300 amino acids present in various animals, plants, and microbial systems, but only 20 amino acids are coded by DNA to appear in proteins. Cells produce proteins with strikingly different properties and activities by joining the same 20 amino acids in many different combinations and sequences. This indicates that the properties of proteins are determined by the physical and chemical properties of their monomer units, the amino acids.

Definition:

Amino acids are the basic structural units of proteins consisting of an amino group, (-NH2) a carboxyl (-COOH) group a hydrogen (H) atom and a (variable) distinctive (R) group. All of the substituents in amino acid are attached (bonded) to a central α carbon atom. This carbon atom is called α because it is bonded to the carboxyl (acidic) group. ***Except for glycine, where the carbon is attached to four different groups - it is referred to as a chiral center.***



Amino acid structure

Functions of Proteins

I. Enzymes; Proteins are biological catalysts of nearly all reactions in the body of living organism.

II. Antibodies-Proteins fight off infection in the body.

III. Transport & storage : Proteins are key in the movement of materials around hemoglobin for O2,iron is carried by blood plasma, lipids are carried by lipoproteins

IV. Regulatory As hormones, they control metabolism, they also act as hormone receptors

V. Structural through the structural proteins coverings and support skin, tendons, hair, nails, bone.

VI. Movement muscle contraction is achieved through sliding motion of actin and myosin , cilia, flagella.Generation and transmission of nerve impulses

Properties of aminoacids

Acid base properties

In neutral solution (PH = 7), both the α- amino and α carboxyl group are ionized resulting the charged form of an amino acids called zwitterion (dipolar) as shown in the figure below.In dipolar (zwitterion) form the amino group is protonated (-NH3+) and the carboxyl group is dissociated (deprotonated) (-COO-) leading to a net charge zero

- Amphoteric substances act as acids or bases.
  - They are acids when they donate protons.
  - They are bases when they accept protons.

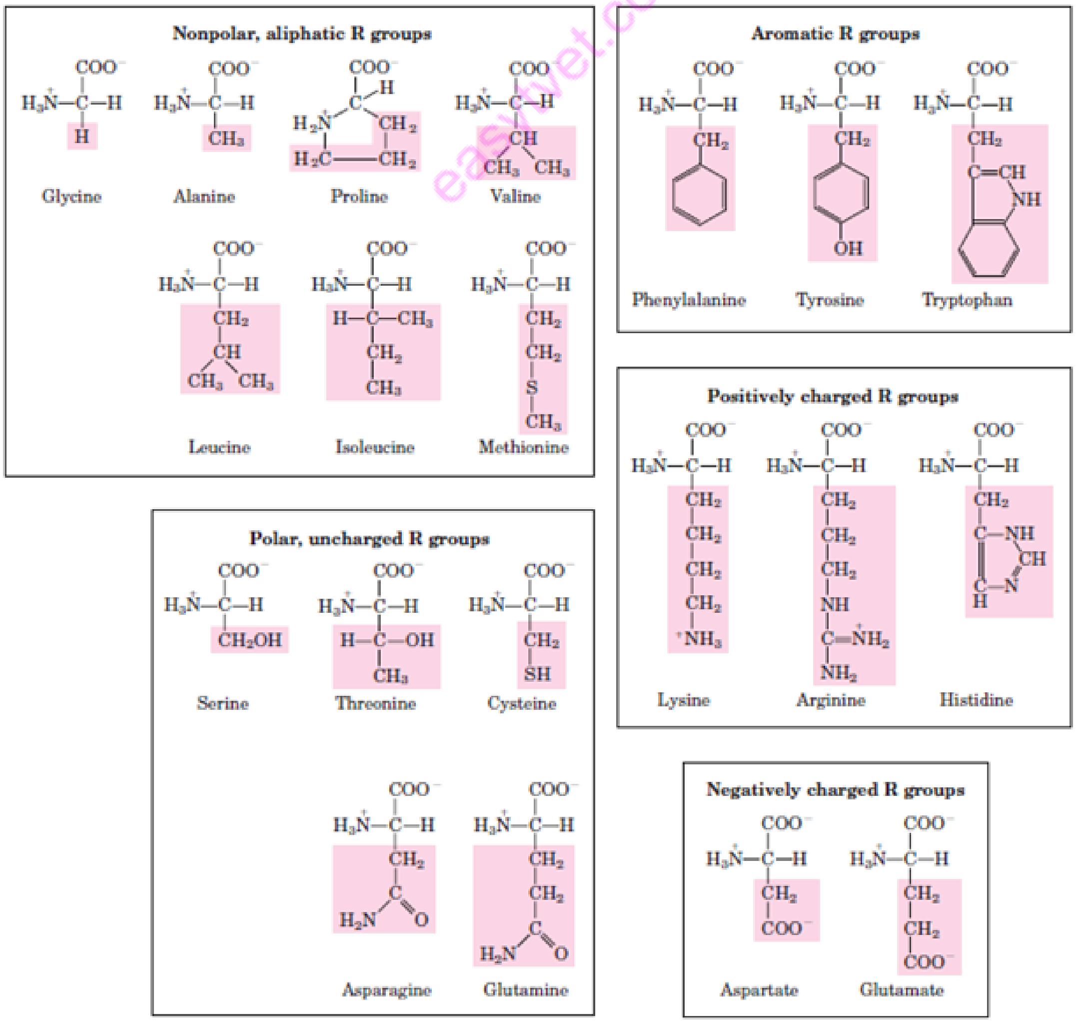
- Amino acids can act as acids or bases. When placed in an acidic solution (low pH), they act as bases by accepting protons and becoming positively charged. In basic solutions (high pH), they act as acids by donating protons and becoming negatively charged.
- When a crystalline amino acid, such as Alanine is dissolved in water, it can act as either an acid (proton donor) or a base (proton acceptor)
- According to Laury and Bronsted theory of acid and bases, and acid is a proton donor and a base is a proton acceptor.

Stereo isomerism

- Amino acids have assymetric carbon hence it exists as stereo isomers.
- All amino acids except glycine exist as D& L isomers
- In D aminoacids –NH2 is on the right hand side while in L aminoacids – NH2 is oriented to the left side
- Nb: in natural proteins of animal and plants genearally contain L aminoacids
- D aminoacids occur in bacteria

Classification of amino acids

A) Classifications of Amino Acids by Chemical Properties



B) Classification based on the source

Essential amino-acids: Arginine, Methionine, Histidine, Phenylalanine, Isoleucine, Threonine, Leucine, Tryptophan, Lysine Valine

Non -Essential Aminoacids: Alanine, Asparagine, Aspartic Acid,Cysteine, Glutamic Acid, Glutamine, Glycine, Proline, Serine, Tyrosine

C) Classification based on the metabolic fate of the carbon skeleton

Amino acids can be classified here as

- Glucogenic (potentially be converted to glucose),
- Ketogenic (potentially be converted to ketone bodies) and
- Both glucogenic and ketogenic.

Those amino acids in which their carbon skeleton gets degraded to pyrurate, α ketoglutarate, succinyl CoA, fumrate and oxaloacetate and then converted to Glucose and Glycogen, are called as Glucogenic amino acids. These include:-Alanine, cysteine, glycine, Arginine, glutamine, Isoleucine, tyrosine

Those amino acids in which their carbon skeleton is degraded to Acetoacetyl CoA, or acetyl CoA. then converted to acetone and β-hydroxy butyrate which are the main ketone bodies are called ketogenic amino acids. These includes:- Phenylalanine, tyrosine, tryptophan, isoleucine, leucine, and lysine.

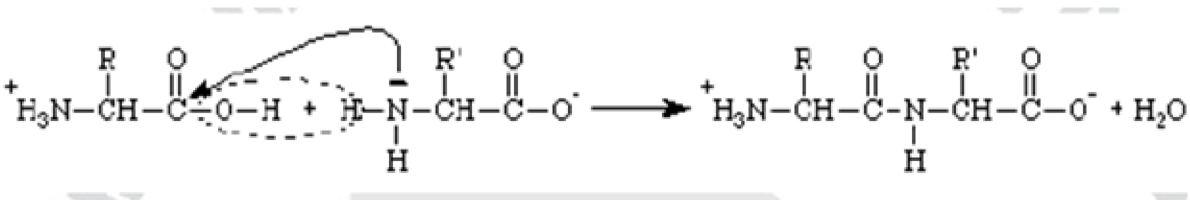
These amino acids have ability to form ketone bodies which is particularly evident in untreated diabetes mellitus in which large amounts of ketone bodies are produced by the liver (i.e. not only from fatty acids but also from ketogenic amino acids) Degradation of Leucine which is an exclusively ketogenic amino acid makes a substantial contribution to ketone bodies during starvation. The division between ketogenic and glucogenic amino acids is not sharp for amino acids (Tryptophan, phenylalanine, tyrosine and Isoleucine are both ketogenic and glucogenic).

Some of the amino acids that can be converted in to pyruvate, particularly (Alanine, Cysteine and serine, can also potentially form acetoacetate via acetyl CoA especially in severe starvation and untreated diabetes mellitus.

Peptide bond and its characteristics

Proteins are macromolecules with a backbone formed by polymerization of amino acids in a polyamide structure. These amide bonds in protein, known as peptide bonds formed by linkage of α - carboxyl group of one amino acid with α- amino groups of the next amino acid by amide bonds.These are chains of aminoacids joined together by peptide bonds in linear sequence.

Peptide bond



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Classification

Even though there is no universally accepted classification system, proteins may be classified on the basis of their composition, solubility and overall shape

I) Classification based on composition

a) Simple protein:

These are made of pure amino acids and no other major organic or inorganic hydrolysis products

b) Conjugated Proteins

Yields amino acids and other non-protein organic and inorganic components

e.g. Nucleoprotein (a protein containing Nuclei acids)

Lipoprotein (a protein containing lipids)

Phosphoprotein (a protein containing phosphorous)

Metalloprotein (a protein containing metal ions of Fe2+)

Glycoprotein (a protein containing carbohydrates)

II. Classification based on the Solubility

a) Albumins: These proteins such as egg albumin and serum albumin are readily soluble in water and coagulated by heat.

b) Globulins: these proteins are present in serum, muscle and other tissues and are soluble in dilute salt solution but sparingly in water.

c) Histones: Histones are present in glandular tissues (thymus, pancreas etc.) soluble in water; they combine with nucleic acids in cells and on hydrolysis yield basic amino acids

III. Classification based on the Overall Shape

A. Fibrous proteins

In these protein, the molecule are constituted by several coiled cross-linked polypeptide chains, they are insoluble in water and highly resistant to enzyme digestion. The ratio of length to breathe (axial ratio) is more than 10 in such protein. A few sub groups are listed below.

1. Collagens: the major protein of the connective tissue, insoluble in water, acids or alkalis. But they are convertible to water-soluble gelatin, easily digestible by enzymes.

2. Elastins: present in tendons, arteries and other elastic tissues, not convertible to gelatin.

3. Keratins: protein of hair, nails etc.

B. Globular proteins:
These are globular or ovoid in shape, soluble in water and constitute the enzymes, oxygen carrying proteins, hormones etc. the axial ratio is 3 to 4 or less. Subclasses include:- Albumin, globulins and histones.

PROTEIN CONFORMATION

Primary, secondary, tertiary and quaternary.

a) Primary Structure of Proteins

The primary structure of a protein is defined by the linear sequences of amino acid residues. Protein contain between 50 and 2000 amino acid residues.

The mean molecular mass of an amino acid residue is about 110 Dalton units (Da). Therefore the molecular mass of most proteins is between 5500 and 220,000 Da. The amino acid composition of a peptide chain has a profound effect on its physical and chemical properties of proteins. Protein rich in polar amino acids are more water soluble. Proteins rich in aliphatic or aromatic amino groups are relatively insoluble in water and more soluble in cell membranes (can easily cross the cell membrane).

The primary structure cannot represent the 3D-nature of a protein molecule since the extended chain of amino acids is co-planar as the covalent bind of peptide is right.

Secondary Structure

The secondary structure of a protein refers to the local structure of a polypeptide chain, which is determined by Hydrogen bond. The Interactions are between the carbonyl oxygen group of one peptide bond and the amide hydrogen of another nearby peptide bond.

There are two types of secondary structure, the α - helix and the β- pleated sheet.

The α - helix

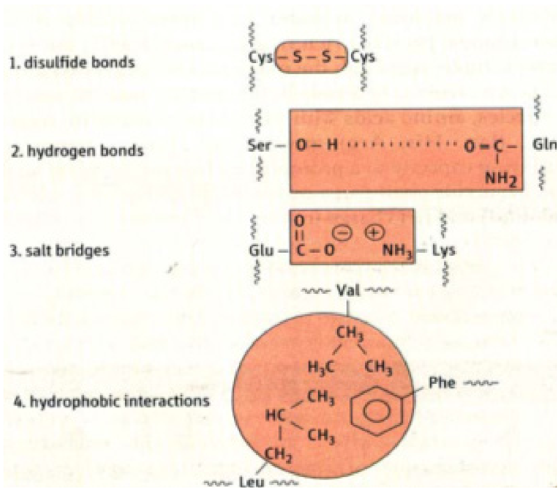
The α - helix is a rod like structure with peptide chains tightly coiled and the side chains of amino acid residues extending outward from the axis of spiral. Each amide carbonyl group is hydrogen bonded to the amide hydrogen of a peptide bond that is 4 - residues away along the same chain. There are 3.6 amino acids residues per turn of the helix the complete turn has 0.54 mm pitch. (1nm = 10-9 m) including nearly 3.6 amino acid residues. This enable every = NH group to bind with a carbonyl O, fourth in line behind the primary structure and the helix winds in a right handed manner in almost all natural protein, i.e. turns in a clockwise fashion around the axis. Since all the carbonyl oxygen and peptide nitrogen are thus involved in the hydrogen bonds, the hydrophilic nature of the helical region is greatly minimized. As the free energy involved in hydrogen bond is very low, it is formed spontanemsly being weak bonds these are disrupted easily when the chain is extended by a little force and reformed when force is released.

The β- pleated sheet

The β – pleated sheet is an extended structure as opposed the coiled - helix. It is pleated because the (C-C) bonds are tetrahedral and cannot exist in a planar configuration. If the polypeptide chain runs in the same direction, if forms a parallel β – sheet. It is said to be parallel, and when in opposite direction, antiparallel. A protein molecule may have both type of secondary configuration in different parts of its molecule. Gylcine (Gly) and proline (Pro) residues often occur in β -turns on the surface of globular proteins. Most immunoglobulins have such β-pleated conformation and some enzymes like Hexokinase contain a mixed α-β conformation.

Tertiary Structure

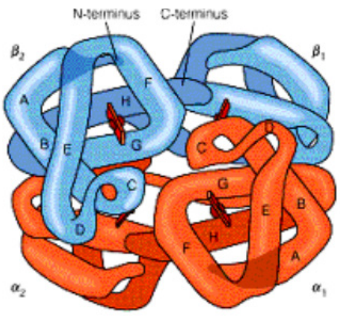
The three dimensional, folded and biologically active conformation of a protein is referred to as tertiary structure. The structure reflects the overall shape of the molecule. The three - dimensional tertiary structure of a protein is stabilized by interactions between sides. Chain functional group, covalent, disulfide bonds, hydrogen bonds, salt bridges, and hydrophobic interactions. In the tertiary structure the side chains of Tryptophan and Arginine serve as both hydrogen bond donors and acceptors. Lysine, aspartic acid Glutamic acid, tyrosine and Histidine also can serve as both donors and acceptors in the formation of ion-pairs (salt bridges). Two opposite - charged amino acids, such as glutamate with a γ -carboxyl group and lysine with an ε – amino group, may form a salt bridge, primarily on the surface of proteins.



Elements of tertiary structure of proteins

Quaternary Structure

Quaternary structure refers to a complex or an assembly of two or more separate peptide chains that are held together by non- covalent or, in some case, covalent interactions.
If the subunits are identical, it is a homogeneous quaternary structure; but if there are dissimilarities, it is heterogeneous. For instance insulin consists of A and B chain which are different. Hemoglobin has 4 chains, two of them are α and two are β. these, the polymers may be dimers, trimers, tetramers and so on.



Denaturation of Proteins

Proteins have finite lifetimes. They are also subject to environmental damages like oxidation proteolysis, denaturation and other irreversible modifications. Denaturation involves the destruction of the higher level structural organization (20, 30 and 40) of protein with the retention of the primary structure by denaturing agents. A denatured protein loses its native physico-chemical and biological properties since the bonds that stabilize the protein are broken down. Thus the polypeptide chain unfolds itself and remain in solution in the unfolded state. The denatured protein may retain its biological activity by refolding (renaturing) when the denaturing agent is removed

Agents of Protein Denaturation

1. Physical Factors

Temperature, pressure, mechanical shear force, ultrasonic vibration and ionizing radiation causes the protein to lose its biological activity.

2. Chemical Factors

Acids and alkalis, organic solvents (actone, ethanol), detergents (cleaning agents), certain amides urea, guandidine hydrochloride, alkaloids, and heavy metal salts (Hg, Cu, Ba, Zn,

Cd…) Cause the denaturation.

Effects of Denaturation

A. an increase in number of reactive and functional group in the composition of the native protein molecule (side chain group of amino acids, COOH, NH2, SH, OH … etc)

B. Reduced solubility and pronounced propensity for precipitation this occurs due to loss of the hydration shell and the unfolding of protein molecules with concomitant exposure of hydrophobic radicals and neutralization of charged polar groups.

C. Configurational alteration of the protein molecule.

D. Loss of biological activity evoked by the disarrangement of the native structural molecular organization.

E. Access of proteolytic enzymes in comparasion with the native protein

Clinical Application of Denaturation

The amounts of proteins found in the urine, serum, CSF are utilized to asses various pathological conditions. The appearance of proteins like Albumin and Globulin in the urine can be detected by precipitating them using ammonium sulphate. This could be used to assess the degree of kidney impairment and glomerular permeability.

In some disease, abnormal proteins may be present in plasma and be filtered at the glomerule. The most important member is Bence-jons' protein which is most often associated with multiple myeloma. So recognition of such protein in the urine may be useful in the diagnosis of the disease.

This could be done by treating few ml of urine with few ml of hydrochloric acid giving a white ring at the junction of the two fluids.

In the case of CSF protein estimation and analysis, a saturated phenol solution is used where 2 drops of CSF with 2ml of 10gm phenol dissolved in distilled water to check for turbidity

Digestion and Absorption of Proteins

Proteins are larger polypeptide molecules coiled by weaker bonds in their tertiary structure the digestion of proteins involves the gradual breakdown of this polypeptide by enzymatic hydrolysis in to amino acid molecules which are absorbed in the blood stream. The protein load received by the gut is derived from two sources 70-100g dietary protein which is required daily and 35 -200g endogenous protein (secreted enzymes and proteins in the gut or from intestinal epithelia cell turnover) Only 1-2g of nitrogen equivalent to 6-12g of proteins are lost in the feces on a daily basis. Thus the digestion and absorption of protein is more efficient.

The process of protein digestion can be divided, depending on the sources of peptidases.

A. Gastric Digestion

Entry of a protein in to stomach stimulates the gastric mucosa to secrete a hormone gastrin which in turn stimulates the secretion of Hcl by the parietal cells of the gastric glands and pepsinogen by the chief cells.

The HCL thus produced lower the pH of stomach to (pH1.5 – 2.5) and acts as an antiseptic and kills most of the bacteria and other foreign cells ingested along with.

The acid denatures the protein and the whole protein susceptible to hydrolysis by the action other proteolytic enzymes. Proteases are endopeptidases which attack the internal bonds and liberate large fragments of peptides. Then pepsinogen having an inactive precursor or zymogen is converted in to active pepsin in the stomach itself. In this process 44 amino acids get removed from the amino terminal end and the portion of the molecule that remain intact is enzymatically active pepsin. This active pepsin cleaves the ingested protein at their amino terminus of aromatic amino acids (Phe, Tyr, and Trp.) The major products of pepsin action are large peptide fragments and some free amino acids.

B. Pancreatic Digestion

Pancreatic zymogens proceed digestion as the acidic stomach contents pass in to the small intestine, A low pH triggers the secretion of a hormone Secretin in the blood. Secretin stimulates the pancreas to secrete HCO-3 (bicarbonate), which in the small intestine neutralizes the gastric HCL and abruptly change the pH to 7.0. The entry of large peptide fragments and some free amino acids in the upper part of the small intestine (Duodenum), excites the release of a hormone cholecytokinin (CCK).

1) Stimulates gall bladder contraction.

2) Stimulate secretion of several pancreatic enzymes

Three of these pro-enzyme are trypsinogen, chymotrypsinogen and procarboxy peptidase, localized in the exocrine cells. Synthesis of these enzymes as inactive precursors protects the exocrine cells from destructive proteolytic attack. When the proenzyme reach the lumen of the small intestine, initially the enteropeptidase (old name Enterokinase) a protease produced by duodenal epithelial cells, activates pancreatic trypsinogen to trypsin by the removal of a hexapeptide from NH2 – terminus Trypsin in turn auto catalytically activates more trypsinogen to trypsin and other proenzymes and liberating chymotrypsin elastas, and carboxypeptidase's

As shown below:

$$\underset{\text{(inactive)}}{\textbf{Trypsinogen}} \xrightarrow[\text{(or Trypsin)}]{\text{Enteropeptidase}} \underset{\text{(active)}}{\textbf{Trypsin}}$$

$$\underset{\text{(inactive)}}{\textbf{Chymotrypsinogen}} \xrightarrow{\text{Trypsin}} \underset{\text{(active)}}{\textbf{Chymotrypsin}}$$

$$\underset{\text{(inactive)}}{\textbf{Procarboxypeptidase}} \xrightarrow{\text{Trypsin}} \underset{\text{(active)}}{\textbf{Carboxypeptidase}}$$

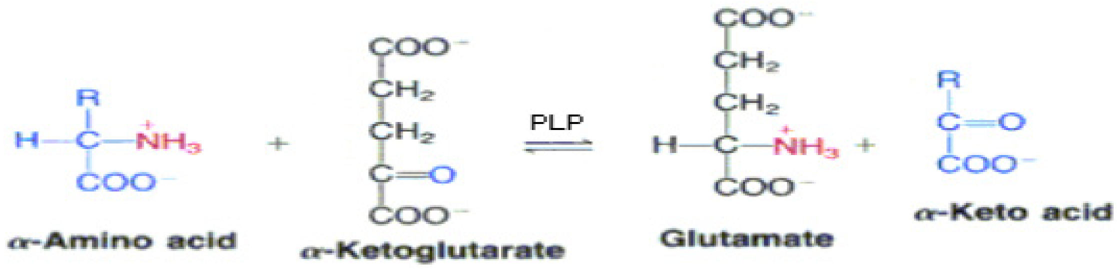
$$\underset{\text{(inactive)}}{\textbf{Proelastase}} \xrightarrow{\text{Trypsin}} \underset{\text{(active)}}{\textbf{Elastase}}$$

By the sequential action of these proteolytic enzymes and peptides ingested proteins are hydrolyzed to yield a mixture of free amino acids which can be transported across the epithelial lining of the small intestine.

Amino Acid Catabolism

Transamination

The nitrogen component of amino acids, the α - amino groups, must be removed before the carbons can be used in other metabolic pathways. There are several ways that this can be achieved. The first step in the catabolism of most amino acids is the transfer of their α - amino group to α - ketoglutarate where the products are α - ketoacids and glutamate. This transfer of amino groups from one carbon skeleton to another is catalyzed by a family of transaminases which are also



The two most important transminase reactions of high clinical important are Alanine transminase and Aspartate transaminase catalyzed reactions.

Alanine + α-Ketoglutarate <-> Pyruvate + Glutamate

Oxaloacetate + Glutamate <-> Aspartate +-ketoglutarate (Urea cycle)

In addition to their roles as building blocks of proteins, the carbon skeletons may be used to produce energy in oxidative metabolism by the end stages of glycolysis (such as pyruvate from

Alanine) and tricarboxylic acid (such as oxaloacetate from Asparate) thereby providing a metabolic fuel for tissues that requre or prefer glucose. In addition, the carbon skeletons of certain amino acids can produce the equivalent of acetyl-CoA or Acetoacetate termed

Ketogenic, indicating that they can be metabolized to give immediate precursor of lipids or ketone bodies.

Alanine transaminase (ALT) also called as glutamate pyruvate transaminase (GPT) and Aspartate transaminase (AST) also called as glutamate oxaloacetate transaminase (GOT) are the two most important transaminases of clinical importance. These enzymes are abundant in heart and liver they are released as part of cell injury that occurs in Miocardial infraction (MI), infections hepatitis and damage to either organ. An elevated level of both SGOT and SGPT

(S=Serum) indicates damage to the Liver. However a rise in SGOT accompanied by only a moderate rise in SGPT suggests damage to heart muscle, skeletal muscle, kidney etc. Assays of these enzyme activities in blood serum can be used both in diagnosis and in monitoring the progress of a patient during treatment.

SGOT: Oxaloacetate + Glutamate <-> Aspartate + -Ketoglutarate

SGPT: Glutamate + Pyruvate -------> -Ketoglutarate + Alanine

Aminotransferases utilize a coenzyme - pyridoxal phosphate - which is derived from vitamin B6. The functional part of pyridoxal phosphate is an aldehyde functional group attached to a pyridine ring. Catalysis involves a Schiff base intermediate.

Oxidative deamination

Involves the oxidative removal of the amino group, also resulting in ketoacids. The amino acid oxidases are flavoprotein, and produces ammonia.

Nitrogen Balance:

A healthy adult eating a varied and plentiful diet is generally in "Normal Nitrogen Balance" a state where the amount of nitrogen ingested each day is balanced by the amount excreted resulting no net change in the amount of the body Nitrogen. In a well fed condition, excreted nitrogen comes from digestion of excess protein or from normal turnover.

Protein turnover (Synthesis and degradation)

Under some conditions. The body is either in negative or positive nitrogen balance. In negative nitrogen balance more nitrogen is excreted than ingested. This occurs in starvation and certain diseases. During starvation the carbon skeleton of most amino acids from proteins fed in to gluconeogenesis to maintain the blood glucose level; in this process ammonia is released and excreted mostly as urea and is not reincorporated in to protein.

Positive nitrogen balance occurs in pregnancy and during feeding after starvation. A diet deficient in an essential amino acid also leads to a negative nitrogen balance since body proteins are degraded to provide the deficient essential amino acid. Positive nitrogen balance occurs in growing children who are increasing their body weight and incorporating more amino acids in to protein than they breakdown. Cysteine and Arginine are not essential in adults but essential in children because they are synthesized from Methionine and ornithine. These amino acids are readily available in adults but limited in children. Negative Nitrogen balance occurs in injury when there is net destruction of tissue and in major trauma or illness.

Nitrogen Excretion and the Urea Cycle:

Excess amino Nitrogen from amino acids is removed as ammonia, which is toxic to the human body. Some ammonia is excreted in urine, but nearly 90% of it is utilized by the liver to form urea, which is highly soluble and is passed in to circulation for being excreted by the kidneys. Daily excretion of urea amounts to about 30g with a protein intake of nearly 100g in the food. It is less with lower protein intake. The urea-cycle starts in the mitochondrial matrix of hepatocytes and few of the steps occur in the cytosol: the cycle spans two cellular compartments. The first amino group to enter the cycle is derived from ammonia inside the mitochondria. Some ammonia also arrives at the liver via the portal vein from the intestine, when it is produced by bacterial oxidation of amino acids.

6.3.5.3 Self-Assessment

1. Describe the classification of the following biomolecules
2. Calculate the net energy output for the complete oxidation of a glucose molecule
3. Describe the formation of ketone bodies
4. Discuss the process of lipid catabolism
5. Dietary fats after absorption appear in the circulation as
   A. HDL
   B. VLDL
   C. LDL
   D. Chylomicron
6. Which one of the following is not a properties of monosaccharides
   A. Coloured crystalline solids
   B. Soluble in water
   C. Taste is sweet-tasting
   D. Mosaccharides are cyclic
7. Describe three agents of protein denaturation
8. The tissues with the highest total glycogen content are
   A. Muscle and kidneys
   B. Kidneys and liver
   C. Liver and muscle
   D. Brain and Liver
9. Gluconeogenesis is increased in the following condition:
   A. Diabetes insipidus
   B. Diabetes Mellitus
   C. Hypothyroidism
   D. Liver diseases
10. Tissues form lactic acid from glucose. This phenomenon is termed as
   A. Aerobic glycolysis
   B. Oxidation
   C. Oxidative phosphorylation
   D. Anaerobic glycolysis

11. Denaturation of proteins results in
    A. Disruption of primary structure
    B. Breakdown of peptide bonds
    C. Breakdown of hydrogen bonds
    D. Loss of physiological function

6.3.4.4 Tools, Equipment, Supplies and Materials

- Anatomical model
- Projector
- Video
- Laboratory and laboratory equipment
- Microscope
- Stationery

6.3.4.5 References

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CHAPTER 7:

COONDUCT RESEARCH METHODS AND STATISTICS

7.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to conduct research in nutrition pharmacy. It involves proposal writing: identifying a research problem upon literature review, formulating objectives, hypothesis and or research questions, conducting literature review, developing research methodology, conducting data collection, conducting data analysis and presentation and preparing research report. Statistical methods: types of data, descriptive statistics, inferential statistics, confidence intervals.

7.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to identify a suitable research topic based on the area of interest; develop a research proposal as per resource materials and institutional guidelines; carry out the research process consistent with institutional research guidelines; write a project report and do a power point presentation of the research project in accordance with organizational procedures.

7.3 Learning Outcomes

7.3.1 List of the Learning Outcomes

1. Identify terminologies in research methods and statistics
2. Develop a research proposal
3. Conduct data collection
4. Conduct data analysis and presentation
5. Preparation of reports and dissemination

7.3.2 Learning Outcome 1: Identify terminologies in research methods and statistics

7.3.2.1 Learning Activities

Learning Activity	Specific instructions
Demonstrate ability identify and describe terminologies in research methods and statistics a. Define research and research design b. Define research methodology c. Describe statistics	Define the terms research, research design and statistics Describe different types of research • Descriptive • Experimental • Case study • Correlational
Identify and describe importance of research • Identify and describe types of research • Identify and describe sources of data	Explain different types of research • Descriptive • Experimental • Case study • Correlational Explore the sources of data in research Demonstrate competency in collecting data from different sources
Identify and describe statistical methods • Discuss the types of statistical formulas	Apply different types of statistical formulas used in research Identify and calculate the sample size using different sampling formulas

7.3.2.2 Information Sheet

Definitions

Research is defined as a systematic method of inquiry for generating new knowledge, asking questions, highlighting new experiences, solving problems and understanding current situations. It is also an organized and systematic way of finding answers to questions.

Research methods: refer to a process of creating a random sequence of steps to solve a particular problem.

Research methodology: refers to a process of acquiring solutions by means of a proven method in which selected cases are considered.

Research design: the conceptual structure within which the research is conducted. It constitutes the blue print for the collection, measurement and analysis of data.

Population: an entire group of individuals, events or objects having a common observable characteristic.

Characteristics of research

Research has the following attributes;

- It is purposive
- It is systematic.
- It involves formulation and testing of hypotheses.
- It involves recording data and reporting of the findings.
- It is critical, logical and objectives

Research is usually aimed at;

- Thorough testing of theories.
- Testing hypotheses and laying solid foundations for future research and study.
- Establishing the underlying causes and relationship between different occurrences.

Objectives of research

- Research extends knowledge
- Research establishes generalizations and general laws
- Research verifies and tests
- General laws developed through research
- Research analyze inter-relationships
- Applied research aims at finding solutions
- It aims to develop tools, concepts
- Rational decision making

Importance of research

Research work has several benefits which include;

- Helping to identify research problems needing solutions.
- Helping to create new methods tools, ideas, practices.
- Discovering cures of a disease.
- Improving the quality of services offered.

- Obtaining of funding from donors to carry out the research.
- Research knowledge is transferred to the public.

The purpose of research,

To:

- Review or synthesize existing knowledge
- Investigate existing situations or problems
- Provide solutions to problems
- Explore and analyse more general issues
- Construct or create new procedures or systems
- Explain new phenomenon
- Generate new knowledge

Types of research

There are different major types of research which include;

1. Quantitative research
2. Qualitative research
3. Basic research
4. Applied research or Action research
    - Impact Assessment Research
    - Participatory action research (PAR)
    - Evaluation research
    - Marketing research
5. Analytical research
    - Historical Research
    - Philosophical Research
    - Review
    - Research synthesis (meta-analysis i.e. analysis of the review already published)
6. Experimental research
7. Descriptive research
    - Survey Research
    - The Case Study
    - Correlational Study
    - Comparative Study
8. Conceptual research

Quantitative research

This type of research is based on measurement of quantity or amount. The emphasis of quantitative research is on collecting and analysing numerical data; it concentrates on measuring the scale, range, frequency etc. of phenomena. This type of research, although harder to design initially, is usually highly detailed and structured and results can be easily collated and presented statistically. Examples include Weighing, measuring etc. This type of research usually includes comparison studies, cause and effect relationship among others.

Qualitative research

This type focuses on phenomena relating to quality or kind e.g. character, personality and mankind are examples of variables used to measure qualitative research. Qualitative research is more subjective in nature than Quantitative research and involves examining and reflecting on the less tangible aspects of a research subject, e.g. values, attitudes, perceptions. Although this type of research can be easier to start, it can be often difficult to interpret and present the findings; the findings can also be challenged more easily. Word association test, sentence completion test are some of the examples of qualitative research.

Basic research

Also known as pure/fundamental research. It is driven by a researcher's curiosity or interest in a scientific question. It is concerned with generalizations and with the formulations of a theory. The primary motivation of this type of research is to improve man's knowledge and not to create or invent something. Basic research focuses on finding information that has a broad base of application natural phenomenon and mathematics are examples of basic research.

Basic research focuses on finding answers to questions such as:

- What are protons composed of?
- How did the universe begin?
- How do slime moulds reproduce?

Applied/Action research

This refers to scientific study and research that seeks to solve practical problems. This type of research is initiated to solve every day/immediate problems or a reflective process of progressive problem solving. It involves testing the efficacy of theories and principles. This type of research is useful in finding solutions such as cure for diseases and development of innovative technologies, rather than acquire knowledge for knowledge's sake. Also, a research aimed at finding social or political trends that may affect a particular institution is an example of applied research

Examples:

Applied researcher may investigate ways to:

- Improve agricultural crop production
- Treat or cure a specific disease
- Improve the energy efficiency of homes, offices, or modes of transportation

Analytical research

This type of research involves in-depth study and evaluation of available information in an attempt to explain complex phenomenon. Analytical research often extends the Descriptive approach to suggest or explain why or how something is happening, e.g. underlying causes of industrial action. An important feature of this type of research is in locating and identifying the different factors (or variables) involved. The researcher has to use facts or information already available and analyse these to make a critical evaluation of the material.

Descriptive research

Descriptive research include surveys and fact finding enquiries of different kinds, with an aim of studying the relationship of the variables. It can be used to identify and classify the elements or characteristics of the subject, e.g. number of days lost because of industrial action. The main purpose of descriptive research is the description of the state of affairs as it exists in present. The researcher who chooses this method has no control over the variables and he is only mandated to report what has happened or what is happening only. Quantitative techniques are most often used to collect, analyse and summarise data.

Examples include:

Do teachers hold favourable attitudes toward using computers in schools?

What kinds of activities that involve technology occur in sixth grade classrooms and how frequently do they occur?

What have been the reactions of school administrators to technological innovations in teaching the social sciences

How does competency based education and Training (CBET) compare to the conventional knowledge based approach of training?

CASE STUDIES

A case study offers an opportunity to study a particular subject, e.g. one organisation, in depth, or a group of people, and usually involves gathering and analysing information; information that may be both qualitative and quantitative.

Experimental research

In this type of research, the researcher studies the effects of the variables on each other. Experimental studies are done in carefully controlled and structured environments and enable the causal relationships of phenomena to be identified and analysed. By nature, this research type is a systematic and scientific approach to research in which the researcher manipulates one or more variables, and controls and measures any change in other variables. This type of research is commonly used in sciences such as pharmacy, medicine, chemistry, biology, food processing etc. This is because laboratories tend to offer the best opportunities for controlling the variables in a rigorous way, although field studies can be done in a more 'real world' environment.

Exploratory research

Exploratory research is undertaken when few or no previous studies exist. The aim is to look for patterns, hypotheses or ideas that can be tested and will form the basis for further research. Typical research techniques would include case studies, observation and reviews of previous related studies and data.

Sources of data for research

The sample is the section of the wider population that will be engaged in the survey and sampling is the process of identifying who you will aim to contact from that population. The word 'population' is used to describe the target group, and while this may be the national popula tion as a whole, it may also be a smaller group such as lone parents, or business members of a Chambers of Commerce in a particular location. Detailed consideration of sampling needs to be made to ensure the validity of your results, and the following issues need consideration: Who is the respondent? The first thing you need to under - stand is who your respondent is going to be. This is the person that will provide the data you are asking for. If the survey is distributed amongst households, who in particular will be filling in the survey? Do you want to specify who the survey is to be completed by? And do you understand why you are specifying this person? The same is true when surveying organisations or groups. A survey will have much greater success if it is directed to the right respondent. Identifying the person best suited to completing a survey will help to increase the response rate and generate more accurate data. What is your sampling frame? A sampling frame is a list of members of a population from which members of a sample are then selected. A sampling frame needs to be accurate, complete, up-to-date and relevant to the purposes of the survey for which it is to be used. Once you have an established sampling frame, depending on its size you may need to adopt a sampling technique to extract your final sample. For example random sampling, simple random sampling or stratified sampling. Are response rates likely to be a problem? With any survey, you need to look at the profile of the people who did responded and satisfy yourself that they are about the same as the people who didn't respond – and also, that they're about the same as the overall population that you're sampling. If you send out a survey to a population, which is 50% male, and 50% female, but your responses are 80% from females then your findings will not represent your target population. Response rates can be low for surveys, under 20% for a postal survey is not uncommon. However, all the considerations in this section can help to improve your response rate. Statistical significance: Understanding your population, sample size, and response rates are important for calculating interval and confidence levels, which are vital in determining how many people you need to interview in order to get results that reflect the target population as precisely as needed. Secondary information – Information that is readily available. E.g. - Internet, Magazines, books,

Primary information – Information that needs to be found by conducting Survey, Observation or experimentation

Data types and statistical methods

The main types of data which should be collected include primary and secondary data. Quantitative context may involve the manipulation of statistical data. It differs from primary research techniques in that the researcher does not collect the data directly and cannot control the actual data collected, but can bring to bear new insights through interpretation or presentation.

There are a number of different types of secondary information. Some of the most common types are identified as follows:

Official statistics - This refers to national data sets relating to issues such as population, employment and unemployment and businesses. Much of this information can be acquired from the Office for National Statistics and www.neighbourhood.statistics. gov.uk;

Other statistics - A wide range of other types of numerical data can be drawn on for evaluation purposes. E.g. project monitoring information of beneficiaries, funding information, service data.

Sampling formulas

A number of formulas are available for working out sample size and examples include;

Estimating the sample size based on a proportion

To calculate the sample size based on the sample required to estimate a proportion with an approximate 95% confidence level 1, you can use the following formula:

$$nr = \frac{4pq}{\mathrm{d2}} \qquad \text{Or} \qquad n = \frac{(1.96)^2 pq}{d^2}$$

Where nr = required sample size, p = proportion of the population having the characteristic, q= 1-p and d = the degree of precision. The proportion of the population (p) may be known from prior research or other sources; if it is unknown use p = 0.5 which assumes maximum heterogeneity (i.e. a 50/50 split). The degree of precision (d) is the margin of error that is acceptable. Setting d = 0.02, for example, would give a margin of error of plus or minus 2%.

We apply this formula in the example in the worked example below;

You are investigating the use of mobile phones for online banking and want to estimate what proportion of the population uses their phones in this way at an approximate 95% confidence level. Since no data are available on the proportion currently using their mobile phones you take the worst case scenario and set p = 0.5 (and therefore q = 1-0.5 = 0.5). As this is a preliminary study you are prepared to accept a margin of error of ± 5% so you set d = 0.05. To determine the minimum sample size you then apply the formula:

$$n = \frac{4pq}{d^2} = \frac{4 \times 0.5 \times 0.5}{0.05^2} = \frac{1}{0.0025} = 400 \quad \text{or} \quad n = \frac{(1.96)^2\sigma^2}{d^2}$$

So your minimum sample size would be 400.

Estimating the sample size based on a mean

The second formula applies when estimating the arithmetic mean (average) of a particular variable for a population. Suppose, for example, that you wanted to know the average employee satisfaction level in your organisation.

To calculate the sample size based on the sample required to estimate a population mean with an approximate 95% confidence level2, you can use the following formula:

$$n_r = \frac{4\sigma^2}{d^2} \quad \text{or} \quad n = \frac{(1.96)^2\sigma^2}{d^2}$$

Where nr = required sample size, σ (sigma) = the population standard deviation, a measure of the variation in the population and d = the degree of precision required by the researcher. A drawback with this formula is the need to know the population standard deviation. This may be known from prior research; if a good estimate is unavailable the formula will not be reliable. We apply this formula in the example below.

Worked example

You are investigating the average (mean) level of employee satisfaction and want to know the required sample size. You decide on a 95% confidence level. Prior studies have reported a standard deviation (σ) of 1.5 so you decide to use the same figure in your estimate. Satisfaction will be measured on a 7-point scale and you set a margin of error of ±0.25 units. To determine the minimum sample size you then apply the formula:

$$n_r = \frac{4\sigma^2}{d^2} = \frac{4 \times 1.5^2}{0.25^2} = \frac{9}{0.0625} = 144$$

So your minimum sample size would be 144

Sources of error in research

There are three broad categories;

- Errors of non-observation: coverage, sampling, non-response
- Errors of observation: survey instrument, respondent, interviewer
- Processing errors: coding, editing, adjustment

The errors in testing hypothesis may emanate from

- Selection of faulty study design selected
- Adoption of faulty sampling procedure
- Inaccurate data collection method;
- wrong analysis
- application of inappropriate statistical procedures
- drawing

Statistical analysis of data and statistical tests

Statistical analysis is a mathematical method of interrogating data. This is done by looking for relationships between different sets of data. There are two types of statistics:

- Descriptive statistics: numerical summaries of samples (what was observed);
- Inferential statistics: from samples of populations (what could have been or will be observed).

It is important to understand which type of statistics you are working with before embarking on analysis. The main statistical used in analyses of data is hypothesis test. The general idea of statistical analysis is to summarise and analyse data so that it is useful and can inform decision-making.

Descriptive statistics

These are indices that describe a given sample e.g. measures of central tendency (mean, mode, median), measures of dispersion (range, standard deviation), distributions and relationships.

Inferential statistics

This is a branch of statistics used by researchers to draw inferences about a given phenomena in the population. The inferences are based on the results from a randomly selected sample. Inferential statistics help to test hypothesis thereby enabling the researcher to generalize the results from the sample to the population.

Confidence interval

Confidence Interval: An interval with random endpoints which contains the parameter of interest (in this case, μ) with a pre-specified probability, denoted by $1 - \alpha$. The confidence interval automatically provides a margin of error to account for the sampling variability of X. With a confidence interval, we report a range of numbers, in which we hope the true parameter will lie. The interval is cantered at the estimated value, and the width ("margin of error") is an appropriate multiple of the standard error.

We can think of the margin of error as "fuzz", introduced to account for sampling variability.

Point estimates

In statistics, point estimation involves the use of sample data to calculate a single value (known as a point estimate since it identifies a point in some parameter space) which is to serve as a "best guess" or "best estimate" of an unknown population parameter (for example, the population mean). More formally, it is the application of a point estimator to the data to obtain a point estimate.

In summary

The research process is as follows;

Phase 1: Deciding what to research

Step 1: Formulating a research problem

Phase 2: Planning a research study

Step 2: conceptualizing a research design

Step 3: constructing an instrument for data collection

Step 4: selecting a sample

Step 5: Writing a research proposal

Phase 3: Conducting a research study

Step 6: Data collection

Step 7: Processing and displaying data

Step 8: Writing a research proposal

7.3.2.3 Self-Assessment

1. Describe the meaning of research.
2. The process of acquiring solutions by means of a proven method in which selected cases are considered is called _____________
   A. Research
   B. Research design
   C. Research methodology
   D. Research methods
3. The following are aims of research (indicate True/False for each statement)
   A. Enhance thorough testing of theories
   B. Establishing the underlying causes and relationship between different occurrences
   C. Testing hypothesis and laying solid foundations for future research study
   D. Enhance recording and reporting of the findings
4. The main types of data which should be collected include;
   A. Qualitative and quantitative data
   B. Primary and secondary data
   C. Reliable and unreliable data
   D. Present and past data
5. Discuss the difference between formularize and summative applied research.
6. Describe the benefits of research to the researcher and the society.
7. Describe the difference between qualitative and quantitative research.
8. State the differences between applied and basic research.
9. Give an example of a participatory action research and formative research.
10. State the difference between research methods and research methodology.

7.3.2.4 Materials and resources

Research methods textbooks

LCD projector

Stationery

Videos

7.3.2.5 References

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https://www.slideshare.net/MATEENYOUNIS/types-of-research-33967388?next_slideshow=1

Conducting surveys *http://www.oag-bvg.gc.ca/internet/English/meth_gde_e_19734.html*

7.3.3 Learning outcome 2: Develop a research proposal

7.3.3.1 Learning Activities

Learning Activity	Specific instructions
Identification of research problem/title	Identify an objective research topic which is SMART (specific, measurable, realistic and time-bound • Brainstorm for ideas in areas of interest Review literature in your area of interest critically so as to identify the research gap • Avoid too long and irrelevant information State the research topic ensuring it does not go beyond 25 words
Identify and describe components of research proposal	Plan research early in advance Develop a research proposal which captures the following components; • Front matter • Chapter one • Chapter two • Chapter three • Back matter Defend the proposal developed in competent manner

7.3.3.2 Information Sheet

Research proposal: A document that is typically written by a scientist or academic which describes the ideas for an investigation on a certain topic.

Hypothesis: a proposition that is stated in a testable form and that predicts a particular relationship between two (or more) variables.

Research design: a procedural plan that is adopted by the researcher to answer questions validly, objectively, accurately and economically.

Research proposal

The research proposal outlines the process from beginning to end and may be used to request financing for the project, certification for performing certain parts of research of the experiment, or as a required task before beginning the research project.

Identifying a research topic

Finding a research topic is the first step before beginning any research. The identified research topic is converted to research questions or a problem statement. For the research to be relevant, you have to make sure that the research topic has benefits (or solutions) to a particular problem within the society country or organization

To select a research topic, you need to have ideas on what you intend to study. A gap in the understanding of phenomenon may lead to the development of a hypothesis.

A topic may be developed by a researcher so as to satisfy their curiosity. This curiosity may lead them to solving a particular practical or theoretical problem.eg; researchers in the world are still in the process of carrying out research so as to come up with a HIV/AIDS vaccine.

A topic in research may also be developed due to the unsolved problems in the nation, country or in a particular organization e.g. the effect of water pollution on the workers in a certain industry. The main aim of such is to find an immediate solution to that particular problem.

A research topic can also be developed as a result of an experience one had encountered before e.g the effect of stress during pregnancy. This may provoke the researcher to want to study on such an area so as to raise awareness and to provide possible solutions.

Trying out new methods: One may develop a research topic so as to enable them to try out a new method to see how reliable it could be as compared to the previous method e.g the use of an alternative method of drug administration. Such type of a research topic may be developed if the researcher has found shortcomings in the previous method used and want to provide a solution

Social issues may also lead the researcher to come up with a research topic e.g one may want to study the role of village elders within a society, why the youth are so rebellious to the authority, illiteracy within a country etc.

In summary, the structure of your research will be guided by the following questions;

- What are you going to do? The subject of your research.
- Why are you going to do it? The reason for this research being necessary or interesting.
- How are you going to do it? The research methods that you will use to carry out the project.
- When are you going to do it? The programme of the work.

A good research topic needs to be

- Interesting
- Significant
- Manageable
- Researchable
- Ethical
- Specific

Sources of research ideas

Sources of research ideas include literature. This further includes historical records, books, journals, scientific papers, magazines, government reports e.t.c

As you read literature, you identify missing information that may lead you to identifying the gap of knowledge that you will desire to fill, hence you come up with a research topic.

The community, nation states and society are also sources of research ideas as they have some practical problems that may require solutions e.g. unemployment, global recession education e.t.c

The community, nation states and society are also sources of research ideas as they have some practical problems that may require solutions e.g. unemployment, global recession education

Introduction to proposal development

A research proposal should communicate the following contents clearly and specifically such that anyone going through it should be able to undertake all the tasks:

A good research proposal should contain the following components:

Front matter; title page, declaration, dedication, acknowledgement, table of content, acronyms, tables and figures and abstract.

Chapter One; background information/introduction, problem statement and justification, objectives, hypothesis/research questions, significance of the study, scope of the study, limitations, delimitations, conceptual frame work and operational definition of terms.

Chapter Two; literature review based on objectives.

Chapter Three; research methodology; study design, study area, study variables, sample size determination, Sampling procedures, data collection tools and procedures, Validity and reliability of data tools ethical issues in research, reference, Formulate questionnaire and other data collection tools

Back matter; Appendices; questionnaire, consent forms, budget, time frame

Introduction

Introduction helps to guide on the information listed by acquainting the researcher with the available literature in the area of study and providing information on the methods and procedures other researchers have used in past situations.

It is always good to start with a very broad perspective of the main subject area, before gradually narrowing the focus to the central problem under investigation. In doing so, cover the following aspects of your study area:

- An overview of the main area under study;
- A historical perspective (development, growth, etc.) Pertinent to the study area;
- Philosophical or ideological issues relating to the topic;
- Trends in terms of prevalence, if appropriate;
- Major theories, if any;

- The main issues, problems and advances in the subject area under study;
- Important theoretical and practical issues relating to the central problem under study;
- The main findings relating to the core issue(s).

Identification of research problem

This is also known as the research gap which the researcher intends to study or address. Although there are problems all around us, the process of identifying a research gap should be taken with a lot of keenness so that it can meet the following criteria;

- stated clearly and concisely;
- Significant i.e. not trivial or a repeat of previous work;
- Delineated, in order to limit its scope to practical investigation;
- Possible to obtain the information required to explore the problem;
- Possible to draw conclusions related to the problem, as the point of research is to find some answers.

Hypothesis

A hypothesis is written in such a way that it can be proven or disproven by valid and reliable data- it is in order to obtain these data that we perform our study. (1988: 200)

From the above definitions it is apparent that a hypothesis has certain characteristics:

1. It is a tentative proposition.
2. Its validity is unknown.
3. In most cases, it specifies a relationship between two or more variables.

A hypothesis is not very essential in research but it is important in bringing clarity to the research problem. Hypothesis serves the following functions;

- The formulation of a hypothesis provides a study with focus. It tells you what specific aspects of a research problem to investigate.
- A hypothesis tells you what data to collect and what not to collect, thereby providing focus to the study.
- As it provides a focus, the construction of a hypothesis enhances objectivity in a study.
- A hypothesis may enable you to add to the formulation of theory. It enables you to conclude specifically what is true or what is false.

Errors in testing a hypothesis

Incorrect conclusions about the validity of a hypothesis may be drawn if:

- the study design selected is faulty;

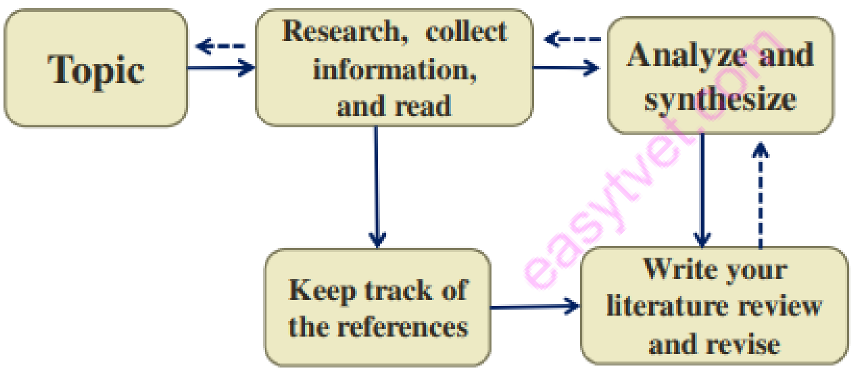
- the sampling procedure adopted is faulty;
- the method of data collection is inaccurate;
- the analysis is wrong;
- the statistical procedures applied are inappropriate; or
- the conclusions drawn are incorrect

Literature review

This refers to the systematic identification, location and analysis of documents containing information related to your research topic/problem

What do we already known/ what has already been done…What type of research has been done in the area? What has been found in previous studies? Place your research in a logical or theoretical framework Provide the rationale for your research; where your study will be situated? Give possible directions what needs to be done; what suggestions do other researchers make for further study? What has not been investigated?

The literature review process should be organised as follows;



Step 1: Identify a list of key words

Step 2: Search for primary and secondary sources that are relevant to your research topic

Step 3: Screen and evaluate the sources

Step 4: Analyze and organize the sources

Step 5: Write the literature review

The researcher should search for relevant documents (books, journals, articles, reports, thesis etc). The kind of information one expects to get is as follows;

- Primary sources: firsthand information (an original research, study report by the person who conducted it)

- Secondary sources: second-hand information (a review, description of a study conducted by someone else).

Once all the information has been gathered, an outline should be made as follows;

- Definitions
- Introduction of the main theory or theories that may support your research
- Overview of previous research in this field or related field, organize and summarize in a meaningful way; avoid too broad and irrelevant info
- Similarities and differences identified in previous studies (does it support or justify your planned research? Does it point to certain directions of research)?

How to write literature review

Once a clear outline has been laid out, writing should begin. One should quote or provide a source when using arguments/opinions or presenting findings from other studies.

Content should be organized logically, explaining each concept and relevant/potential relationships. Being precise and consistent is of great essence when using terms.

Remember….

- Avoid too long, irrelevant information
- Avoid big words, or being too general
- Avoid repetition, summarize them
- Be focused, well-organized
- It is important to develop a logical framework for your study
- Bear in mind that what is important is not just what has been done, but why do you conduct this research

Conceptualizing a research design

Through a research design you decide for yourself and communicate to others your decisions regarding what study design you propose to use, how you are going to collect information from your respondents, how you are going to select your respondents, how the information you are going to collect is to be analysed and how you are going to communicate your findings.

Research design has two main functions whereby the first relates to the identification and/or development of procedures and logistical arrangements required to undertake a study, and the second emphasises the importance of quality in these procedures to ensure their validity, objectivity and accuracy.

A research design, therefore, should do the following:

- Name the study design per se – that is, 'cross-sectional', 'before-and-after', 'comparative', 'control experiment' or 'random control'.
- Provide detailed information about the following aspects of the study:
- Who will constitute the study population?

- How will the study population be identified?
- Will a sample or the whole population be selected?
- If a sample is selected, how will it be contacted?
- How will consent be sought?
- What method of data collection will be used and why?
- In the case of a questionnaire, where will the responses be returned?
- How should respondents contact you if they have queries?
- In the case of interviews, where will they be conducted?
- How will ethical issues be taken care of?

7.3.3.3 Self-Assessment

1. ________________________ outlines the process from beginning to end and may be used to request financing for the project, certification for performing certain parts of research of the experiment, or as a required task before beginning the research project.

   A. Research design

   B. Research topic

   C. Research proposal

   D. Research methodology

2. Historical records, books, journals, scientific papers, magazines and governemet reprts are collectively known as;

   A. Sources of research ideas

   B. Research report

   C. Research data sources

   D. Literature review

3. _________________________ helps to guide on the information listed by acquainting the researcher with the available literature in the area of study and providing information on the methods and procedures other researchers have used in past situations.

   A. Introduction

   B. Literature review

   C. Table of content

   D. Background information

4. Briefly discuss four sources of research topics.
5. Outline the steps in identifying a suitable research topic.
6. Describe factors that will help you to differentiate between a scholarly and a non-scholarly article.
7. Describe the components of a research proposal
8. What are the two main functions of a research design?
9. Describe how you formulate a problem statement in research

7.3.3.4 Tools, Resources, and Materials

Research methods textbooks

Sample proposal document

LCD projector

Stationery

Videos

7.3.3.5 References

Clarke, S. (2014). Introduction to research. An Introduction to Theory and Reasoning in Nursing: Fourth Edition, 226–259. https://doi.org/10.5005/jp/books/12430_2

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7.3.4 Learning outcome 3: Conduct data collection

7.3.4.1 Learning Activities

Learning Activity	Specific instructions
Collect data • Follow the guideline provided by the proposal developed • Perform pre-testing of data collection tools • Carry out sampling of the respondents • Perform data management and data quality checks	Study through the proposal and understand what the study requires Follow the "how to" guideline provided in the proposal Show ability to collect the data captured in the proposal using the proposed data collection tools

7.3.4.2 Information Sheet

Definitions

Data: any observation collected in respect of any characteristic or event

Data collection: process of collecting information from all the relevant sources to find answers to the research problem, test the hypothesis and evaluate the outcomes.

Sampling: is the use of a subset of the entire population.

Research data management: a term that describes the organization, storage, preservation, and sharing of data collected and used in a research project. It involves the everyday management of research data during the lifetime of a research project.

Data collection

Data collection is a term used to describe a process of Systematic gathering of data for a particular purpose from various sources that has been systematically observed, recorded, organized.

Purpose of data collection

- To obtain information
- To keep on record
- To make decisions about important issues,
- To pass information on to others
- For research study

Factors to be considered before collection of data

- Nature , scope & Objective of the enquiry
- Sources of information
- Availability of fund
- Techniques of data collection
- Availability of trained persons

Types of data

Qualitative data	Quantitative data
Deals with descriptions.	Deals with numbers
Data can be observed	Data can be measured
Data cannot be measured	
Example: feather colour in poultry	Example: height, weight, length, weight

Sources of data

These are mainly divided into external and internal sources of data

Internal sources of data	External sources of data
Many institutions and departments have information about their regular functions , for their own internal purposes When those information are used in any survey is called internal sources of data. Eg…social welfare societies.	When information is collected from outside agencies is called external sources of data. Such types of data are either primary or secondary. This type of information can be collected by census or sampling method by conducting survey.

Primary data is the data that has been collected from first-hand experience. Primary data has not been published yet and is more reliable, authentic and objective. Primary data has not been changed or altered by human beings, therefore its validity is greater than secondary data.

Secondary data is a type of data that has already been published in books, newspapers, magazines, journals, online portals etc. There is an abundance of data available in these sources about your research area. Therefore, application of appropriate set of criteria to select secondary data to be used in the study plays an important role in terms of increasing the levels of research validity and reliability.

Quantitative data collection methods are based in mathematical calculations in various formats. Methods of quantitative data collection and analysis include questionnaires with closed-ended questions, methods of correlation and regression, mean, mode and median and others.

Quantitative methods are cheaper to apply and they can be applied within shorter duration of time compared to qualitative methods. Moreover, due to a high level of standardisation of quantitative methods, it is easy to make comparisons of findings.

Qualitative research methods, on the contrary, do not involve numbers or mathematical calculations. Qualitative research is closely associated with words, sounds, feeling, emotions, colours and other elements that are non-quantifiable. Qualitative studies aim to ensure greater level of depth of understanding and qualitative data collection methods include interviews, questionnaires with open-ended questions, focus groups, observation, game or role-playing, case studies etc.

Your choice between quantitative or qualitative methods of data collection depends on the area of your research and the nature of research aims and objectives.

Factors affecting method of data collection

- Type of research subject
- Purpose of research study
- Size of study sample
- Distribution of target population
- Time frame of the study
- Literacy level of subjects

Data collection tools

There are three main types of interviews;

Structured interviews: involve the use of questionnaires based on a predetermined and identical set of questions. The questions are usually read out by a researcher in a neutral tone of voice to avoid influencing or prompting a particular response from a participant.

Semi structured interviews: The interviewer will have a list of themes and areas to be covered and there may be some standardised questions, but the interviewer may omit or add to some of these questions or areas, depending on the situation and the flow of the conversation.

Unstructured interviews: These are informal discussions where the interviewer wants to explore in-depth a particular topic with another person in a spontaneous way. However, even in unstructured interviews it is likely that the researcher would have a pre-decided range of topics to cover in the discussion.

Focus Groups

Focus groups are used to gather data, usually in the forms of opinions, from a selected group of people on a particular and pre-determined topic, e.g. consumer topic; political topic etc. The researcher creates a relaxed atmosphere and records in some way what is being said (e.g. by use of a tape-recorder, video, note-taker etc). The purpose of the discussion is introduced and discussion ground-rules agreed. The researcher encourages free discussion, but is ready to intervene if necessary to resolve group problems. Focus groups can be a useful way of finding out what the main issues and concerns of any group are. This can help in questionnaire design or to develop a future interview strategy. They can be a useful way too, of bringing to the surface issues that might not otherwise have been discovered: the dynamics of a group can often make people bolder in advancing their opinions.

Participant Observation

As discussed earlier, participant observation is when a researcher attempts to observe in some way in the group being researched and to share in the experiences being recorded and analysed. It can be used in association with other research approaches or as the primary way of gathering data. It can be a good way of getting below the surface of any situation and to help reveal or unravel complex causal

Questionnaires

Main points to remember when designing and using questionnaires;

1. Questionnaires facilitate the collection of data by asking all, or a sample of people, to respond to the same questions. They can be in both printed and electronic forms.
2. There are five types of questionnaire approaches:
   - On-line (electronic)
   - Postal (printed)
   - Delivery & collection (printed)
   - Telephone (electronic/printed)
   - Interview face to face/group (electronic or printed)
3. You need to absolutely clear before you design a questionnaire what it is you want to learn and what data you need to obtain to enlighten you in this search. You also need to think ahead about how you are going to collate the information you gather. There is no point in designing a questionnaire that produces a range of information you find very difficult to collate in any meaningful quantitative or qualitative way.
4. The validity (the extent to which the data accurately measures what they were intended to measure) and reliability (the extent to which the data collection method will yield consistent findings if replicated by others) of the data you collect depend on the design of the questionnaire and the words that you use.

5. Questions can be open or closed: Open questions: a question is posed, but space is left for the respondent's own answer (the questions posed to you in this workbook have all been open questions) e.g. Please tell me which brand you prefer, and why in the space that follows Closed: where a limited number of alternative responses to the set question are provided. These can be in list, category, ranking, scale/rating, grid or other quantitative form. They can be pre- coded on a questionnaire to facilitate analysis. e.g. Please tick the box shown below with the brand you prefer
6. The order and flow of questions should be logical to the respondent.
7. There can be a low rate of return with questionnaires, so they need to be introduced carefully and courteously to potential respondents.
8. All questionnaires should be piloted, if possible, with a small group before the main research to assess their value, validity and reliability.

Guidelines for designing questionnaires

1. Explain the purpose of the questionnaire to all participants
2. Keep your questions as simple as possible
3. Do not use jargon or specialist language (unless the recipients really prefer and understand it)
4. Phrase each question so that only one meaning is possible
5. Avoid vague, descriptive words, such as 'large' and 'small'
6. Avoid asking negative questions as these are easy to misinterpret
7. Only ask one question at a time
8. Include relevant questions only
9. Include, if possible, questions which serve as cross-checks on the answers to other questions
10. Avoid questions which require participants to perform calculations
11. Avoid leading or value-laden questions which imply what them required answer might be
12. Avoid offensive questions or insensitive questions which could cause embarrassment
13. Avoid asking 'difficult' questions, e.g. where the respondent may struggle to answer (people hate to look stupid by not knowing the 'answer').
14. Keep your questionnaire as short as possible, but include all the questions you need to cover your purposes.

Pre-testing of data collection tools

Pre-testing is the administration of the data collection instrument with a small set of respondents from the population for the full scale survey. If problems occur in the pre-test, it is likely that similar problems will arise in full-scale administration. The purpose of pre-testing is to identify problems with the data collection instrument and find possible solutions.

It is not possible to anticipate all of the problems that will be encountered during data collection. Terminology used in questionnaires or interviews may not be understood by respondents and information to be retrieved from documents may not be readily available. Reducing error to acceptable levels requires the pre-testing of data collection instruments.

Because standardized procedures are essential for ensuring that general statements can be made, it is advisable to make as few adjustments as possible to data collection instruments once data collection has actually started. In the case of mailed questionnaires, adjustments are impossible once the data collection instruments have been distributed. Pre-testing mail questionnaires or other data collection instruments allows adjustments to be made before full scale administration of the instrument, helping to ensure that standardized procedures are applied during data collection.

Principles for pre-testing

Pre-testing should be conducted in circumstances that are as similar as possible to actual data collection and on population members as similar as possible to those that will be sampled.

Careful notes should be taken on the problems encountered and possible solutions should be identified.

Pre-testing questionnaires

One important objective of pre-testing questionnaires is to get at the thinking behind the answers so that the auditor can accurately assess whether the questionnaire is being filled out properly, whether the questions are actually understood by respondents, and whether the questions ask what the auditor thinks they are asking. Pre-testing also helps assess whether respondents are able and willing to provide the needed information.

In pre-testing, the respondents should actually fill out the questionnaire, giving their views along the way or afterward. One approach is to give the questionnaire as an interview, asking for clarification of answers and clarifying questions along the way. The respondents' views can also be obtained during a post-questionnaire interview or in a focus group. Another common approach is to have respondents think out loud as they answer.

Sampling/ identification of respondents

Sample design and sample size

Sampling is usually done as it is not possible to study the entire population as this would be tedious, expensive and time consuming.

There are many types of sampling procedures which are determined by factors such as:

- The objectives of the study
- The nature of the research(qualitative or quantitative)
- Experience of the researcher
- The research questions
- Where detailed analysis of the sample is required

During the process of sampling there may be bias in sampling. These are the data errors that may occur hence resulting to false finding. Bias in sampling can be due to;

- Faulty research instruments(e.g. rulers, measuring tapes, weighing scales)
- Non responses
- Late return of questionnaires
- False information from the respondents
- Biasness of the interviewer concerning a certain culture or political differences

Sampling techniques

There are two main types sampling techniques that are used in research;

- Probability sampling
- Non probability sampling

A. Probability Sampling:

Where the researcher has a significant measure of control over who is selected and on the selection methods for choosing them. Sampling methods allow for representative cross-sections, or particular groups to be identified or targeted.

Main Methods:

i. Simple Random Sampling: (selection at random by the researchers from a choice of subjects).

Each item in the population has the same probability of being selected as part of the sample as any other item. This is usually achieved by the use of computers that will generate the table of random numbers. The lottery method can also be used. In this method, names of the subject or objects, in the population frame are written on pieces of paper and put in a container .The pieces of paper are then thoroughly mixed so as each item has an equal chance of being selected. Random sampling can be done with or without replacement. If done without replacement, an item is not returned in the population after being selected and thus can only occur once in the sample.

ii. Systematic Sampling: (selecting by the researchers at numbered intervals, e.g. every one person in five in the target group).

Every nth element from the list is selected as the sample is, starting with a sample element n randomly selected from the first k elements. For example if a population has 1000 elements and a sample size of 100 is needed, then k would be 1000/100=10.If number 5 is randomly selected from the first ten elements on the list, the sample would continue down the list selecting the 5th element from each group of ten elements

iii. Stratified Sampling:

This is sampling within particular sections of the target groups, e.g. you target a specific number of people based on the percentage of the total group that share the same characteristics. So, for example, in a study of an organisation that had 50 supervisors & 800 labourers, a 10% representative sample of this population would target 5 supervisors & 80 labourers to interview.

The population is first divided into subgroups known as the strata based on mutually exclusive criteria. Random or systematic samples are then taken from each of the subgroup (stratum). The sampling fraction for each of the subgroup may be taken in the same proportion as the subgroup has in the population. For example, if 40 students are to be selected,5%are first years,25%are second years,60%are third years and 10% are fourth years, then 2 first years,10 second years 24 third years and 4 fourth years will be selected randomly so as to be part of the sample population of 40.Statified sampling can also sample an equal number of items from each subgroup.

Advantages over other sampling methods include;

- Improves the accuracy/efficiency of estimation
- Permits greater balancing of statistical power of tests of differences between strata by sampling equal numbers from strata varying widely in size.
- Allows use of different sampling techniques for different subpopulations.
- Focuses on important subpopulations and ignores irrelevant ones.

Disadvantages

- Requires selection of relevant stratification variables which can be difficult.
- Is not useful when there are no homogeneous subgroups.
- Can be expensive to implement.

iv. Cluster Sampling: (surveying a particular cluster of the subject group)

Also known as block sampling. In cluster sampling, the population that is being selected is divided into groups known as clusters. Instead of these groups being homogenous based on a certain criteria, a cluster is as heterogeneous as possible to match the population. For example all the clusters in the population are listed (e.g. Hospitals, markets, restaurants, and colleges).Subjects are then selected from each cluster ensuring that the selected subjects are a representative of the entire population.

v. Multistage sampling

This is a complex form of cluster sampling. Two or more levels of the units are imbedded one into the other. For example geographic areas (primary units), factories (secondary units), employees (tertiary units).At each stage, a sample of the corresponding unit is selected. At first, a sample of primary units is selected, then, in each of those selected, a sample of secondary units is selected, and so on. All ultimate units (individuals, for instance) selected at the last step of this procedure are then surveyed. The reasons for adopting such a design may be reducing costs, for example, when interviewers are assigned to persons located in a restricted area, or reducing the sample error. Multi-stage sampling is sometimes used when no general sample frame exists. In this case, a first step is to select, at random, a sample of areas, collective units, or villages from a list where they are all registered (primary units). Then, for each selected primary unit, a comprehensive enumeration of all units of lower rank is made, thus obtaining a local sample frame among which a sample of secondary units will be selected.

B. Non-Probability Sampling:

Where the researcher has little initial control over the choice of who is presented for selection, or where controlled selection of participants is not a critical factor.

Main Methods include:

i. *Convenience Sampling:* (sampling those most convenient; those immediately available)

ii. *Voluntary Sampling:* (the sample is self-selecting; they come forward voluntarily in response to an appeal)

iii *Purposive Sampling:* (enables you to use your judgement to choose people that are presented or are available that best meet your objectives or your target groups).

Subjects are selected because of some characteristic. Purposive sampling targets a particular group of people. When sampling the desired population for the study is rare or very difficult to locate and recruit for a study, purposive sampling may be the only option. For example, you are interested in studying cognitive processing speed of young adults who have suffered closed head brain injuries in automobile accidents. This would be a difficult population to find.

iv. 'Snowball' Sampling: (building up a sample through informants. You start with one person – who then suggests another & so on).

This sampling method is used if the sample for the study is very rare or is limited to a very small subgroup of the population. This type of sampling technique works like chain referral. After observing the initial subject, the researcher asks for assistance from the subject to help identify people with a similar trait of interest.

The process is much like asking your subjects to nominate another person with the same trait as your next subject. The researcher then observes the nominated subjects and continues in the same way until the obtaining sufficient number of subjects.

For example, if obtaining subjects for a study that wants to observe a rare disease, the researcher may opt to use snowball sampling since it will be difficult to obtain subjects. It is also possible that the patients with the same disease have a support group; being able to observe one of the members as your initial subject will then lead you to more subjects for the study. The process is cheap and cost efficient and needs little planning. The disadvantages of this method are that the researcher has little control over this method and the representative of the sample is not guaranteed.

v. Event Sampling (using the opportunity presented by a particular event, e.g. a conference, to make contacts)

vi. Time Sampling (recognising that different times or days of the week or year may be significant and sampling at these times or days.

Administering questionnaires and other data collection tools

The methods used in data collection include;

- Questionnaire
- Interviewing
- Observation

Data-collection techniques allow us to systematically collect information about our objects of study (people, objects, phenomena) and about the settings in which they occur.

In the collection of data we have to be systematic. If data are collected haphazardly, it will be difficult to answer our research questions in a conclusive way.

Example:

Various data collection techniques can be used such as:

- Using available information
- Observing
- Interviewing (face-to-face)
- Administering written questionnaires
- Focus group discussions
- Projective techniques, mapping, scaling

Using available information

Usually there is a large amount of data that has already been collected by others, although it may not necessarily have been analyzed or published. Locating these sources and retrieving the information is a good starting point in any data collection effort.

For example, analysis of the information routinely collected by health facilities can be very useful for identifying problems in certain interventions or in flows of drug supply, or for identifying increases in the incidence of certain diseases.

Analysis of health information system data, census data, unpublished reports and publications in archives and libraries or in offices at the various levels of health and health-related services, may be a study in itself. Usually, however, it forms part of a study in which other data collection techniques are also used.

Interviews

In interviews, information is obtained through inquiry and recorded by enumerators. Structured interviews are performed by using survey forms, whereas open interviews are notes taken while talking with the respondent. The notes later interpreted for further analysis.

Types of interviews

Face to face interview

An interview is used to obtain information from one person about particular situations, problems or topics. This kind of interview involves a direct meeting between interviewer and interviewee. The interview can be structured or semi-structured.

The structured interview is designed to elicit specific responses to specific questions. Responses to a structured interview will normally be easier to quantify and interpret since uniform questions tend to yield a narrower range of responses. The semi-structured interview uses open-ended questions to explore broad issues in a non-directive, non-threatening manner.

Advantages

1. The main advantage of face-to-face or direct interviews is that the researcher can adapt the questions as necessary, clarify doubt and ensure that the responses are properly understood, by repeating or rephrasing the questions.
2. The researcher can also pick up nonverbal cues from the respondent. Any discomfort, stress and problems that the respondent experiences can be detected through frowns, nervous taping and other body language, unconsciously exhibited by any person.

Disadvantages

1. The main disadvantages of face-to-face interviews are the geographically limitations they may impose on the surveys and the vast resources needed if such surveys need to be done nationally or internationally.
2. The costs of training interviewers to minimize interviewer's biases for example differences in questioning methods, interpretation of response are also high.
3. Respondents might feel uneasy about the anonymity of their responses when they interact during face to face interviews.

Telephone interviews

This is a prescheduled interview that takes place between the interviewer and the interviewee. Unlike the face to face interview, there is no meeting with the parties involved

Advantages

1. Telephone interview enable a researcher to gather information rapidly.
2. Wide geographical access. People from all over the globe can be accessed.
3. The people are likely to cooperate due to the confidentiality involved.
4. Access to dangerous or politically sensitive areas.

Disadvantages

1. Some people may not have telephones
2. People often dislike the intrusion of a call to their home.
3. Telephone interviews need to be relatively short otherwise the people will feel imposed upon.
4. Many people do not have publicly listed telephone numbers
5. The interviewer has no view on the situation in which the interviewee is situated. Because of this the interviewer has lesser possibilities to create a good interview ambience.

E-Mailed interviews.

Advantages

- There is extended access to participants.
- The questionnaire may be handed to the respondents or mailed to them, but in all cases they are returned to the researcher via mail.
- Cost is very low, since bulk postage is cheap in most countries.
- Respondents can answer at their own convenience.
- No interviewer bias introduced
- Large amount of information can be obtained: some mail surveys are as long as 50 pages

Disadvantages

- Long time delays, often several months, before the surveys are returned and statistical analysis can begin
- Not suitable for issues that may require clarification

Questionnaires

A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents.

Advantages

- The responses are gathered in a standardized way, so questionnaires are more objective unlike interviews.
- Generally it is relatively quick to collect information a questionnaire. However in some situations they can take a longtime not only to design but also to apply and analyze.
- Questionnaires are very cost effective when compared to face-to-face interviews especially for studies involving large sample sizes and large geographic areas. Written questionnaires become even more cost effective as the number of research questions increases.
- They are easy to analyze. Data entry and tabulation for nearly all surveys can be easily done with many computer software packages.
- Questionnaires are familiar to most people. Nearly everyone has had some experience completing questionnaires and they generally do not make people apprehensive.
- Questionnaires reduce bias. There is uniform question presentation and no middle-man bias. The researcher's own opinions will not influence the respondent to answer questions in a certain manner. There are no verbal or visual clues to influence the respondent.
- Questionnaires are less intrusive than telephone or face-to-face surveys. When a respondent receives a questionnaire in the mail, he is free to complete the questionnaire on his own time-table. Unlike other research methods, the respondent is not interrupted by the research instrument.

Disadvantages

- Questionnaires, like many evaluation methods occur after the event, so participants may forget important issues.
- Questionnaires are standardized so it is not possible to explain any points in the questions that participants might misinterpret. This could be partially solved by piloting the questions on a small group of students or at least friends and colleagues. It is advisable to do this anyway.
- Open-ended questions can generate large amounts of data that can take a long time to process and analyze. One way of limiting this would be to limit the space available to students so their responses are concise or to sample the students and survey only a portion of them.
- Respondents may answer superficially especially if the questionnaire takes a long time to complete. The common mistake of asking too many questions should be avoided.

- Students may not be willing to answer the questions. They might not wish to reveal the information or they might think that they will not benefit from responding perhaps even be penalized by giving their real opinion. Students should be told why the information is being collected and how the results will be beneficial. They should be asked to reply honestly and told that if their response is negative this is just as useful as a more positive opinion. If possible the questionnaire should be anonymous

1. Open ended or unstructured (qualitative)

The interviewee is at liberty to answer the questions without any limitation. Examples

- Tell me about yourself.
- Why do you indulge in alcohol
- What is your opinion on traditional birth attendants?

2. Semi- structured

Semi-structured interviews are conducted with a fairly open framework which allow for focused, conversational, two-way communication. They can be used both to give and receive information. A semi-structured interview is flexible, allowing new questions to be brought up during the interview as a result of what the interviewee says. The interviewer in a semi-structured interview generally has a framework of themes to be explored.

3. Structured questionnaires

The aim of this approach is to ensure that each interview is presented with exactly the same questions in the same order. This ensures that answers can be reliably aggregated and that comparisons can be made with confidence between sample subgroups or between different survey periods. The answers are answered in on way (e.g. yes or no)

4. Focus group discussion

This is a form of qualitative research method where people from similar backgrounds or experiences (e.g., mothers, HIV/AIDS patients, students) are brought together to discuss a specific topic of interest to the investigator(s). Homogeneous samples are preferred because mixing age/ gender groups may inhibit some people, especially women, from expressing their views. Questions are asked in an interactive group setting where participants are free to talk with other group members. The main characteristic of a focus group is the interaction between the moderator and group, as well as the interaction between members. The objective is to give the researcher an understanding of the participants' perspective on the topic in the discussion. Focus groups are rapidly gaining popularity in health and medical research.

Advantages of focus groups include:

- Quick, cheap and relatively easy to assemble
- Good for getting rich data in participants' own words and developing deeper insights
- People are able to build on one another's responses and come up with ideas they might not have thought of in a 1-on-1 interview
- Good for obtaining data from children and/or people with low levels of literacy
- Provides an opportunity to involve people in data analysis (e.g. "Out of the issues we have talked about, which ones are most important to you?")
- Participants can act as checks and balances on one another - identifying factual errors or extreme views

Limitations of focus groups include:

- The responses of each participant are not independent
- A few dominant focus group members can skew the session
- Focus groups require a skilled and experienced moderator
- The data which results from a focus group requires skill and experience to analyze

Observation

Observational research techniques solely involve the researcher or researchers making observations.

To develop an observation tool, you want first to establish the indicators for the observation. Indicators are based on what you expect to find in the environment, product or process as a result of your program. The second thing you want to do is consider each of the indicators and measure them for their presence or absence, and then, their quality. The observed resorts may be recorded by methods such as video taping, taking notes or counting occurrences

Advantages

- In terms of validity, observation findings are considered strong as compared to other methods because the researcher is able to collect a depth of information about a particular behaviour.

Disadvantages

- There are problems with reliability. Reliability refers the extent that observations can be replicated. Seeing behaviours occur over and over again may be a time consuming task.
- There is a possibility of the researcher being bias. Often; it is assumed that the researcher may see what they want to see.

- Data management and data quality checks
- Research Data Management is part of the research process, and aims to make the research process as efficient as possible, and meet expectations and requirements of the university, research funders, and legislation. It concerns how data is created and plan for its use, how data is organized and how it is kept.

Research data management concerns the organization of data, from its entry to the research cycle through to the dissemination and archiving of valuable results. It aims to ensure reliable verification of results, and permits new and innovative research built on existing information.

Data quality relies on a chain of events: what is asked for and how, how it is entered, what is edited and when, and finally how data is reviewed, stored, and used. Since data quality is affected by virtually every part of the business process, data quality is an integral part of what must be a Total Quality Management concept.

Clean data is the result of some combination of two efforts: making sure that data entered into the system are clean, and cleaning up problems once the data has been accepted. The first part is best interactive and immediate, although it may include some "close of business day" review and rework processes. The second type of effort is, fundamentally, a batch data cleanup exercise.

Clean data is also the result of a shared sense of responsibility and never-ceasing vigilance. Every time data is entered to the system, the person doing the entry should feel responsibility for and pride in the quality of the data and success of the mission. Managers responsible for a business area must be aware of their responsibilities for the data around which their work is structured. Business and technical experts must realize that anytime the business changes, the data might change. Responsibility is typically defined as a combination of data stewardship and ownership.

Characteristics of good quality data

Accuracy: degree to which data value meets the source assumed to be correct. This means that the data is free of error

Completeness: degree to which values are present in the attributes that require them

Consistency: data maintained in such a way that they are free from variation or contradiction

Timeliness: extent to which a data item is provided at the specified time

Uniqueness

Validity: satisfies the acceptance requirements

7.3.4.3 Self-Assessment

1. Define the following terms as used in research studies
   A. Sample
   B. Sampling
2. Data collection methods can be divided into two main categories;
   A. Qualitative and quantitative data collection methods
   B. Questionnaire and interviews data collection method
   C. Primary and secondary data collection methods
   D. Focus groups and participant observation data collection methods
3. The following are disadvantages of stratified sampling except?
   A. Requires selection of relevant stratification variables which can be difficult.
   B. Does not allow efficiency of estimation
   C. Is not useful when there are no homogeneous subgroups.
   D. Can be expensive to implement.
4. Convenience sampling, voluntary sampling and purposive sampling are the main methods of ;
   A. Non-probability sampling
   B. Multi stage sampling
   C. Systematic sampling
   D. Stratified sampling
5. Giving relevant examples, differentiate between probability and non-probability sampling?
6. Discuss the advantages and disadvantages of using focused group discussions during data collection
7. Describe any two data collection tools citing the advantages of each
8. Bias in sampling can result to data errors that may occur hence resulting to false finding. Explain.

9. Explain the characteristics of good quality data

1.0. Explain the characteristics of good quality data

7.3.4.4 Materials and resources

Sample data collection tools

Research methods textbooks

LCD projector

Stationery

Videos

Research proposal

7.3.4.5 References

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7.3.5 Learning outcome 4: Conduct data analysis and presentation

7.3.5.1 Learning Activities

Learning Activity	Specific instructions
Analyse data • Identify an appropriate data analysis software • Identify the variables in research	Demonstrate the ability to classify the data Perform data cleaning Perform data coding Differentiate dependent and independent variables Run the data through the software for analysis Use the analyzed data to write the research report
Present research findings • Identify and describe the methods of presenting the analysed data	Identify the appropriate data presentation method for the different data sets

7.3.5.2 Information Sheet

Definitions

Variable is any measured characteristic or attribute that differs for different subjects

Data analysis: the process of bringing order, structure and meaning to the mass of collected data.

Introduction to data analysis

Data analysis is a messy, ambiguous, time-consuming, creative, and fascinating process. It does not proceed in a linear fashion; it is not neat. Qualitative data analysis is a search for general statements about relationships among categories of data.

The 'raw' research data needs to be edited, tabulated and analyzed to find the results and to interpret them.

– The method used may be manual or computer based.

– The analysis plan follows from the research objective of the study.

– Association and relationships of variables are identified and discussed in the light of the specific marketing problem.

The analysis process is the most important process in the research as the results are generated on the basis of data preparation. After the data collecting stage the collected data is;

– edited

– Coded

– transcribed

– corrected if required and

– validated.

Uni/multivariate techniques are used for analyzing data when there is a single/multiple measurement of each element or unit in the sample data.

The purpose of analysing data is to obtain usable and useful information. The analysis, irrespective of whether the data is qualitative or quantitative, may:

- Describe and summarise the data
- Identify relationships between variables
- Compare variables
- Identify the difference between variables

Variables in research

There are two main types of variables in research;

1. Independent variable

The independent variable is the variable that is representing the value being manipulated or changed. It is what the experimenter changes so as to carry out an experiment.

This is what the experimenter changes or enacts in order to carry out the experiment

For instance: if you are measuring the growth rate of bacteria under aerobic conditions for 12 hours a day versus bacteria that is only exposed to aerobic conditions for 6 hours, the amount of time per day that the bacteria is exposed to aerobic conditions per day is the independent variable-the value that you control. The growth rate of the bacteria would be a dependent variable.

2. Dependent variable

The dependent variable is what changes when the independent variable changes (the dependent variable depends on the outcome of the independent variable). Example: You are interested in how stress affects heart rate in humans. Your independent variable would be the stress and the dependent variable would be the heart rate. You can directly manipulate stress levels in your human subjects and measure how those stress levels change heart rate.

Extraneous and Confounding Variables

The independent and dependent variables are not the only variables present in many experiments. In some cases, extraneous variables may also play a role. This type of variable is one that may have an impact on the relationship between the independent and dependent variables.

For example, in our previous description of an experiment on the effects of sleep deprivation on test performance, other factors such as age, gender and academic background may have an impact on the results. In such cases, the experimenter will note the values of these extraneous variables so this impact on the results can be controlled for.

There are two basic types of extraneous variables:

> *Participant Variables:* These extraneous variables are related to individual characteristics of each participant that may impact how he or she responds. These factors can include background differences, mood, anxiety, intelligence, awareness and other characteristics that are unique to each person.
>
> *Situational Variables:* These extraneous variables are related to things in the environment that may impact how each participant responds. For example, if a participant is taking a test in a chilly room, the temperature would be considered an extraneous variable. Some participants may not be affected by the cold, but others might be distracted or annoyed by the temperature of the room.

In many cases, extraneous variables are controlled for by the experimenter. In the case of participant variables, the experiment might select participants that are the same in background and temperament to ensure that these factors do not interfere with the results. If, however, a variable cannot be controlled for, it becomes what is known as a confounding variable. This type of variable can have an impact on the dependent variable, which can make it difficult to determine if the results are due to the influence of the independent variable, the confounding variable or an interaction of the two.

Tools to support data analysis

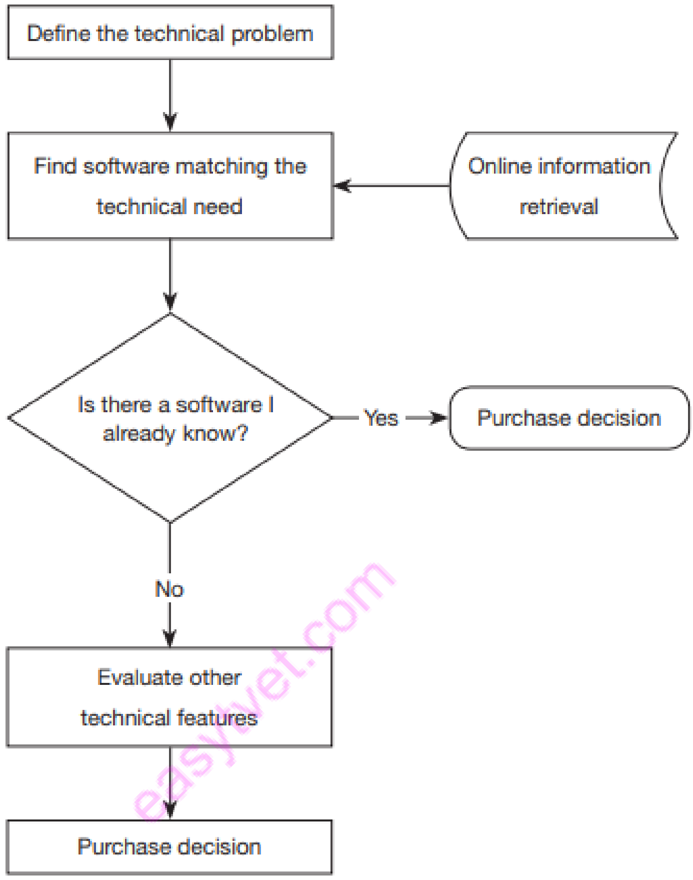
- Spreadsheet – simple to use, basic graphs
- Statistical packages e.g SPSS
- Qualitatitive data analysis tools
    - o Categorization and theme-based analysis
    - o Quantitative analysis of text-based data
- Nvivo and Atlas.ti support qualitative data analysis

Organizing the data for analysis

- Organize all forms/questionnaires in one place
- Check the completeness and accuracy
- Remove those that are incomplete or do not make sense; keep a record or your ecisions
- Assign a unique identifier of each form/questionnaire

Identification of data analysis software's

Use of statistical/data analysis software is very critical in the current research era. Choosing the right software tool is a strategic move for any research department. The success of a software selection is determined by several factors such as software usability, technical support, training materials/courses, and community of users. It is important for the buyer to consider the technical problem being addressed and then follow the steps suggested in Figure below.



Purchase decision model for software

Various types of data analysis softwares are available in the market today. Examples include;

- Stats software
- Statistical package for the social sciences (SPSS)
- SAS
- MAXQDA
- Quirkos
- Qualtrics
- Raven's Eye e.t.c

Interpretation of data

Interpretation is the process of attaching meaning to the data. It demands fair and careful judgements. Often the same data can be interpreted in different ways

Data presentation

Research data can be presented either in tabular (simple and complex tables) or graphical method. In graphical method, quantitative data is presented using histogram, frequency polygon, frequency curve, line chart, normal distribution curve, cumulative distribution curve and scatter diagram. For qualitative data, bar charts, pictograms, pie charts and map diagram are used in the graphical method of data presentation

Principles of data presentation

(a) To arrange the data in such a way that it should create interest in the reader's mind at the first sight.

(b) To present the information in a compact and concise form without losing important details.

(c) To present the data in a simple form so as to draw the conclusion directly by viewing at the data.

(d) To present it in such a way that it can help in further statistical analysis.

Various methods are used to present that analysed data for easy interpretation. Some of the commonly used methods include;

1. Tabulation

Tables are the devices that are used to present the data in a simple form. It is probably the first step before the data is used for analysis or interpretation.

General principles of designing tables

1. The tables should be numbered e.g. table 1, table 2 etc.
2. A title must be given to each table, which should be brief and self-explanatory.
3. The headings of columns or rows should be clear and concise.
4. The data must be presented according to size or importance chronologically, alphabetically, or geographically.
5. If percentages or averages are to be compared, they should be placed as close as possible.
6. No table should be too large
7. Most of the people find a vertical arrangement better than a horizontal one because, it is easier to scan the data from top to bottom than from left to right
8. Foot notes may be given, where necessary, providing explanatory notes or additional information.

Types of tables

i. Simple tables :Measurements of single set are presented

ii. Complex tables :Measurements of multiple sets are presented

Frequency distribution table

- In the frequency distribution table, the data is first split up into convenient groups (class interval) and the number of items (frequency) which occur in each group is shown in adjacent columns.
- Hence it is a table showing the frequency with which the values are distributed in different groups or classes with some defined characteristics.

Rules for construction of frequency table

i. The class interval should not be too large or too small

ii. The number of classes to be formed more than 8 and less than 15

iii. The class interval should be equal and uniform throughout the classification.

iv. After construction of table, proper and clear heading should be given to it

v. The base or source of data should be mentioned with the pattern of analysis in footnote at the end of table

2. Charts and diagrams

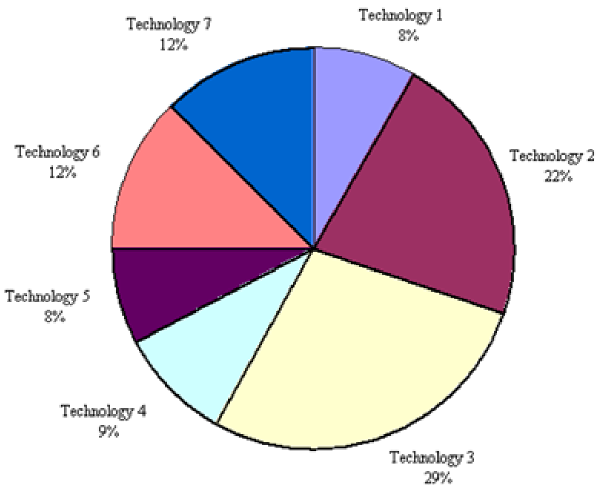
Charts and diagrams are useful methods of presenting simple data. They have powerful impact on imagination of people. Gives information at a glance. Diagrams are better retained in memory than statistical table. However graphs cannot be substituted for statistical table, because the graphs cannot have mathematical treatment whereas tables can be treated mathematically. Whenever graphs are compared, the difference in the scale should be noted. It should be remembered that a lot of details and accuracy of original data is lost in charts and diagrams, and if we want the real study, we have to go back to the original data.

Common diagrams

- Pie chart
- Simple bar diagram
- Multiple bar diagram
- Component bar diagram or subdivided bar diagram
- Histogram
- Frequency polygon
- Frequency curve
- O give curve
- Scatter diagram
- Line diagram
- Pictogram
- Statistical maps

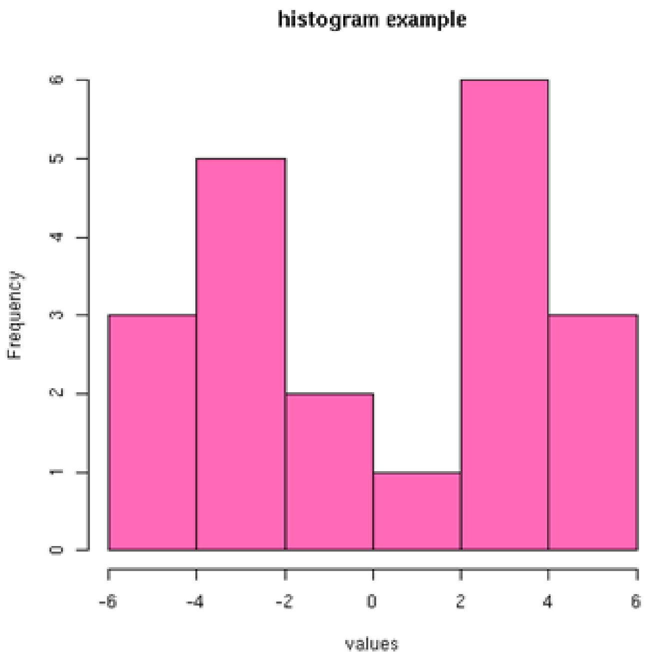
3. Pie charts

A pie chart (or a circle graph) is a circular chart that is divided into sectors, illustrating proportion. In a pie chart, the arc length of each sector (and consequently its central angle and area), is proportional to the quantity it represents. Pie charts can be an effective way of displaying information in some cases, in particular if the intent is to compare the size of a slice with the whole pie, rather than comparing the slices among them. Below is an example of a pie chart



4. Histogram

The histogram provides a graphical summary of the shape of the data's distribution. It often is used in combination with other statistical summaries such as the boxplot, which conveys the median, quartiles, and range of the data. Below is an example of a histogram.



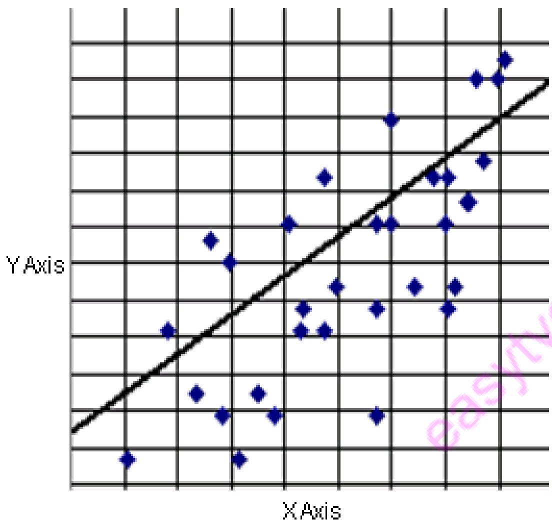
5. Scatter plots

Scatter plots show the relationship between two variables by displaying data points on a two-dimensional graph. The variable that might be considered an explanatory variable is plotted on the x axis, and the response variable is plotted on the y axis.

Scatter plots are especially useful when there is a large number of a data point. They provide the following information about the relationship between two variables:

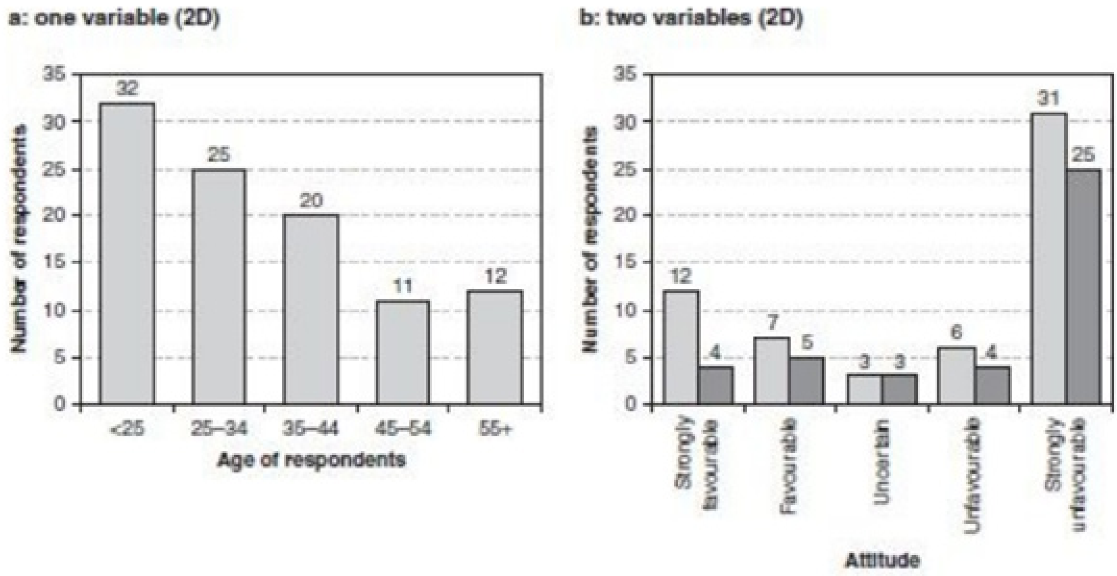
- Strength
- Shape - linear, curved, etc.
- Direction - positive or negative
- Presence of outliers

A correlation between the variables results in the clustering of data points along a line. The following is an example of a scatter plot suggestive of a positive linear relationship.



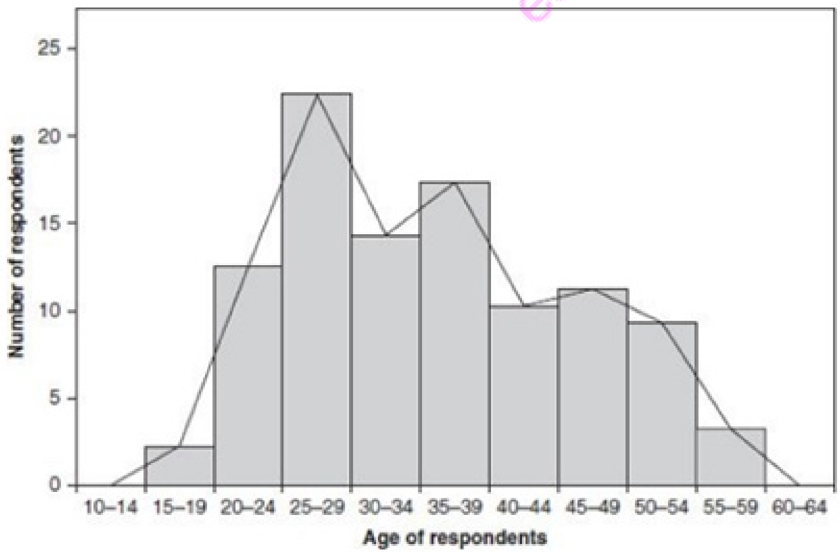
6. Bar chart

The bar chart or diagram is used for displaying categorical data (See the followingFigure). A bar chart is identical to a histogram, except that in a bar chart the rectangles representing the various frequencies are spaced, thus indicating that the data is categorical. The bar chart is used for variables measured on nominal or ordinal scales. The discrete categories are usually displayed along the x-axis and the number or percentage of respondents on the y-axis. However, as illustrated, it is possible to display the discrete categories along the y- axis. The bar chart is an effective way of visually displaying the magnitude of each subcategory of a variable.



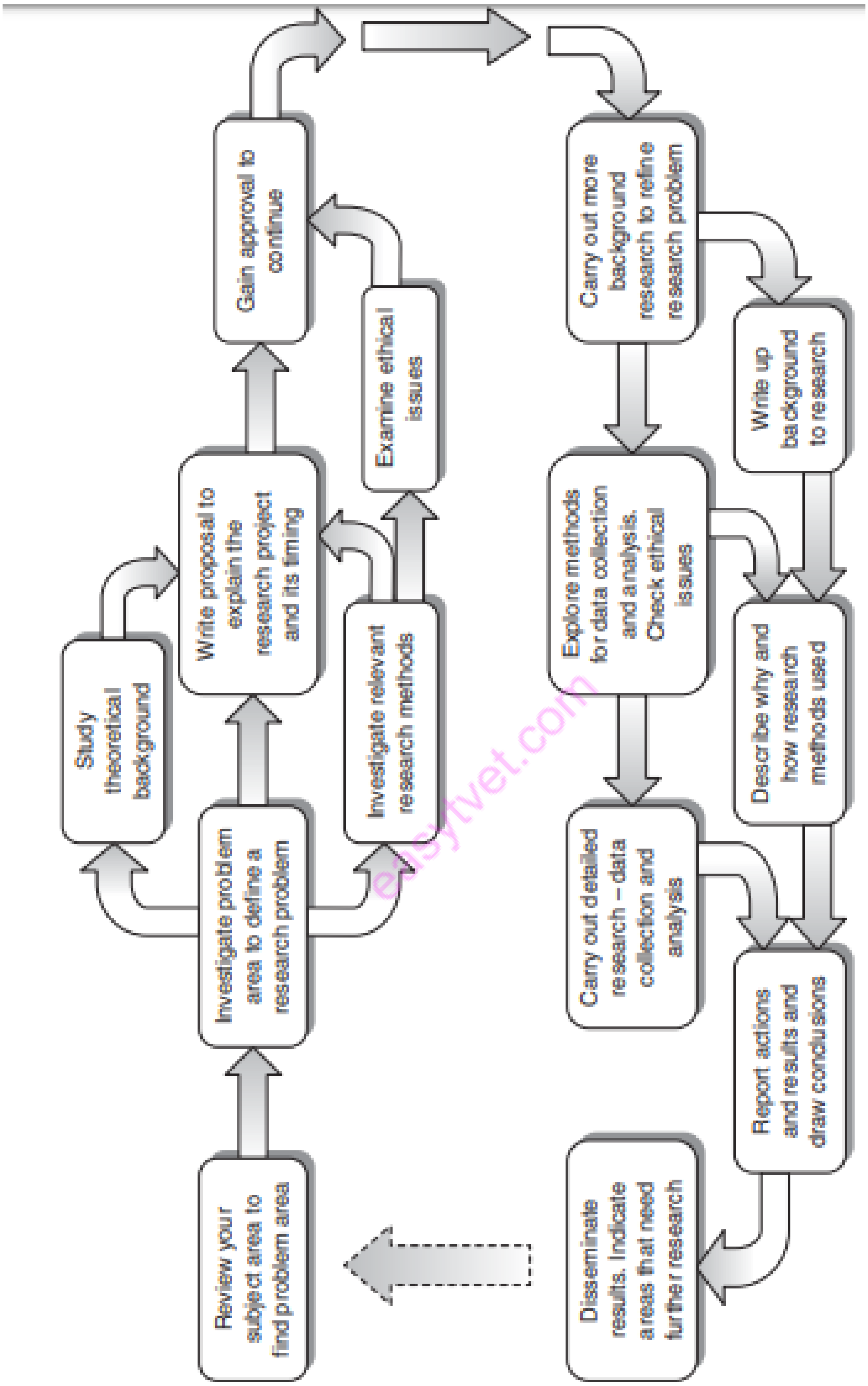
7. Frequency polygon

The frequency polygon is very similar to a histogram. A frequency polygon is drawn by joining the midpoint of each rectangle at a height commensurate with the frequency of that interval (Figure below). One problem in constructing a frequency polygon is what to do with the two categories at either extreme. To bring the polygon line back to the x-axis, imagine that the two extreme categories have an interval similar to the rest and assume the frequency in these categories to be zero. From the midpoint of these intervals, you extend the polygon line to meet the x-axis at both ends. A frequency polygon can be drawn using either absolute or proportionate frequencies.



Frequency polygon

In summary…..



Flow of a typical research process

7.3.5.3 Self-Assessment

1. Define a variable in reference to research
2. ____________________ is the variable that is representing the value being manipulated or changed.
   A. Independent variable
   B. Extraneous variable
   C. Dependent variable
   D. Confounding variable
3. In graphical method of data presentation the following tools are used (),Indicate true or false)
   A. Frequency distribution table
   B. Frequency polygon
   C. Frequency curve
   D. Histogram
4. The following are tools used to support data analysis
   A. Spreadsheet
   B. Statistical packages
   C. Qualitative data analysis tools
   D. MS Word
5. State the differences between an independent and a dependent variable
6. State three ways of data presentation
7. Define data analysis
8. Identify the steps through which raw data should be taken through before it is analyzed
9. Describe the factors that will lead to a research choosing one statistical software over others
10. Give a summary of conducting research methodology

7.3.4.4 Equipment, Materials and Resources

- Computer/laptop
- Research methods textbooks
- Stationery
- Data analysis software
- LCD projector
- Videos

7.3.5.5 References

Clarke, S. (2014). Introduction to research. An Introduction to Theory and Reasoning in Nursing: Fourth Edition, 226–259. https://doi.org/10.5005/jp/books/12430_2

Macdonald, S., & Headlam, N. (2011). Introductory guide to research methods for social research. Retrieved from www.cles.org.uk

Neville, C. (2007). Effective Learning Service: Introduction to Research and Research Methods. Bradford University School of Management, 1–44.

Cavaliere, R. (2015). How to choose the right statistical software? - A method increasing the post-purchase satisfaction. Journal of Thoracic Disease, 7(12), E585–E598. https://doi.org/10.3978/j.issn.2072-1439.2015.11.57

Mugenda & Mugenda (2003). Research Methods Quantitative and Qualitative Approaches. Nairobi: ACTS Press.

Walliman, N. (2010). Research Methods: The Basics. Research Methods: The Basics. https://doi.org/10.4324/9780203836071

7.3.6 Learning outcome 5: Preparation of reports and dissemination

7.3.6.1 Learning Activities

Learning Activity	Specific instructions
i) Do scientific writing of research document • Demonstrate ability to cite authors in research • Identify the areas of scientific dishonesty • Identify the report format • Prepare research report as per set standards • Observe ethics in research • Insert in text citations correctly	Present findings of the research Change the tense used in the proposal into past tense Determine and present research findings Use different formats of quoting research references Write a research project report
i) Do power point presentations • Conduct peer review of the research and publications	Prepare a power point presentation Ensure all the text is readable Avoid having text in less than 25 point font Avoid using more than two typefaces Limit the use of animations and other special effects Avoid using more than six lines per slide Use six words per line Use a light background with dark text Perform a power point presentation of research project

7.3.6.2 Information Sheet

Definitions

Ethics: These are the moral principle governing research.

Informed consent: Participants have adequate information regarding the research, are capable of comprehending the information and have the power of the free choice, enabling them to consent or to decline participation voluntarily.

Scientific research

Scientific research therefore relies on the application of the scientific methods for the purpose of satisfying curiosity or to correct previous knowledge as well as to come up with a solution concerning a particular problem within a topic of interest. Scientific research is funded by public authorities, by charitable organizations and by private groups, including many companies.

Citing authors in research

To avoid plagiarism in research projects, a researcher is required to acknowledge the sources of words, facts or ideas borrowed from other scholars. Most academic disciplines or professional bodies require special documentation formats or styles in research projects reports. Consequently; the style should be consistent with the requirements of each discipline.

In-text citations

The method of citing authors within the text varies with the format and the number of authors being cited.

Work by two authors:

Name both authors in the signal phrase or in the parentheses each time you cite the work. Use the word "and" between the authors' names.E.g (Gerald & Beatrice, 2010).

Work by Three to Five Authors:

All the authors in the signal phrase should be listed in the signal phrase or in the parentheses the first time you site the .E.g (Osteen, Myles, Jakes, Benny, & Copeland, 1993)

In subsequent citations, only use the first author's last name followed by "et al." in the signal phrase or in parentheses.E.g (Osteen et al., 1993).

Six or More Authors:

Use the first author's name followed by et al. in the signal phrase or in parentheses.

David et al. (2001) argued that malaria is common……………….

(David et al., 2001).

Two or More Works in the Same Parentheses:

When your parenthetical citation includes two or more works, order them the same way they appear in the reference list, separated by a semi-colon.

(David , 2002; Faith, 1983)

Authors with the Same Last Name:

To avoid confusion, use first initials with the last names.

(E.Joel, 2001; L. Robert, 1998).

American Psychological Association (APA) format.

This is the most commonly used to cite sources within the field of social sciences, psychology and education.

In-Text Citations in APA Format

When citing references in the text of a paper, the author's name should be used followed by the date of publication. E.g. (Eriksson, 2000)

Reference Page in APA Format

- All references should begin on a new page that will be titled "References" and center the title text at the top of the page.
- All entries should be in alphabetical order
- The first line of a reference should be flush with the left margin. Each additional line should be indented (usually accomplished by using the TAB key.)
- Each reference should be single-spaced, though double spacing should be used between the references.
- All sources cited should appear both in-text and on the reference page. Any reference that appears in the text of your report or article must be cited on the references page, and any item appearing on your reference page must be also included somewhere in the body of your text.
- Titles of books, journals, magazines, and newspapers should appear in italics. Below is an example of a reference page using the APA format:

References

[1] Bremen, J. (2001). The ears of hippopotamus: manifestation, determinants, and estimates of malaria burden. Am. J. Trop. Med. Hyg. 64 (1, 2) S, 1-11

[2] Charlwood, J. D. Kihonda, J. Sama, S. Billingsley, P.F., Hadji, H. Verhave, J.P. Lyimo, E. Luttikhuizen, P.C. Smith, T. (1995). The rise and fall of Anopheles arabiensis (Diptera: Culicidae) in a Tanzanian village. Bulletin of Entomological Research, 85:37-44.

[3] Detinova, T.S. (1962) Age-grouping methods in Diptera of medical importance with special reference to some vectors of malaria. WHO monograph series 47, Geneva?

[4] Frevert, U. (1993). Malaria circumsporozoites protein binds to heparin sulphate

proteoglycans associated with the surface membrane hepatocytes. J. Exp. Med. 177: 1287-1298.

MLA (Modern Language Association) format

MLA citation style refers to the rules that were established by the Modern Language Association for acknowledging the sources used in a research paper. MLA citation style uses a simple two-part parenthetical documentation system for citing sources: In-text citations of a paper are used to point to an alphabetical works cited list that appears at the end of the paper. Together, these references identify and credit the sources used in the paper and allow others to access and retrieve this material. The general rules of the MLA format include:

- Leave one inch margins all around the text of the paper (left side, right side, top and bottom) except for page numbers.

  -The research paper should be double spaced.
- The research paper does not need a title page. At the top of the first page, at the left-hand margin, type your name, your instructor's name, the course name and number, and the date all on separate, double-spaced lines.
- Number your pages consecutively throughout the manuscript (including the first page) in the upper right-hand corner of each page, one-half inch from the top. Type your last name before the page number.
- Tables should be labeled "Table," given an Arabic numeral, and captioned (with those words flush to the left-hand margin). Other material such as photographs, images, charts, and line-drawings should be labeled "Figure" and be properly numbered and captioned.

Areas of scientific dishonesty

1. Plagiarism

Plagiarism is defined in dictionaries as "the wrongful appropriation, close imitation, or purloining and publication, of another author's language, thoughts, ideas, or expressions, and the representation of them as one's own original work. Understanding plagiarism helps us to know how to go about sharing information and writing scientific paper since knowledge is generated from knowledge. The problem of plagiarism is on the increase especially in learning institutions. The consequences may vary depending on the nature of the offence and the number of time one commits the offence. In learning institute The problem of plagiarism is on the increase especially in learning institutions. The consequences may include disqualification of the entire work, getting a lower grade, loss of reputation, academic probation and even expulsion from the learning institution. As a student is expelled from one institution, they may find it hard to get admission into another institution. To avoid plagiarism the person making the statement, presenting their view etc. in the book or publication must be referenced next to the extract from the book, or in a footnote at the bottom of the page on which the extract exists.

Paraphrasing: Involves putting a passage from source material into your own words. A paraphrase must also be attributed to the original source. Paraphrased material is usually shorter than the original passage, taking a somewhat broader segment of the source and condensing it slightly.

Quotations: Must be identical to the original, using a narrow segment of the source. They must match the source document word for word and must be attributed to the original author.

Summarizing: Involves putting the main idea(s) into your own words, including only the main point(s). Once again, it is necessary to attribute summarized ideas to the original source. Summaries are significantly shorter than the original and take a broad overview of the source material.

2. Fabrication

This is the publication of intentional (deliberate) or misleading research for one purpose or the other. It is subdivided into three:

Obfuscation: This refers to the use of jargon (difficult words or terms) so as to make something difficult to understand. Doctors may use obfuscation to conceal some information from patients. Obfuscation is also used to prevent work from being duplicated (e.g. soft wares).

Base rate fallacy: Using weak evidence to make a probability judgment without taking into account known empirical statistics about the probability.

Falsifications: This refers to the act of making a false statement concerning a particular thing or mispresentation of results.

3. Poor data storage and retention

Data collected during the process of research need to be kept safely and with due regards to issues of confidentiality and anonymity. Information on video tapes, auto tapes, Cds, DVDs should be stored in fireproof lockable cabinets. Data kept electronically should be password protected. It should also be protected from any computer virus or Trojan.

4. Non publication of data

This involves not including data in your research paper because it does not support your hypothesis. Researchers may be tempted to do this especially if there is funding involved. Non publication of data is also referred to as suppression. Examples include failure to publish information if the information states that the disease being researched is no longer a threat in the community or the drug the researcher intends to use is harmful.

5. Faulty data gathering.

This can Faulty data gathering in research will automatically result to bias in the research findings are as a result of collecting data from subjects (participants) who are not meeting the objectives of the research. It can also result from the malfunctioning of the instruments being used to collect data e.g. rulers, weighing scale, tape measure e.t.c.Others include inappropriate treatment of the research subjects and recording data incorrectly.

6. Misleading authorship.

Authorship credit is determined by the contributions of the researchers towards the research paper. Meaning the person who comes up with the research idea automatically becomes the first author. This has to be decided before the research is started. Authorship should include only those who directly contributed to the research. This means that technicians who may have helped in data collection or anyone else should not be included as an author

Research involving human subjects

Ethical considerations have to be put in mind especially if the research is involving human subjects. There are several ethical issues that must be considered when designing research that will utilize participants who are human beings.

- The investigator should be primarily concerned with the safety of the subject (participant). Meaning; the interest of the researcher should not outweigh the wellbeing of the subject. This can be achieved by carefully considering the risk/benefit ratio. The investigator must therefore do a through research concerning what he intends to study.
- The investigator must obtain informed consent from each person participating in the research. This should be obtained in writing but at times oral consents are sometimes acceptable. After the participant has had the opportunity to carefully consider the risks and benefits and to ask any questions. Informed consent should be seen as an ongoing process. It is the duty of the investigator to first inform the subject on what the research is all about before they (participants) give the consent.
- The investigator must consider the privacy and confidentiality concerns will be approached. Researchers must be sensitive to know only how information is protected from unauthorized observation, but also if and how participants are to be notified of any unforeseen findings from the research that they may or may not want to know.
- The investigator must consider how adverse events will be handled; they must ensure that there is a qualified person who will provide care incase there are adverse effects (e.g. injuries or reaction to the treatment) on the research subjects. In addition, before enrolling participants in an experimental trial, the investigator should be in a state of "equipoise," that is, if a new intervention is being tested against the currently accepted treatment, the investigator should be genuinely uncertain which approach is superior. In other words, a true null hypothesis should exist at the onset regarding the outcome of the trial.

Principles of research in human subjects.

1. The principle of autonomy.

Autonomy refers to the ability of a person to self determine what they want. The subject should be at free will to decide if they want to be part of the research or not. They are also at free will to withdraw from the research if they so wish. A researcher should therefore respect the principle of autonomy.

2. The principle of beneficence.

The principle of beneficence stands for the proposition that it is the physician's duty to do good for his patient. This is certainly a foundational principle of medical practice finding its roots in Hippocrates. For centuries, beneficence was actualized through the process of the patient presenting himself to the physician for examination and inquiry and then following the advice of the physician. In recent decades, societal needs for self determination have sometimes brought this principle into conflict with autonomy.

3. The principle of non- maleficence.

Non-maleficence means to "do no harm." Physicians must refrain from providing ineffective treatments or acting with malice toward patients. This principle means that harm to the patient should not be done in the first place, hence prevention is better than cure.

4. The principle of justice

Study participants have a right to fair and equal treatment before, during and after their participation in the study.

Scientific writing of research document;

- All the content in proposal should be changed to past tense
- Chapter Four; and Five should be included containing research findings and discussions, conclusions and recommendations respectively
- It is the report which communicates properly and result to changes

REPORT WRITING

Report writing is an essential skill for professionals in almost every field. A report aims to inform, authority within the stipulated period. Report helps to know what has been done , why it was done how it was done , what result was obtained & what conclusion.

Features of a report

- It should be accurate & written in simple language
- It is Complete and Self-explanatory
- It is Comprehensive but Compact
- It has a Proper Date and Signature
- A good report should be able to sustain reader's interest

PROJECT PROPOSAL AND REPORT GUIDELINES

General considerations.

Length spacing and font size

One and a half line spacing and a standard font size of 12 should be used for the text and front matter materials except for the title page where different lien spacing and fonts may be used. Times New Roman font should be used.

Pagination.

The preliminary pages of a research project should be paginated appropriately with small roman numbers at the bottom center of the page i.e. i, ii, iii, IV

Format

COVER PAGE/TITLE PAGE (contain information related to title, name of the student, year, month of submission &afiliation)

The cover page should appear as below.

Title

Name of the student……………………Reg No……………………………………

Signature……………………………..Date……………………………………………

Name of the supervisor……………………………………………………………

Signature……………………………..Date……………………………………………

A project proposal/report submitted in partial fulfillment for the award of a diploma/ certificate in………….(state your course) of Thika School of Medical and Health Sciences in the department of…………

Year………..

Declaration

This page contains the students' declaration of the originality of the work and approved by the supervisor.

This project/report is my original work and has not been presented previously for the award of any academic qualification in another institution.

Name of the student……………………Reg No………………………………………..

Signature………………………………..Date……………………………………………

Name of the supervisor…………………………………………………………………

Signature………………………………..Date……………………………………………..

ABSTRACT

This is a brief summary of the entire proposal/project

ACRONYMS AND ABBREVIATIONS

Acknowledgement (it indicate the name of person, institutions & organisations who have sanctioned & help in various in conduct of research & preparation of report in various ways)

Dedication

TABLE OF CONTENTS

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

1.2 Problem statement.

1.3 Justification.

1.4 Research questions/hypothesis.

1.5 Objectives.

1.6 Significance.

1.7 Limitations and delimitations.

CHAPTER TWO

2.0 Literature review

CHAPTER THREE

3.0 METHODOLOGY

3.1 Research design.

3.2 Location of the study.

3.3 Target population.

3.4 Sampling procedure.

3.5 Data collection techniques.

3.6 Ethical considerations

CHAPTER FOUR (only in the report)

4.0 Data analysis and presentation

CHAPTER FIVE (only in the report)

5.0 Discussion.

5.1 Conclusion

5.2 Recommendations

Work plan

Budget

References

Preparation of Power point presentations and peer reviewed publications

The presentations should be no more than 10 minutes long. Plan on needing about 1 minute per slide. The trick to giving good presentations is distilling your information down into a few bulleted lists, diagrams, tables and graphs.

- Title slide (1 slide). Title of the research project, candidate's name and number.
- Introduction (typically 3-4 slides). Explain why your work is interesting. Place the study in context – how does it relate to / follow from the scientific literature on this subject. If it relates to any applied issues (e.g., environmental problems), mention this here. Use some pretty visuals (photographs, drawings, etc.) to get the audience excited about the issue and questions you are addressing. Clearly state your hypotheses.
- Materials and Methods (typically 2-3 slides). Clearly summarize the design. Show any pictures you may have taken during the research work. Mention what parameters you measured but do not go into detail on exact procedures used. Do state what statistical tests you used to analyze your data.
- Results (typically 2-4 slides). First show a photograph (or sketch) that shows an interesting qualitative results and state that result. Then display the results in graphical form, reminding the audience of your hypothesis and stating whether it was supported as you do so.

- Use simple, clean, clearly labeled graphs with proper axis.Do not use light colors (yellow, light green, or pink) in your figures, they do not show up well when projected. Indicate the results of the statistical tests on the slides by including p-values (or asterisks/letters that indicate the significance level) on the same slides with the graphs.If you have multiple results, state them in a logical order.
- Implications and Conclusions (typically 2-3 slides). Correctly interpret your results. Constructively address sources of error and methodological difficulties. Place your results in context and draw implications from them.
- Acknowledgments (1 slide). Thank anyone who provided advice or assistance. Verbally thank your audience for their attention and tell them you would be happy to answer any questions.

Tips for presenting data in power point

- All text should be readable

Presentation design

– Don't overload your slides with too much text or data.

– FOCUS. In general, using a few powerful slides is key.

– Give slides a title.

– Proofread everything.

– Keep similar topics together

– Keep slides simple

Visual elements

– 28 to 34 bold font (Arial is easiest)

– Use clear, simple visuals. Don't confuse the audience.

– Use contrast: light on dark or dark on light.

– Graphics should make a key concept clearer.

– Place your graphics in a similar location within each screen.

Charts

– Charts need to be clearly labeled.

– Numbers in tables are both hard to see and to understand. Be creative!

How to do a good power point presentation

Practice your presentation. It will be obvious if you don't.

Don't attempt to memorize your text; your words will probably be different each time you practice. Use index cards as supplements.

Think about the ideas, and your words will follow naturally.

Data dissemination

Effective dissemination should create informed users (the center block in the decision framework), who can then make informed decisions that ultimately lead to improved health.

The goal of dissemination is to provide accurate and up-to-date information for evidence-based decision-making. Evidence-based decisions lead to better programs and, ideally, better health outcomes.

Purpose of Dissemination

Disseminating data can help potential users by providing them with information to;

- Understand current health status
- reach decisions based on quality data
- make changes to existing health programs and policies
- take other actions to improve health outcomes.

Planning for dissemination

Print materials are the most common way to disseminate results. If funding permits, however, it is helpful to use other kinds of materials in addition. For example, some projects prepare PowerPoint presentations of findings and makes those presentations available in the country. The more ways in which information is made available, the more likely that information is to reach a wide audience and be used.

Videos are an effective way to disseminate survey findings because they can include visuals of the country and interviews with women and men. This helps give survey data a human face and makes the information more compelling. However, video production can be expensive and time-consuming.

Dissemination materials are most useful if they draw conclusions, summarize major points, and highlight key ideas. This lets the materials do most of the work for the user. It may also be better to leave out some of the results in order to make sure that the major points stand out. This is better than flooding people with so much information that they feel overwhelmed and cannot absorb it.

A good way to present information is to categorize it by characteristics, such as wealth, education, province, and region.

Maps are particularly persuasive and easy to understand. They are more compelling than words because they present geographic differences so clearly.

Other graphics—including bar graphs, line graphs, and pie charts—allow the eye to grasp large amounts of information and to see trends more easily than in written text or tables.

Dissemination plan

Developing a dissemination plan is a key part of the collaborative research planning process. Although the decision makers and researchers working together won't know the results of the research until it's completed, working through an initial dissemination plan can help your team focus the project and identify key audiences. When the research results come in, you'll be ready to flesh out key messages, review and finalize the plan, and then implement it.

Components of a dissemination plan

The following is a list of some of the key elements that should be included in a dissemination plan. While this is not a detailed guide to developing a dissemination plan, it provides a good overview of some of the most critical things that should be considered.

1.Project overview

Describe the current environment or context that provides the impetus for the research being

Undertaken — what is your research aiming to clarify or change? Who is or should be interested in the results?

Briefly sketch out the research project and its objectives. How will it address the context or challenges you have identified?

2.Dissemination goals

What are you hoping to achieve by disseminating this research? You may have a single long-term goal, such as a change in a policy, practice, or even culture, but make sure to also include any supporting or shorter-term goals.

3.Target audiences

These are the groups you want to reach with your research results — and who you will target in your dissemination activities. Be as specific as you can — who are the people who can use this research?

You may want to divide your list into primary audiences (more important) and secondary audiences (less important) and allocate dissemination efforts according to audience importance.

4.Key messages

In your first stab at a dissemination plan, you won't be able to develop specific key messages because you won't know the results of your research project. However, you can plan broadly around what you anticipate the content will be.

Effective messages explain what your research results mean, why they are important, and what action should be taken as a result. They are not simply a summary of the results. Note the wider context if applicable — how the results fit with the body of related research on the topic.

Make messages clear, simple, and action-oriented. The style and content should be tailored for each audience. Messages should be based on what that audience wants to know, rather than on what you think it should hear.

5.Sources/messengers

Since using influential spokespersons to spread your messages can help ensure uptake of your research results, identify the people or organizations that are viewed as credible with each of your target audiences.

Then think about how you can get those people and organizations "on board" — maybe you can partner with them in a workshop, or ask them to include an article about your research results on their web site or in their newsletter.

6.Dissemination activities, tools, timing, and responsibilities

This is the meat of your dissemination plan. Here you describe the activities (such as briefings or presentations) you will undertake to reach each target audience, and the tools (such as printed materials or web sites) that will support these activities. You also set out timing (what you will do first and when you will do it) and assign responsibilities to team members.

Successful dissemination activities go beyond traditional vehicles such as publication in scholarly journals — look for activities that promote a two-way dialogue, not a one-way flow of information.

Face-to-face meetings or briefings are a very effective way to reach decision makers.

Make each member of your collaborative research team responsible for carrying out at least one dissemination activity, and schedule meetings to report back and ensure commitments are being met.

A good dissemination plan will have activities that reach each of your target audiences, taking into account their attitudes, habits, and preferences.

7.Budget

Time and budget requirements for dissemination are frequently underestimated. Effective dissemination involves resources and planning — think about travel, layout and printing, translation, equipment, and space rental costs when allocating a budget for dissemination activities. Don't forget to include resources the individual(s) will need to do the future planning and co-ordination of the activities you have identified!

8.Evaluation

Evaluation is most effective when it is built in from the start. Decide how you will evaluate the success of your team's dissemination efforts, selecting measurable criteria for each dissemination activity. Focus less on efforts (how much you did) and more on outcomes (what was the result).

7.3.6.3 Self-Assessment

1. The following are the categories of citing authors within the text based on the number of authors being cited (write true/false for each answer)

   A. In-text citations

   B. Work by two authors

   C. Work by six or more authors

   D. Work by three to five authors

2. Plagiarism in research writing can be avoided through the following ways except?

   A. Fabrication

   B. Quotations

   C. Summarizing

   D. Paraphrasing

3. ________________________ refers to the use of jargon (difficult words or terms) so as to make something difficult to understand.

   A. Base Rate Fallacy

   B. Falsification

   C. Fabrication

   D. Obfuscation

4. Explain qualities of a good power point presentation
5. Describe how to go about proper publication in research
6. Explain the contents of the informed consent form
7. Discuss the consequences of plagiarism in research writing
8. Explain the different areas of dishonesty in research
9. Discuss the components of a dissemination plan

7.3.6.4 Tools, Equipment, Supplies and Materials

- Research methods textbooks
- LCD projector
- Stationery
- Videos
- Computer/laptops
- Sample research project report

7.3.6.5 References

Cavaliere, R. (2015). How to choose the right statistical software? - A method increasing the post-purchase satisfaction. Journal of Thoracic Disease, 7(12), E585–E598. https://doi.org/10.3978/j.issn.2072-1439.2015.11.57

Clarke, S. (2014). Introduction to research. An Introduction to Theory and Reasoning in Nursing: Fourth Edition, 226–259. https://doi.org/10.5005/jp/books/12430_2

Canadian Health Services Research Foundation. Developing a Dissemination Plan. Available at: http://www.chsrf.ca/knowledge_transfer/pdf/dissemination_plan_f.pdf

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Macdonald, S., & Headlam, N. (2011). Introductory guide to research methods for social research. Retrieved from www.cles.org.uk

Neville, C. (2007). Effective Learning Service: Introduction to Research and Research Methods. Bradford University School of Management, 1–44.

Mugenda & Mugenda (2003). Research Methods Quantitative and Qualitative Approaches. Nairobi: ACTS Press.

Walliman, N. (2010). Research Methods: The Basics. Research Methods: The Basics. https://doi.org/10.4324/9780203836071

CHAPTER 8:

NUTRITION IN EMERGENCY

8.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to apply nutrition in emergency. It involves conducting rapid assessment on the nutrition situation, selecting food and nutrition emergency responses and plan, providing nutrition and health interventions and monitoring implementation of interventions

8.2 Performance Standard

By the end of this unit of learning/competency, the trainee should demonstrate ability to carry out rapid assessment commensurable with workplace procedures; select food and nutrition emergency response as per WHO guidelines and nutrition situation; provide nutrition and health interventions during emergency situations based on patient's nutritional needs and workplace procedures and monitor implementation/outcomes of intervention through re-assessments in line with client's requirements.

8.3 Learning Outcomes

8.3.1 List of Learning Outcomes

1. Conduct rapid assessment on the nutrition situation
2. Select food and nutrition emergency responses and plan
3. Provide nutrition and health interventions
4. Monitor implementation of interventions
5. Document nutritional intervention during emergencies

8.3.2 Learning Outcome 1: Conduct rapid assessment on the nutrition situation

8.3.2.1 Learning Activities

Leaning activity.	Special instructions.
1. Carry out anthropometric assessment • Mid upper arm circumference (MUAC) • Height/length • Weight	• Identify the appropriate materials/ equipment • Assess MUAC • Take weight and measure length/height

2. Carry out physical and clinical assessment	• Observe clinical features • Document observations
3. Document nutrition condition	• Determine the number of people affected by an emergency • Describe how well the affected population is coping • Triangulate collected information • Record outcomes • Maintain documents

8.3.2.2 Information Sheet

Definitions

- **Nutritional assessment**; the process followed when determining and individual's nutritional status; through collecting and analysing anthropometric, biochemical, clinical and dietary data
- **Rapid assessment and response** is a way of making a comprehensive assessment of a specific public health issue
- **Emergency**: They are unusual event that occur and are not part of normal life.
- **Nutrition in emergency:** the process of providing or obtaining the food necessary for health and growth of the vulnerable groups of people e.g.refugees, people affected by natural calamities
- **Complex emergency** is an internal crisis in the state where the capacity to sustain livelihood and life is threatened by primarily political factors and, in particular, high levels of violence
- **Mid upper arm circumference (MUAC):** the circumference of the left upper arm measured at the midpoint between the tip of the shoulder and the elbow tip.
- **Body mass index (BMI)**: a person's weight in kilograms (kg) divided by his or her height in meters squared. Used to compare a person's weight and their height.
- **Client** : any individual child/adult who is under any form of management for malnutrition
- **Disaster**: a serious disruption of the functioning of a society causing widespread human material or environmental losses which exceeds the ability of the affected society to cope with its own resources

Types of Disasters

- **Natural disasters**: They are normally of sudden impact or slow onset. The sudden ones occur due to natural causes like earth quake, tropical storm, floods, and volcanic eruptions. The slow onsets are like drought, famine, pest infection, deforestation. Epidemic diseases e.g. waterborne vector borne diseases like Cholera.

- **Man-made disasters:** mainly occurs due to human errors and sometimes are of industrial origin e.g. fires, pollution, explosion and spillages.
- **Complex emergencies** : this includes wars, civil strike and armed aggression due to political issues or condition

Introduction

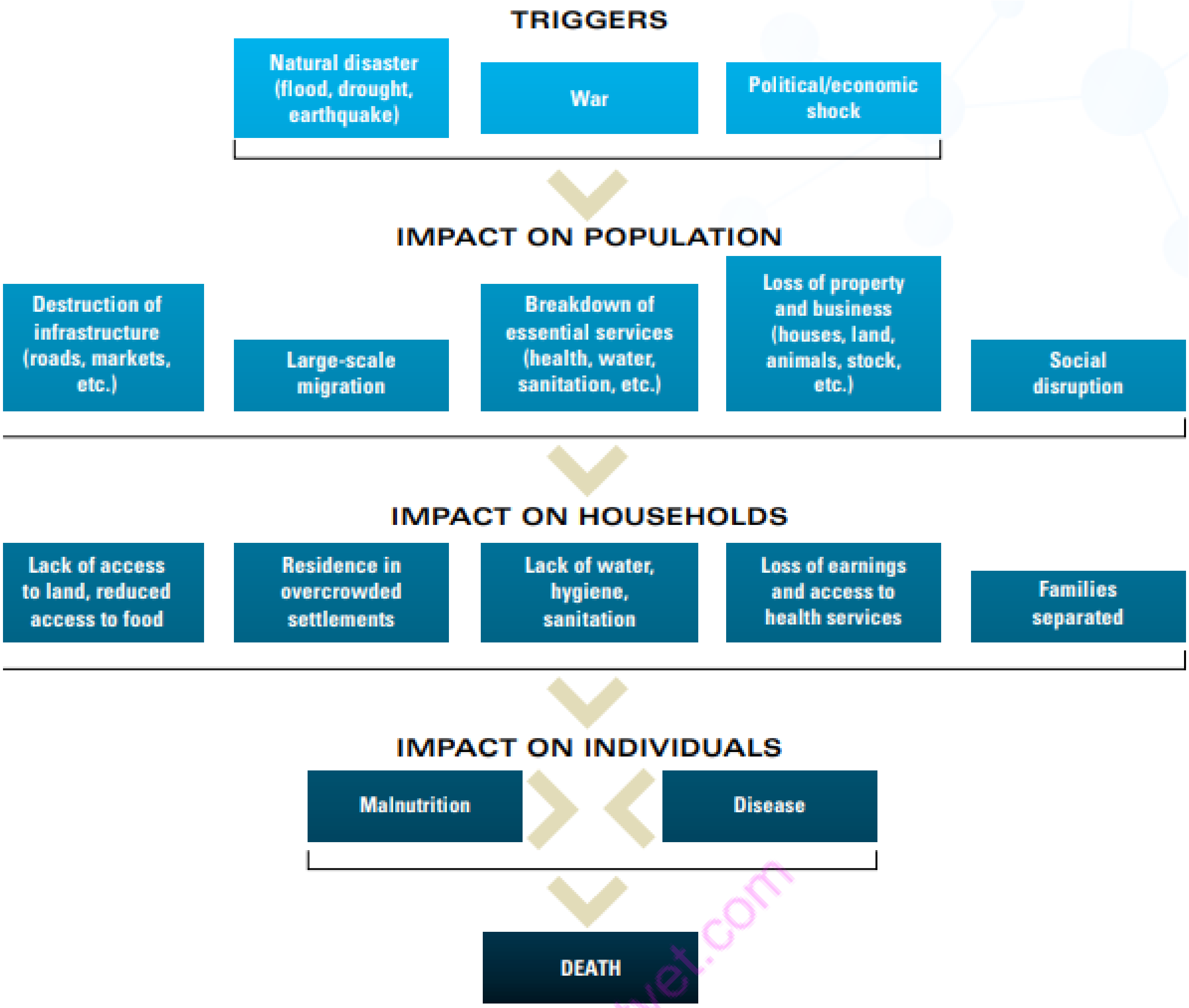
Disasters disrupt normal life for communities and individuals. This includes food access and feeding behaviour and so affects their nutritional status. This situation puts many people at risk of malnutrition. In some instances where populations depended on food assistance, it is imperative to provide an adequate food ration so as to meet the minimum energy, protein and fat requirements for survival and light physical activity among the population. This is because multiple forms of malnutrition such as: wasting, severe stunting, micronutrient deficiencies, obesity are usually reported in the context of crisis. Nutrition care in emergency becomes necessary in such circumstances to treat malnutrition and prevent those at risk from suffering from malnutrition.

Triggers of Nutrition emergencies

- Political instability & crises
- HIV & AIDs
- Poverty and urban pressure of marginalised populations
- Natural disasters emanating from unpredictable climate changes e.g. drought, flooding, storms, global warming and insect infestation
- Existing health and nutrition situation
- Conflict situations
- Global food prices fluctuations
- Severe shortages of food combined with disease epidemics.
- Poor infrastructure
- Chronic food insecurity
- Economic shocks

Impact of Nutrition emergencies on nutrition status

Emergencies have an impact on a range of factors that can increase the risk of malnutrition, illness (morbidity) and death (mortality) (see Figure). Emergencies can be a critical moment, revealing and exacerbating underlying pre-existing nutrition concerns. If a population has a quite good nutritional status just before an emergency, it is important to protect this through suitable responses as it can worsen during the emergency. Populations that have a poor nutritional status at the onset of an emergency are usually more vulnerable to widespread nutritional crises as a result of an emergency



Impact of an emergency on Nutrition Status

Vulnerable groups in nutrition emergencies

The most vulnerable people within a population include young children, the old, chronically ill, disabled, pregnant and lactating women.

Different population groups usually experiences different categories of nutritional vulnerability according to their;

- **Physiological vulnerability**: caused by;
    - o High nutrient requirement among vulnerable groups
    - o Reduced appetite and ability to feed e.g. geriatrics, people living with disability, chronically ill
    - o **Children- under five years** children are vulnerable as their nutrient requirements are high to support growth and development.
    - o **Low birth weight babies-** their requirements are high for catch up growth.
    - o **0-24-month-old children-** their growth rate is high thus they require a lot of nutrients for both growth and development
    - o **Lactating and pregnant mothers** are physiologically compromised with high nutritional requirements and the work output to generate food is low.

- o **Elderly, disabled and people with chronic illness** have low productivity and the condition calls for dependency on other people services including getting food and even consuming it. In some cases resources are diverted to medical bills.

- **Geographical vulnerability-** people living in areas where they are exposed to food and nutrition insecurity e.g. populations living in drought or flood or conflict prone areas
- **Political vulnerability-** This vulnerability occurs due to political related instabilities for example the post-election violence. In most case these lead to displaced populations' and refugee status e.g. people who are oppressed
- Internal displacement and refugee status
- Socio-economic vulnerability: those who limited source of livelihoods e.g. the por. In emergencies the poorest households are mostly vulnerable

Emergency needs assessment

Rapid assessment during nutrition emergency

In any emergency response the first step is usually to assess the extent and impact of the damage caused by the disaster and the capacity of the affected population to meet its immediate survival needs.

Local assessment includes assessment of household livelihoods, food security, safe drinking water supply, sanitation, health care and child feeding practices, the latter as part of a nutrition survey if data are unavailable

Local food and nutrition assessment plays the following role:

- To determine the existence of an emergency food and nutrition problem, including the cause(s) and the magnitude of the emergency
- To offer recommendations for a course of action to reduce or prevent a food and nutrition emergency by considering the available data and field observations;
- To communicate this information to the concerned decision makers and government authorities, both local and national;
- To assess local capacity and the capacity of other organisations such as Non-Governmental Organizations (NGOs) and UN agencies to respond.

The survey report should present the acute malnutrition rate, the severe acute malnutrition rate and the prevalence of kwashiorkor in order to discuss the real situation about household food security, public health, child feeding practices and humanitarian assistance based on the information collected during the local field assessment. The findings should be communicated as soon as possible to both local and national authorities.

Assessments can take the following forms:

i) *Rapid assessment*: carried out immediately after a disaster in order to provides information on needs, possible courses of action and resource requirements. It normally takes up to a week.

ii) *Detailed assessment*: carried out after a rapid assessment and is a more detailed assessment. It checks if the situation is changing and to find out if more information is needed. It takes about one month, depending on the size of the area and the complexity of the situation.

iii) *Continual assessment*: Emergency situations can evolve rapidly and include unexpected knock-on effects, such as population movements. Assessment should therefore be an ongoing process throughout the emergency phase.

Rapid assessment during nutrition emergency

- Rapid assessment involves focusing on the characteristics of the health problem, the population groups affected, key settings and contexts, health and risk behaviour and social consequences. Through rapid assessment, existing resources and opportunities for intervention are identified which helps in planning, developing and implementing interventions and programmes as a result. This method is used when information is needed urgently. It is helpful when there is limited accessibility to populations and assessments need to be urgent.

Type of data to collect during rapid assessment

- The type of information to be collected should be related to (Table below):
- Access and security – How are the communication networks of the area? How safe the area is from secondary disasters e.g. fires, chemical spills etc.
- Population affected – Number of affected, gender ratio, age, vulnerable groups, total population, displaced etc.
- Community resources – Infrastructure affected (Hospitals, Schools, drainage system, skilled persons availability, Disaster plans, evacuation plans/centers available/how much effective, Early warning system available/affected, means of communication etc.
- Health – Medical facilities, health infrastructure, diseases, pregnant women/child health
- Water – Sanitation system, water storage facilities, water testing & distribution systems,
- Food and non-food items – Food supply available, cooking facility, equipment, fuel etc.
- Shelters – how much required, capacity in the area? How fast can it become available?

Rapid assessment checklist

1. Security and access • Route(s) to the location • Damage severity • Road accessibility, building collapse • Secondary disaster; chemical disaster. Fire • Pipeline damage: gas, water, sewage • Ongoing safety and security concerns • Weather conditions • Phone/internet connectivity	8. Water • Water sources • Water distribution system • Water storage • Distance from homes to water source • Water testing system

2. Population affected
• Population before disaster
• Number of population displaced
• Estimated sex ratio
• Vulnerable groups with special needs
  • Dialysis patients, oxygen-dependent patients, immobile elderly, unaccompanied minors, pregnant women, etc.
	9. Sanitation
	• Toilet facilities
	  • Types
	  • Numbers
	  • Location (distance from shelter/housing)
	  • Lights, locks
	  • Maintenance
	  • Menstrual hygiene material
	• Sanitation
	  • Lavatories, buckets, warm water, shower
	  • Privacy in bathing/washing spaces

3. Community resources
• Community disinter infrastructure
  • Emergency warning system
  • Community disasters plan and drills
  • Pre-designated shelters
• Means of transportation
• Means of communication
  • Mobile phones, landlines, internet, television, radio
	10. Food and Non-food items
	• Food supply and calories intake
	• Cooking (self-preparation, communal kitchen)
	• Food sources, staples, and food storage methods
	• Essential items for daily living
	  • Electricity, gas and gasoline supplies
	  • Water containers, blankets, bedding/mattresses, soaps, cooking tools and equipment (e.g. utensils, stoves, etc.), lighting, heating/air-conditioning equipment.

4. (to 7) Mortality and health Impact • Mortality (crude mortality rate, under 5 mortality rate) • Main diseases and morbidity • Damage and impact to medical facilities, staff, and supplies • Public health infrastructure (surveillance, immunization) • Child health • Damage to emergency medical services • Reproductive health (emergency obstetric care, prevention of sexual violence).	11. Shelter (including temporary housing) • Status and need for temporary shelters • Number of shelters and each capacity • Covered area • Availability of partitions (family-based or for different sex).

Sources and Methods of Data collection

- Reports from first responders, relief workers, media and government announcements
- Existing official records, national census and maps
- The affected population
- Other relief teams
- Key informant interviews e.g. Officials at the local city hall, community leaders, public health centres, providers at hospitals, and other responders
- Methods include aerial survey of the affected area, direct observations

In the process, the assessor should focus on the following 5 key points.

1. Assessment of the general layout of the affected area
2. Estimation of the number of affected people and local infrastructures and resource
3. Living conditions, water supply, sanitation, food supply, health and healthcare services, as well as level of insecurity
4. The extent to which "normal life" and social structure have been disrupted
5. How well the affected population is coping

Shortcoming of rapid assessment

- Speed is more prioritized than data accuracy hence high chances of data compromise
- Biasness in the information obtained: Not in depth, for complete information detailed study must be done.
- Difficulties in assessing some areas due to insecurity and inaccessibility issues
- Dilemma of whether to continue with assessment or attend to people with need of assistance.

Things to Consider Before Conducting a Rapid Assessment

- Assessment team to comprise of disaster experts, staff familiar with the local area, and relevant specialists such as public health, epidemiology, logistics, etc.), who fully understand the sphere standards
- Decision on comprehensive assignment of each team
- Plan to complete the survey within a maximum of three (3) days
- Information on local
- Information about local health concerns, security, safety, and communication infrastructure is very vital for logistics

- Materials for rapid assessment need to be gathered beforehand (food, water, fuel, tent/ sleeping bags, climate appropriate clothing, compass, maps, list of contacts, camera, flashlight, backpack, batteries, chargers/adapters, communication devices, data entry supplies such a calculator, pens, paper, iphone etc)

8.3.2.3 Self-Assessment

1. Explain the types of nutrition assessment conducted in emergencies
2. List five causes of emergencies
3. Outline the aims of nutrition in emergencies
4. Explain the factors that influence nutrition in emergencies
5. ______a serious disruption of the functioning of a society causing widespread human material or environmental losses which exceeds the ability of the affected society to cope with its own resources
   A. Emergency
   B. Disaster
   C. Nutrition Problem
   D. Crisis
6. Which one of the following is a man-made disaster?
   A. Earth Quake
   B. Floods
   C. Pollution
   D. Volcanic Eruptions
7. Which one of the following is a type of geographical vulnerability?
   A. Low birth weight babies
   B. The oppressed
   C. Populations living in drought or flood or conflict prone areas
   D. The poor
8. Which of the following is not a type of physiological vulnerability?
   A. Children- under five years
   B. Low birth weight babies
   C. Poor people
   D. Lactating and pregnant mothers

9. Which one of the following is NOT a trigger of nutrition emergencies
   A. Political instability & crises
   B. War
   C. Poverty
   D. Natural disasters

8.3.2.4 Tools, equipment, materials and supplies

- Nutrition guidelines
- Rapid assessment checklist
- Rapid assessment form
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

8.3.2.5 References

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8.3.3 Learning Outcome 2: Select food and nutrition emergency responses and plan

8.3.3.1 Learning Activities

Leaning activity.	Special instructions.
1. Determine nutrition status as per client history • Review anthropometric assessment	➢ Interpret nutritional assessment data ➢ Identify individuals at risk of malnutrition ➢ Use standard methods to conduct a population survey to assess acute and severe malnutrition ➢ select appropriate indicators ➢ utilize the appropriate reference standards when comparing measurements ➢ Document findings
2. Design therapeutic feeding program • Review types of feeding programmes	➢ Calculate the energy requirements of the population ➢ identify commodities that meet the energy, protein, fat and micronutrients of the target population ➢ Create a partnership with stakeholders ➢ Choose appropriate feeding programme ➢ Plan the therapeutic feeding programme
3. Determine heath status of clients • Identify the extent of client condition	➢ Categorise client on health status ➢ Identify the most vulnerable groups

8.3.2.2 Information Sheet

The following factors should be considered when planning nutrition care in emergency:

- **Environmental temperature:** The environmental conditions of a place influences energy expenditure. Living in a cold environment increases energy expenditure. This should be an important consideration when planning nutrition care .
- **Demographic characteristics:** This factor considers population characteristics and composition, which influences the average energy requirement of a population.
- **Health and nutritional status**: Presence of disease in a population during emergencies increases nutritional requirements. Some diseases may increase nutritional requirements through reduced food intake, increased nutrient loss via vomiting and diarrhea, and catabolism.
- **Physical activity level:** Physical activity level determines nutritional requirement. Individuals and communities who lead a sedentary lifestyle need less energy compared to those who are active. Activity level for communities may be determined by socio-economic activities practiced by community members.

Aim of nutrition in emergency

- To reduce malnutrition mortalities
- To improve nutritional status of the affected people
- To prevent their situation from deteriorating.

The scale of emergency nutrition

The objectives of nutrition action in emergencies typically include;

a) Reduction of wasting levels to below conventionally defined emergency rates of thresholds

b) Reduction and/or prevention of micronutrient deficiencies, because these clearly increase mortality risks

c) Reduction of the specific vulnerability of infants and young children in crises through the promotion of appropriate child care, with special emphasis on infant and young child feeding practices

d) Prevention of a life-threatening deterioration of nutritional status by ensuring access by emergency affected populations to adequate, safe and nutritious foods that meet minimum nutrient needs

Stages of a food and nutrition emergency

Potential cause of a food and nutrition emergency (drought, flood, armed conflict, economic shock, population displacement, poverty); early warning indicators

↓

Field assessment of affected population(s); information indicates a food emergency exists

↓

Procurement and distribution of general food ration to the affected population; food security situation stabilizes

↓

Nutrition monitoring of the affected population

↓

Potential increase in acute malnutrition; implementation of micronutrient supplementation and supplementary and therapeutic feeding as needed

↓

Nutrition monitoring of the affected population

↓

Food security situation improves and stabilizes for decrease in acute malnutrition

Planning a ration

Once the initial planning figure of 210 kcal/person/day is adopted, adjustments should be made based on factors such as temperature, health or nutritional status of the population, distribution of the population and activity levels. The following steps are followed;

1. Calculation of the energy requirements of the population.
2. Selection of commodities that meet the population's nutrient requirements based on the recommended actions for various nutrition situations (See Table below)
3. Implementation of monitoring and follow up actions, collection of data and analysis of data.
4. Assessment of the ability of the population to access other food sources and adjust the ration (where applicable).
5. Monitor the situation following any such adjustments.

Recommended actions for various nutrition situations

Nutrition situation (prevalence)	Recommended actions
Acute malnutrition rate>15% or 10-14% with aggravating factors	• Emergency food aid: general food ration • Blanket supplementary feeding • Therapeutic feeding of severely malnourished individuals
Acute malnutrition rate 10-14% or 5-9% with aggravating factors	• No general rations • Targeted supplementary feeding • Therapeutic feeding of severely malnourished
Acute malnutrition are <10% with no aggravating factors	• No emergency food and nutrition intervention

Basic principles of planning nutrition emergency response

- A coordinated approach
- Context specific assistance
- A general food basket based on providing 2100 kcal per person per day
- Timely distribution of an adequate, basic ration
- A standard food ration
- Community participation
- Monitoring, adjusting and targeting

Management of nutrition in major emergencies

The following are the daily energy and protein requirements based on FAO/WHO recommendations with an assumption of BMI of 20-22 and on light activity (See Table below);

Energy requirement = 2100kcal/day

Protein requirement= 46g/day

Emergency phases and planning

Phase 1 of the emergency	
This phase covers the outset and during initial stages of emergency	The recommended 2100 kcal/person as a reference figure although the calories can be adjusted based on information available immediately. Measures should be put in place to ensure the food ration's adequacy in addressing both macro- and micronutrient requirements. The food ration should also be adequate to address the nutritional needs of all sub groups. Strategies for collecting information to make necessary adjustments should be outline. This will therefore necessitate establishment of a monitoring system.
Phase 2 of the emergency	
Situation stabilized	This is achieved through periodic reassessment, further revision and adjustment of the reference figure based on the extra information about all the factors affecting energy requirements. It is imperative to lay down a plan detailing longer term assistance or phase down and phase out strategies.

Feeding programme strategies in emergency situations

A. General Feeding programmes

These feeding programmes provide a standard general ration

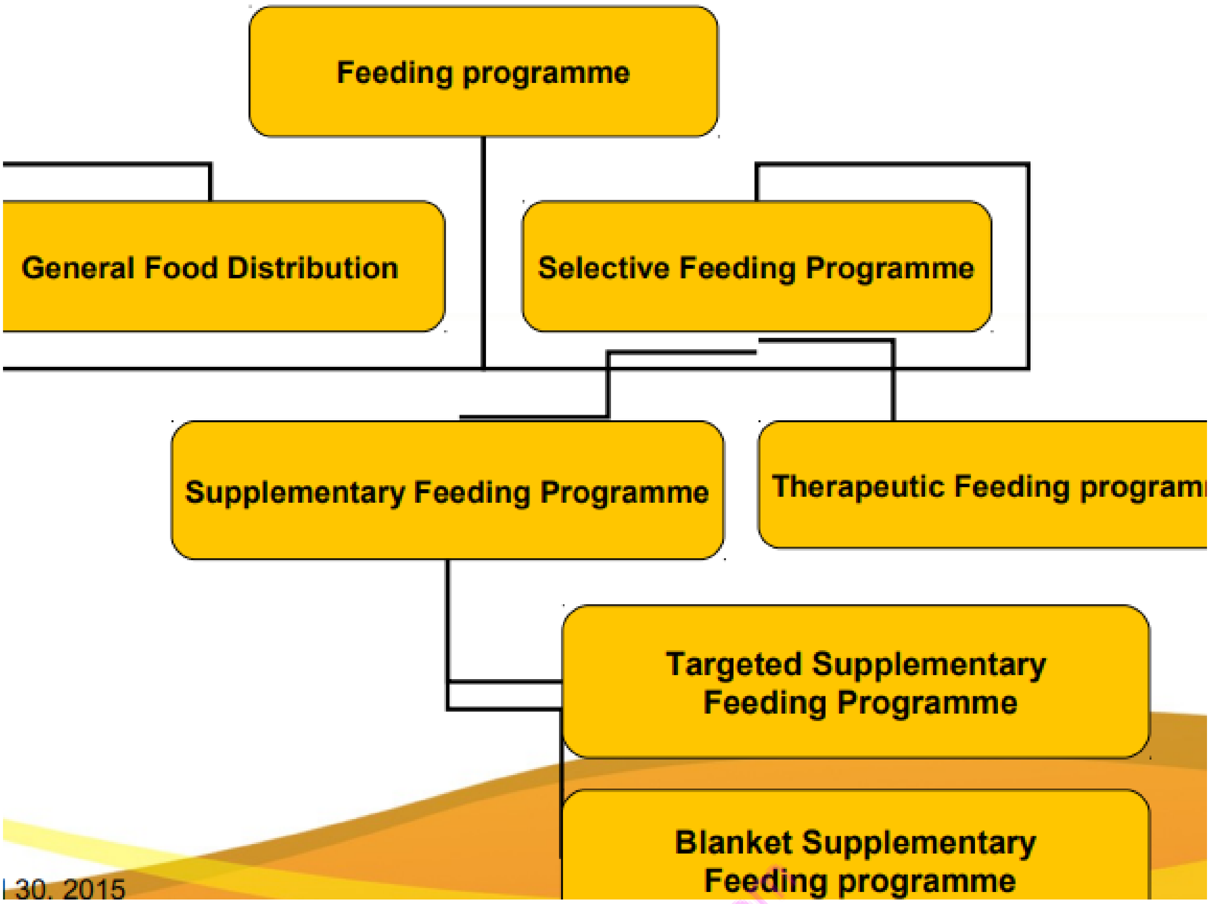
The aim of general feeding programmes in is mainly to cover food and nutritional requirements

B. Selective Feeding Programmes

These are further divided into two forms of Selective Feeding Programme (See Figure);

i) Supplementary Feeding Programme

ii) Therapeutic Feeding Programme



A. Supplementary feeding programmes

These programmes provide both nutrient-dense food and general ration

Supplementary feeding programmes aim to:

- Rehabilitate persons suffering from malnutrition
- Prevent a deterioration of at risk group by providing short-term measures. However, these measures should not be viewed as a means to make up for an inadequate general food ration.

Supplementary feeding programmes (SFPs) are further categorized into;

1. **Targeted SFPs**: aims at preventing moderately malnourished populations from becoming severely malnourished and to rehabilitating them.
    - Objectives;
        - Decrease of cases of acute & severe malnutrition
        - Reduction of excess mortality.
    - **Attributes of targeted SFPs;**
        - Individual registration, monitoring of weight, individual medical treatment.
    - **Target group for SFPs;**

- Individuals with or at risk of mild and moderate malnutrition and selected pregnant and nursing mothers

- **The most appropriate time to start Targeted Supplementary Feeding Program**
    - When the prevalence of malnutrition gets to 10-14%
    - When large numbers of children are predicted to become malnourished
    - When there is a prevalence of 5-9% acute malnutrition in presence of aggravating factors.

2. **Blanket SFPs:**
    - Objective is mainly to prevent increase in PEM & micronutrient deficiency rates.
    - **Attributes;**
        - No individual monitoring or registration
        - Selection of children- < 110cm in length.
        - Preventive medication – vitamin A, measles vaccination.
    - **The most appropriate time to start Targeted Supplementary Feeding Program**
        - At onset of an emergency
        - When problems are experienced during delivery/distribution of general ration.
        - When the prevalence of acute malnutrition is 15% and above
        - When there is a prevalence of acute malnutrition is at 10-14% in presence of aggravating factors.
        - When there is an anticipated increase in rates of malnutrition epidemics.
        - When there is an outbreak of micronutrient deficiency

Ways of distributing supplementary food

On-site feeding (wet) ration: Food is prepared in a central place and the beneficiaries consume the meal or snack at the site. The food will reach the targeted beneficiary but logistics may be expensive hence usually not recommended. Provide a minimum of two or three meals should be provided daily.

i. **Take-home (dry) ration**: The regular (weekly or biweekly) distribution of food in dry form to be prepared at home

ii. **Food by prescription:** Food is provided depending on individual assessment. It is packaged in small quantities (as medicine) to take home and consume as prescribed. The best place for implementing food for prescription intervention is health facility

Characteristics of an adequate food ration

- Nutritionally balanced
- Diversification
- Does not go against cultural practices of the population
- safe for human consumption
- Appropriate and acceptable for all sub-groups of the population.

B. Therapeutic Feeding Programmes

The objectives of TFP are to provide treatment for severely malnourished individuals and to reduce the risk of excess mortality and morbidity.

It consists of intensive medical and nutritional treatment

Criteria for Admission in Therapeutic Feeding Program

- Children below the age of 5 years who are suffering severe malnutrition and/or children with oedema.
- The under-5s, adolescents and adults who are severely malnourished
- Low birth weight (LBW) babies
- Orphaned infants
- Mothers of infants with breastfeeding failure

Criteria for Discharge from Therapeutic Feeding Program:

The usual practice has been to refer a child to a targeted SFP when he/she:

- Maintains a weight-for-height >= 75% of the reference media or ">= -2.5 Z-score" for two consecutive weeks.
- Displays a good appetite and is not sick.

Nutritional Rehabilitation

Phase 1: Acute phase (phase of intensive care)

This phase involves 24-hour inpatient intensive care where the patient is treated to treat/ prevent infection and dehydration. Electrolyte imbalance is expected resolve and nutritional management started. The patient is provided with frequent feeds with therapeutic milk (10-12 per day). This phase should last for a maximum of one week.

Phase 2: Rehabilitation phase

The patients should be provided with at least 6 meals per day in order to regain most of the weight lost. Psychological and medical care is very important during this phase. This phase is not expected to last more than five weeks

Principles of management of nutrition in major emergencies

- Nutritional requirements knowledge
- Identification of the groups which are most vulnerable
- Meeting protein and energy requirements
- Meeting the requirements for minerals, vitamins & other specific nutrient
- monitoring accessibility of food and adequacy of dietary intake

8.3.3.3 Self-assessment

1. Identify vulnerable groups during emergency
2. Discuss methods used in situation analysis
3. Which one of the following groups do not qualify for admission in therapeutic feeding program
   A. Children below the age of 5 years who are malnourished
   B. Poor people
   C. Low birth weight (LBW) babies
   D. Mothers of infants with breastfeeding failure
4. Which one of the following is an aim of nutrition in emergency?
   A. To reduce poverty levels
   B. To reduce malnutrition mortalities
   C. To bring peace in warring communities
   D. To prevent natural disasters
5. The following are characteristics of an adequate food ration except:
   A. Nutritionally balanced
   B. Culturally acceptable
   C. Safe
   D. None
6. _______is a type of food ration prepared in a central place and the beneficiaries consume the meal or snack at the site.
   A. Food by prescription
   B. On-site feeding ration
   C. Take-home ration
   D. Targeted supplementary feeding programmes

8.3.3.4 Tools, Equipment, Supplies and Materials

- Biochemical results
- Calculator
- Anthropometric measurements
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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8.3.4 Learning Outcome 3: Provide nutrition and health interventions

8.3.4.1 Learning Activities

Leaning activity.	Special instructions.
1. Provide nutrition health education a. Identify population composition b. Identify target audience c. Identify barriers of success	• Prioritize problem • Create community partnership • Conduct nutrition education sessions with clients
2. Provide therapeutic feeds a. Identify population composition	• Establish individual nutritional requirements • Budget for therapeutic feeds • Issue therapeutic feeds • Implement supplementary food distribution • Treat severe acute malnutrition and operate therapeutic and supplementary feeding centres • Select commodities that meet the energy, protein, fat and micronutrient requirements of the population • Document therapeutic feeding
3. Check medical/nutrition underlying causes a. Assess client medical observation b. Assess client physical examination	• Identify medical conditions • Relate medical condition and nutritional status of individuals

8.3.3.2 Information Sheet

Nutrition Education

This is a form of health education but specific to nutrition and nutrition related issues. Nutrition education includes;

- Conventional education
- Social marketing
- Health communication
- Empowerment actions.

Consequently, a vast range of activities such as peer education, training of health workers, community mobilization, and social marketing are considered examples of nutrition education interventions

Steps in Conducting Nutrition Education Sessions

- Identify problems
- Prioritize the problem
- Identify the target group/person
- Build consensus about the problem with the individual or group
- Identify blocks e.g. lack of resources, beliefs
- Select appropriate communication channel of communication (e.g. demonstration, songs, poems)

Health Assessment in Emergency

Malnutrition and disease are closely linked and this relationship needs to be addressed while providing nutrition care in emergency.

Health assessment includes determining the disaster has health-related risk factors, existing health problems, risk of increase in morbidity, mortality rate, access to health care services, and availability of health staff.

Factors that affect health are also assessed. For example, housing, water and sanitation and waste management.

Creating Community Partnerships

For effectiveness, nutrition care providers need to partner with communities in finding lasting solutions to their problems. Community partnerships bring stakeholders together to share knowledge and resources.

Steps in creating a community partnership:

- **Identify partners:** Partnerships for sustainable development need interested and committed partners who share the project idea and who can influence and support the partnership goal.
- **Develop a community profile**: Community profile is a snapshot of the community, as a whole. (Population, Income levels, Educational levels, Ethnic make-up, Unemployment rates, Crime statistics).
- **Initiate dialogue among potential partners**: Explain what you're doing, why you're doing it and how you plan to do it.
- **Organize community meetings:** This brings various viewpoint, a
- perfect setting to exchange ideas and information.

- **Identify Issues**: Allow community members to identify problems they're facing, and then identify those that you can help to solve.
- **Formulate your plan** : Formulate objectives and identify roles of various stakeholders
- **Take action / Implement plan**: Implement the proposed solutions. Monitor to identify discrepancies from expected outcomes.
- **Maintain partnership:** Take measures to ensure sustainability of the project so as to avert such disasters in future.

Nutrition programme elements

The choice of actions from a more comprehensive portfolio of intervention includes (but not limited) the following;

a) General food assistance

b) Management of severe acute malnutrition

c) Management of moderate acute malnutrition

d) Delivery of micronutrients

e) Infant and young child feeding in emergencies

f) Treatment of diarrhoea with oral rehydration therapy/zinc

Energy needs are supplied through various commodities such as cereal, blended food and pulses. Protein should account for 10-12% of total energy intake.

17% should be provided by fat, while the rest should be from carbohydrates.

Macronutrient requirements

- Meeting of energy requirements through a range of commodities with adequate protein content.
- According to WHO and FAO recommendation, protein should provide at least 10- 12% of total energy
- It is also recommended that fat should provide.at least 17% of energy in the ration
- An adequate food ration should take into consideration the local dietary preferences.
- Mixing different proteins of plant origin sufficiently meets the requirements of macronutrients of a population

Examples of rations for nutrition emergency (macronutrients) as per international average minimum energy requirement

FOOD ITEMS	RATIONS (g) Examples				
	1	2	3	4	5
Cereals	400	450	350	400	400
Pulses	60	60	100	60	50
Oil (vitamin A fortified)	25	25	25	30	30
Fish/meat	-	10	-	30	-
Fortified blended foods	50	40	50	40	45
Sugar	15	-	20	-	25
Iodized salt	5	5	5	5	5
Energy: kcal	2113	2075	2113		
Protein(in gm and in % kcal)	58g; 11%	71g; 13%	65g; 12%		
Fat(in gm and in % kcal)	43g: 18%	43g; 18%	42g; 18%		

Micronutrients requirement

The population which is affected by emergency situations may suffer endemic micronutrient deficiencies, worsened by a general decline in nutritional status. In order to determine the micronutrient adequacy of a ration, a straightforward comparison of the population's daily micronutrient requirements with the estimated level of micronutrients in the basic ration is required.

The major undoing of depending on food assistance is that the rations tend to put the populations at risk of vitamin and mineral deficiency diseases. This calls for concerted efforts within the context of emergency food assistance programs with an aim to recognize factors that boost the likelihood of deficiency diseases.

Daily micronutrients requirements for emergency food aid

Vitamin/Mineral	Recommended Daily Intake (RDI)	Deficiency diseases
Vitamin A	500 µg	Xerophthalmia
Thiamine (B1)	0.9mg	Beriberi
Riboflavin (B2)	1.4mg	
Niacin (B3)	12mg	Pellagra
Folic acid/Folate	160 µg	
Vitamin C	28.0 mg	Scurvy
Vitamin D	3.8 µg	Rickets

Iron	22mg	Anaemia
Iodine	150 µg	IDD (goitre)

Fortification of food in nutrition emergency

Food fortification refers to the process adding one or more micronutrients to food during processing. Fortified blended food aids in ensuring that a number of micronutrients are consumed and its inclusion forms an important part of the basic ration in an emergency situation, especially for the micronutrient needs of young children, pregnant and lactating mothers, and the elderly.

Different foods should be fortified with the appropriately matched micronutrients (Table X).

Food fortification in nutrition emergency

Food Item	Nutrients fortified
Vegetable oil	Vitamin A and D
Salt	Iodine
Wheat and maize flour	Vitamin A, thiamine (B1), Riboflavin (B2), Niacin (B3), Folic acid, Iron
Blended foods	Vitamin A, thiamine, riboflavin, niacin, folic acid, vitamin c and B12, iron, calcium and zinc

Modification of the ration based on food accessibility by populations

Emergency food needs assessments: this should be carried out while focusing on the overall goals and operational objectives of food assistance. They should include;

- Saving of lives
- Preservation of productive assets
- Prevention of mass migration
- To maintain nutritional status especially among pregnant and lactating women as well as other groups at high risk.
- To ensure access to an adequate diet for all population group
- To minimize damage of food production and marketing systems due to the emergency situations

Meeting special nutritional requirements of the most vulnerable populations

1) Infants and young children

Research shows that malnutrition during the formative years of a child's life has adverse effects on cognitive, motor-skill, physical, social and emotional development which could be life long. Therefore, so as to protect and promote optimal infant and child feeding practices, specific interventions are critical during emergencies.

It is imperative to routinely include and sustain these interventions throughout the period of response in any relief response. It is worth noting that the nutrients found in breast milk exceeds the amount found in breast milk substitutes. Breast milk also plays a role in the protection of children from infections in addition to providing all the nutrient required by the infants.

In most emergencies, breastfeeding becomes even more critical for infant nutrition and health because artificial feeding in emergencies may increase the risk of diarrheal diseases and malnutrition, which in turn significantly increases the risk of infant death. If completely required, infant formula should only be used when all other options have been exhausted.

• Supplementary feeding may be an important intervention for protecting the nutritional status of lactating mothers.

Guiding principles for feeding infants during emergency

All infants (including those born to populations affected) should be put to breast within 30 minutes to 1 hour after birth and be exclusively breastfed for the first 6 months as recommended by the world Health Organization (WHO). In cases where mothers are incapacitated or absent, every effort should be made to come up with ways to breast feed the infants before opting to formula feeding.

A conducive environment that supports exclusive breastfeeding for the first six months, and continued breastfeeding for up to two years should be created and maintained. Strict control measures should be in place to monitor quantity, distribution and use of breast milk substitute e.g. infant formula at emergency sites should be strictly controlled, using the following guidelines:

- The infant formula should have adequate nutrients, be cup-fed, and always be available for infants who need it.
- Adequate training and equipment should be provided for every individual who is responsible for feeding infant formula to ensure its safe preparation and use.
- Feeding infant formula to a minority of children should not interfere with protecting and promoting breastfeeding in majority.
- Use of infant feeding bottles in emergency setting should be discouraged and cup feeding promoted.

Complementary feeding for older infants and young children

Complementary feeding can be a challenge during emergencies, due to some constraints such as difficulties in preparing the available foods into a soft, semi-solid form. Moreover, basic food aid commodities such as cereals, pulses and oil, do not by themselves readily meet nutritional needs of young children.

There are a number of foods that are recommended for use during preparation of suitable complementary foods (See Table).

Options for addressing nutritional needs of older infants and young children

Food source	Examples	Remarks
1.Basic food aid commodities from general ration with supplements of inexpensive locally available food	Cereals, pulses, oil and sugar combined together with a variety of vegetables and fruit	Recipes can be developed using local foods with input from nutrition and/or Health expertise. It is very critical to understand and observe traditional complementary feeding practices
2. Blended foods(as parts of general ration)	Corn—soya blend, wheat-soya blend .	As a measure to increase digestibility of blended foods, they are usually subjected to roasting. Blended foods are fortified with zinc and iron and other micronutrients for growth and development
3. Additional foods in supplementary feeding programs	Fruits, vegetables, fish, eggs among others	Valuable source of vitamins and minerals

Complementary intervention of nutrition for pregnant and lactating women in emergency

1. **Fortified food items**

Fortified blended food commodities containing 10-12 % of energy from fat should be provided. It is very critical to modify the blended food so as to meet two-thirds of daily needs for all micronutrients, with emphasis on iron, folic acid and vitamin A.

2. **Micronutrient supplementation**

It is recommended that pregnant women be prescribed daily supplements of iron (60mg/day) and folic acid (400µg/day) while lactating women receive 400000 IU of vitamin A in 2 doses of 200000 IU each in an interval of a minimum of 24 hours within six weeks after delivery.

3. **Water**

Pregnant and lactating women need to have a sustainable access to sufficient and safe drinking water so as to meet their daily requirements

4. **Malaria in pregnancy**

Pregnant women residing in areas where malaria is endemic should be given sulphadoxinepyrimethamine at the beginning of the second and third trimesters. These women should also be encouraged to use an impregnated bed net throughout pregnancy.

5. Prophylaxis for management of intestinal parasites

Each affected woman should be given 500g of mebendazole during the 2^{nd} and 3^{rd} trimesters.

6. Nutrition education and counselling for women and communities.

Pregnant and lactating women should be given nutrition education and counselling as a way of ensuring they make informed choices on the foods to take and also feed their children.

Nutritional needs of older persons

The energy requirements for older persons normally decreases compared with younger adults resulting from reduced physical activity and decreased basal metabolism. The requirements for micronutrients, however, do not decrease. Therefore, an optimal diet for older persons must meet the micronutrients requirement even with reduced energy intakes.

It is also important to consider that older persons are required to take sufficient intakes of fluids to prevent dehydration and improve digestion.

Theoretically, a well-planned general ration is usually sufficient for older persons.

Considerations to the nutritional needs of older persons

i. Access to easily digestible micronutrient rich foods

Older persons and their households should be provided with blended foods. In situations where blended food is not provided to the whole population, under 5's, pregnant and lactating women and older persons should be prioritized. Access to milling facilities in situations where whole grain cereal is provided. Older persons should be assisted and encouraged in small scale horticultural activities to increase consumption of fresh foods.

ii. Family and community support for food preparation

Those older persons who lack family or community support, can be assisted through community based support programs. Assistance with tasks such as collection of rations, food preparation and collection of water may be required for older persons.

Programme indicators

i. Vulnerability indicators
   - Structural risk
   - Process

ii. Outcome indicators
   - Prevalence of PEM Prevalence of micronutrient deficiencies
   - Mortality
   - Morbidity/epidemics

8.3.4.3 *Self-Assessment*

1. Describe methods of health education in emergency nutrition
2. Describe therapeutic foods offered in emergencies
3. Match the following micronutrients with the deficiency disorder that results from inadequate intake

Vitamin/Mineral	Deficiency diseases
A. Vitamin A	A. Beriberi
B. Thiamine (B1)	B. Goitre
C. Riboflavin (B2)	C. Xerophthalmia
D. Niacin (B3)	D. Ariboflavinosis
E. Vitamin C	E. Anaemia
F. Vitamin D	F. Rickets
G. Iron	G. Pellagra
H. Iodine	H. Scurvy

8.3.4.4 *Tools, Equipment, Supplies and Materials*

- Diet history data
- Biochemical results
- Calculator
- Anthropometric measurements
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

8.3.4.5 **References**

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8.3.5 Learning Outcome 4: Monitor implementation of interventions

8.3.5.1 Learning Activities

Leaning activity.	Special instructions.
1. Evaluate outcomes of nutrition related diet history	• Implement monitoring and follow up actions, data collection and analysis • Assess the ability of the population to access other food sources and adjust the ration. • Compare dietary intake with goals of nutrition intervention • Document outcome
2. Assess anthropometric measurement outcomes a. Analyse anthropometric measurement outcomes	• Document client progress • Compare anthropometric outcomes with goals of nutrition intervention • Review nutrition intervention
3. Evaluate physical and clinical outcomes a. Analyze physical finding outcomes	• Compare physical and clinical outcomes with goals of nutrition intervention • Document client progress • Review nutrition intervention
4. Assess outcome of therapeutic feeds a. Analyze outcome of therapeutic feeds	• Establish variance from expected nutrition goals outcomes • Monitor the situation following any such adjustments

8.3.4.2 Information Sheet

Definitions:

- **Monitoring:** an ongoing review of nutrition intervention outcomes to assess the process of achievement of the goals set at planning. It assesses progress by measuring pre-determined indicators.
- **Evaluation:** Evaluation is the systematic process of assessing the relevance, effectiveness, efficiency and impact of a nutrition intervention against set goals. The outcome helps to make the decision to discharge the client or to modify the care plan.

Monitoring and evaluation in nutrition involves monitoring, measuring and evaluating nutrition care indicators. Through monitoring and evaluation, a nutritionist is able to determine whether or not a certain intervention is effective. Effectiveness is achieved when the goals of the nutrition intervention are achieved.

Data on the nutrition outcome indicators are collected and analyzed, after which the findings are compared to initial nutritional status, goals set for the intervention, as well as reference standards. It helps assess the impact of a nutrition intervention as well as identify gaps in the care process.

Importance of Monitoring and Evaluation

- Helps to establish the progress of a nutrition intervention
- Determines if an intervention is in line with objectives and when alterations may be necessary
- A means of assessing quality of activities involved in a nutrition intervention
- Monitoring and evaluation can be used as proof of an intervention
- Demonstrates the impact of an intervention

Monitoring and Evaluation of nutrition in emergency require routine data quality checks as well as continuous data quality checks in order to improve the quality of indicators. Reporting requires that data should meet the following requirements:

1. **Accuracy:** It is important to accurately record the patients'/clients' vitals such as weight, height, MUAC, HB etc. Equipment-routine maintenance to be done in each facility
2. **Reliability:** Recording accurately is not the only requirement since recorded data needs to be reliable so that the conclusions drawn from analysis are not spurious. For example, the height of an adult should remain the same most of their adult life, and should not vary on every date of distribution. Remember, garbage-in garbage-out
3. **Timeliness:** For effective management of patients, the data collected needs to be collected in good time so as not to delay the decision making process
4. **Completeness:** Indicators are generated from a combination of data components. It is therefore important that the data collected is complete so that the information generated is whole. Good data should be complete, that is, it has every necessary part or every detail that is wanted. For example, in calculating BMI, both variables (weight and height) are needed. It follows that when one misses, BMI cannot be calculated. Similarly, a computer generates accurate Z scores, when date of birth and anthropometric measurements are recorded
5. **Precision:** For all measurements, it is important that the correct readings from the measuring instrument are collected. Ensure that all anthropometric equipment is calibrated before taking measurements
6. **Storage** -all equipment should be properly stored for safety
7. **Confidentiality:** For all patient records, it is important to maintain confidentiality. This means that details of a patient's records cannot be divulged to unauthorized persons. Medical records should also be kept under lock and key

Management of food related issues

i. Temporary substitution of food items

ii. Packaging of food aid commodities

iii. Exchange and trade of rations

iv. Quality control

Indicators of effectiveness of nutritional relief

General feeding programme: one should consider the following;

- Coverage: to see if most vulnerable populations are benefiting from the interventions
- Adequacy of ration
- Impact on the target population

Temporary substitution of food items

If some food commodities are not available, they can be replaced by another food in order to maintain the energy and/or protein level of the food basket. These substitute should only be considered as a temporary measure and should not be implemented for longer than one month.

Inappropriate substitutions- such as the provision of unfamiliar foods, the use of unsolicited donations of expired foods or the use of highly processed commercial foods should be avoided.

Packaging of food aid commodities

Proper food packaging is necessary to preserve and protect the quality of commodities. Proper labelling of food aid commodities provides vital information to field staff. Packaging should be environmentally friendly and, if possible, serve as an additional resource to the population.

Exchange and trade of rations

The practice of exchange, bartering or resale of food aid commodities in emergency situations may facilitate diversification of food and enable access to a number of foods that are not provided in the ration.

The sale of food in the marketplace does not necessarily indicate a food surplus. The rationale for trading food may simply be to diversify the diet and to improve its palatability and quality.

Quality control

A system of quality control for all commodities must be implemented to ensure that food distributed to refugees is of good quality and safe for human consumption.The acceptability and consumption of food is directly influenced by the quality of the food.

Suppliers of food commodities must be carefully scrutinized to ensure that a regular quality control check is done. All food received should have a minimum shelf life of six months. Adequate storage structures should be in place. Written procedures should be in place for checking the quality of food at the distribution stage. Fumigation and food quality control measures should be in place.

Monitoring and follow up

- First of all, a monitoring system must be established to ensure that any inadequacy in the ration are discovered in a timely manner.
- Secondly, a strategy outlining actions to be taken in response to food shortages or inadequate rations should be in place.
- Thirdly, given that access to food can change dramatically over time, and the opportunities for obtaining food through the populations own means differs significantly between situations.
- It is important to make strong links between food aid and the potential for food production from the outset of the emergency.

8.3.5.3 Self-Assessment

1. Discuss characteristics of quality record keeping
2. _____ is an ongoing review of nutrition intervention outcomes to assess the process of achievement of the goals set at planning. It assesses progress by measuring pre-determined indicators.
   A. Nutrition intervention
   B. Monitoring
   C. Evaluation
   D. Diagnosis
3. Indicate whether the following statements are true or false about monitoring and evaluation
   A. Helps to establish the progress of a nutrition intervention
   B. Determines if an intervention is in line with objectives and when alterations may be necessary
   C. It cannot be used to assess quality of activities involved in a nutrition intervention
   D. Monitoring and evaluation can be used as proof of an intervention
   E. Monitoring and Evaluation of nutrition in emergency require routine data quality checks
   F. Demonstrates the impact of an intervention

8.3.5.4 Tools, Equipment, Supplies and Materials

- Diet history data
- Anthropometric equipment
- WHO guidelines

- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

8.3.5.5 References

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8.3.6 Learning Outcome 5: Document nutritional intervention during emergencies

8.3.6.1 Learning Activities

Leaning activity.	Special instructions.
1. Obtain MOH registers	• Record relevant details of the intervention • Maintain records of the intervention
2. Obtain WFP registers	• Record relevant details of the intervention • Maintain records

8.3.6.2 Information Sheet

Emergency plan: policies and procedures developed by an organisation to be used during an emergency or disaster to prevent or minimise damage to an organisation, its people and its resources.

Record: A document regardless of form or medium created, received, maintained and used by an organisation (public or private) or an individual in pursuance of legal obligations or in the transaction of business, of which it forms a part or provides evidence.

Documentation of during emergencies is key since it provides information concerning the care plans and processes undertaken. It also provides information on nutrition and health interventions and how monitoring implementation of interventions was done during nutrition in emergencies.

Emergency plan

The emergency plan should address the following three actions required to help the organisation deal with an emergency:

- readiness: developing a combination of preventive measures to forestall emergencies or disasters and strategies for dealing with disaster should it occur
- response: adhering to procedures to deal with any emergency situation that arises
- recovery: restoring records and facilities to their usual condition and resuming normal activities

Compiling an emergency plan

A disaster plan document should be drawn up by the emergency response team. The disaster plan should do the following.

- It should include an introduction and policy statement by the director of the records and archives institution

- It should briefly describe possible emergencies or disasters that may arise.
- It should set out the objectives of the plan, to
  - o facilitate effective methods of preventing damage to or destruction of records
  - o limit damage and prevent escalation of the situation
  - o facilitate the effective co-ordination of recovery tasks
  - o prevent injury to personnel or property
- It should include a description of emergency procedures for the institution, including information about
  - o how to sound the fire alarm
  - o evacuation procedures
  - o the names of staff who will take charge in the event of an emergency
  - o contacts for assistance with salvage and recovery
- It should include a list of full contact information for all staff who may be called in the event of an emergency, including office and residential telephone numbers. Those listed should include facilities managers, any specialist conservation/ preservation staff, senior management, and so on. Also on the list should be the names and contact information of volunteers who can be called to assist with recovery operations.
- It should include a description of items of special concern, prioritising those records in a salvage operation and indicating their location in the building.
- It should include floor plans of the building that detail power and water supply cut-off points, drainage points, and so on. Areas that may be used for storing records during salvage work (such as for packing material prior to transfer to a freezing facility) should be clearly marked.
- It should list supplies of available emergency equipment and materials. It may be necessary in large organisations to hold duplicate stores at strategic locations throughout the building.
- It should identify the full contact information for any external suppliers who might be able to provide equipment or store, freeze or transport records.
- It should include any agreements that have been negotiated with other agencies for mutual assistance in the event of a disaster.
- It should include guidelines for the salvage of records.
- It should include information about completing an incident report.

Principles of Good Record Keeping

Some key factors underpin good record keeping. The client's records should:

- Be factual, consistent and accurate;
- Be updated as soon as possible after any recordable event;
- Provide current information on the care and condition of the patient;

- Be documented clearly in such a way that the text cannot be erased;
- Be consecutive and accurately dated, timed and all entries signed (including any alterations);
- All original entries should be legible. Draw a clear line through any changes and sign and date;
- Records must be stored securely and should only be destroyed following your local policy;
- Avoid meaningless phrases, speculation and offensive subjective statements/insulting or derogatory language;

The most common deficiencies in record keeping include:

- An absence of clarity
- Inaccuracies
- Spelling mistakes
- Missing information
- Failure to record action taken when a problem has been identified.

Importance of Record Keeping

- Documents nutrition service rendered
- Shows progress of care
- Planning and evaluation of service for future improvement
- Guide for professional growth
- Helps judge the quality and quantity of work done
- Communication tool between nutritionist and other staff involved in the care team.

Characteristics of Quality Record Keeping

- Factual
- Accurate
- Complete
- Organized
- Promotes confidentiality

Initial Damage Assessment Records

The initial damage assessment phase takes phase as soon as access to the site of the incident is granted. This documentation should capture the broad picture quickly, without bogging down in details. Information gathered should include the following:

Is the immediate cause of the emergency under control?

Is the site of the incident safe?

Size/scope:

- How big is the damaged area?
- How many floors are involved?
- How many rooms?
- How many objects?
- What is the nature of the damage?
- How serious is the damage?

4. Objects damaged:
   - What collections are damaged?
   - What types of objects/materials are involved?
   - How long have items been wet?
5. Staff needed:
   - What additional personnel will be needed?
6. Equipment and supplies needed:
   - For mitigation operation
   - For more detailed documentation of damage
   - For move of collections to a safe location
7. Services needed:
   - Will there be need for a triage or alternate storage site?
   - Will there be need for transportation to an alternate site?
   - Will conservators need to be called in?

Emergency Incident Records

These records, which would normally be kept by the Emergency Plan Coordinator, include a detailed chronology of the incident in real time, records of people involved in the incident and the aftermath, and a summary statement after the incident is declared over.

A. Chronology of the Emergency

1. Written records:

Keep a log of:

- Events
- Actions
- Decisions
- Radio, telephone, and in-person communications

For each, note date and time, and the person providing the information.

2. *Photographic records:*

- Photograph or videotape the incident site and damage.
- Photograph or videotape recovery activities.

B. Personnel Records

1. Keep a list of names, addresses and phone numbers of all staff and volunteers involved in the incident and in the recovery operation.

3. Keep track of staff and volunteer time spent on the incident and the recovery.

4. Document injuries or illness related to the incident.

C. Summary Documentation

After the incident has been brought under control, the participants should meet to gather complete information about the incident. Write a summary that includes:

- The type of incident, and the date and time of the incident.
- Who witnessed or discovered the problem.
- Who was notified.
- Describe conditions surrounding the incident: weather, building conditions, warnings, human elements, equipment involved.
- Describe actions taken by staff to address the incident, and who was involved.
- Describe actions taken by outside authorities such as fire and police.
- Describe actions required to recover from the incident: building stabilization, move of collections, conservation, etc.

8.3.6.3 Self-Assessment

1. Describe the principles of good record keeping
2. Which of the following in not an actions required to help the organisation deal with an emergency:

    A. Readiness

    B. Realignment

    C. Response

    D. Recovery

3. ______ are policies and procedures developed by an organisation to be used during an emergency or disaster to prevent or minimise damage to an organisation, its people and its resources.

   A. Personnel management

   B. Emergency plan

   C. Disaster management

   D. Disaster preparedness

4. ____ is a document created, received, maintained and used by an organisation or an individual in pursuance of legal obligations or in the transaction of business.

   A. Emergency plan

   B. Documentation

   C. Record

   D. Plan

8.3.6.4 Tools, Equipment, Supplies and Materials

- Computers.
- Stationeries e.g. registers, files, pens and papers.
- Inventory (keep hard copy off-site)
- Strong Adhesive Labels
- Holdings priorities (hard copy)
- Blank Paper Blank
- Inventory Sheet
- Pencils
- Permanent Markers
- Camera (film, batteries)
- Video Camera
- Clipboard Laptop and
- Battery Back-up
- Photographic Log
- Tape Recorder
- WHO guidelines
- MOH guidelines
- Ministry of Education

- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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CHAPTER 9:

MANAGE NUTRITION IN THE LIFE CYCLE

9.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to manage nutrition in the life cycle. It involves identifying terminologies in nutrition in the life cycle, demonstrating the knowledge of nutrition during pre-pregnancy, Pregnancy, Lactation, Infancy (0-24 months), pre-schoolers (25-59 months), pre-adolescents (6years-12 years), Adolescents (13years-19 years), adults (20years-60 years) and older persons/geriatric nutrition (60years and above).

9.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to describe lifespan stages at a glance and determine the vulnerability associated with each stage based on the existing policies and guidelines; provide nutritional management for clients in the various stages in the lifecycle- pre-pregnancy, pregnancy, lactation, infancy, pre-schoolers, adolescents, adults, and geriatrics- in accordance with RDAs, resource materials and existing policies & guidelines.

9.3 Learning Outcomes

8.3.1 List of Learning Outcomes

1. Identify terminologies in nutrition in the life cycle
2. Demonstrate knowledge in nutrition during pre-pregnancy
3. Demonstrate knowledge in nutrition during pregnancy
4. Demonstrate knowledge in nutrition during lactation
5. Demonstrate knowledge in nutrition during infancy
6. Demonstrate knowledge in nutrition for pre-schoolers
7. Demonstrate knowledge in nutrition for pre-adolescents
8. Demonstrate knowledge in nutrition for adolescents
9. Demonstrate knowledge in nutrition for adults
10. Demonstrate knowledge in nutrition for older persons/geriatric nutrition.

9.3.2 Learning Outcome 1: Identify terminologies in nutrition in the life cycle

9.3.2.1 Learning Activities

Learning Activities		Special instructions
i)	Identify terminologies in the lifecycle	➢ Define terminologies in the life
ii)	Identify and describe stages in the life cycle	➢ Categorize individuals according to nutritional needs ➢ Describe the characteristics of each stage in the lifecycle
iii)	Identified and describe the important roles of nutrition	➢ Demonstrate knowledge of roles of nutrition in different lie stages
iv)	Identify and describe nutrition vulnerability and risks	➢ Identify vulnerable groups in different life stages ➢ Formulate strategies to reduce vulnerability
v)	Identified the factors that determine nutrition needs	➢ Consider factors that determine nutrition needs of individuals

9.3.2.2 Information Sheet

Definition of terms

Nutrition: all aspects of the interaction between food and nutrients, life, health and disease, and the processes by which an organism ingests, absorbs, transports, utilizes and excretes food substances

Malnutrition: A physiological state that results from nutrient inadequacy, excess or imbalance

Throughout the lifespan, human beings require proper nourishment to meet the changing needs in different life stages. Nutrition is necessary for growth and development, maintenance of quality of life. Poor nutrition prior to conception and during pregnancy has a significant effect on quality of later life.

Nutritional deficiencies in childhood cause poor growth and development. This in turn affects growth, development, maturation, functional capacity as well as the risk of morbidity in the latter stages.

Malnutrition in adulthood affects ageing and jeopardizes quality of life. Poor nutrition also increases susceptibility to infections and incidence of chronic diseases in the elderly.

Importance of Nutrition in the Lifespan

- Supports growth and development
- Prevents disease

- Management of disease
- Improves quality of life

Nutritional Vulnerability

All the stages in the human lifespan face a degree of nutritional vulnerability, which is brought about by various factors. Vulnerability is often caused by factors such as change in nutrient and energy needs, changes in food access and intake, changes in physiological demands and changes in functional capacity.

Nutrition Concerns at Various Stages in the Lifespan

Infancy:

This is a vulnerable stage in the lifespan. The main nutritional concerns during this stage are:

- Birth weight
- Breastfeeding concerns
- Complementary feeding
- Ensuring optimal growth and development
- Failure to thrive
- Preventing under nutrition /morbidity/mortality

Pre-school years:

- Ensuring normal growth and development
- Formation of good food habits
- Preventing malnutrition/morbidity/mortality

School-going Children:

- Ensuring normal growth and development
- Establishing appropriate nutrition behaviour
- Preventing obesity

Adolescence:

- Ensuring normal growth and development
- Preparing girls for motherhood
- Ensuring adequate bone mass
- Preventing under nutrition/overweight and obesity

Adulthood:

- Nutrition and productivity
- Nutrition during pregnancy and lactation
- Prevention of obesity and chronic no- communicable diseases
- Quality of life

Older age:

- Maintaining muscle mass
- Preventing cognitive decline
- Ensuring adequate food and nutrient intake
- Quality of life

People who are at Risk of Malnutrition

They include:

- The poor
- Isolated people
- People with chronic illnesses
- Convalescents
- People with eating disorders
- Socially isolated individual
- Refugees and internally displaced people

Factors that Determine Nutrient Needs

- Age
- Sex
- Occupation
- Physical activity level
- Disease
- Physiological status e.g. pregnancy
- Weather/ environmental conditions

9.3.2.3 Self-Assessment

1. Identify groups of people who are vulnerable to malnutrition
2. Identify the factors that determine nutrient requirement
3. _____ is a physiological state that results from nutrient inadequacy, excess or imbalance
   A. Nutritional Status
   B. Stunting
   C. Malnutrition
   D. Vulnerability
4. Which one of the following is not a nutritional concern during infancy?
   A. Birth weight
   B. Breastfeeding
   C. Complementary feeding
   D. Formation of good food habits
5. The following are factors that determine nutrient needs except:
   A. Age
   B. Sex
   C. Race
   D. Disease
6. ____ are the processes by which an organism ingests, absorbs, transports, utilizes and excretes food substances
   A. Nutritional status
   B. Nutrition
   C. Food consumption
   D. Dietary intake
7. Which one of the following factors does not cause nutritional vulnerability?
   A. Changes in nutrient and energy needs
   B. Changes in food access and intake
   C. Changes in physiological demands
   D. None of the above

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9.3.2.4 Tools, Equipment, Supplies and Materials

- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.2.5 References

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9.3.3 Learning Outcome 2: Demonstrate knowledge in nutrition during pre-pregnancy

9.3.3.1 Learning Activities

Learning Activities	Special instructions
i) Identify and describe nutrition needs of men and women before conception	➢ Identify functions of Nutrients in Pre-conception
ii) Identify and describe the importance of pre-conception nutrition knowledge and services	➢ Describe the importance of pre-conception care
iii) Identify and describe he risk factors with nutrition implications	➢ Identify factors related to altered fertility in women and men ➢ Demonstrate knowledge of nutrition-related effects of contraceptives
iv) Identify nutrition needs during preconception	➢ Calculate nutritional needs of men and women in preconception

9.3.3.1 Information Sheet

Definition of terms

Conception: the action of conceiving a child or of one being conceived.

Implantation: attachment of a fertilized egg to the uterine lining

Infertility: This is inability to conceive

Antioxidant: Substances that prevent oxidation or damage of cells by free radicals

Pre-Pregnancy Nutrition

It refers to the nutrition of before conception and pregnancy and it's very important

An optimal level of nutrition during the preconception period ensures that a woman begins pregnancy with all the necessary nutritional stores to produce substances required to maintain a healthy pregnancy and support the developing embryo/foetus.Poor maternal nutritional status prior and during pregnancy has been associated with low birth weight; less than 2500g, intra-uterus growth retardation, premature birth etc

Pre-pregnancy nutrition influences a woman's ability to conceive, determines foetus growth and development, and determines size of foetus as well as the health of a mother.

A woman planning to conceive should ensure optimal nutrition at least 1 year prior to conception and throughout the early months of pregnancy.

Risk Factors with Nutrition Implications

The following factors are related to altered fertility in men and women:

- Nutritional Factors:
  - o Weight loss > 10-15 %of normal weight
  - o Inadequate antioxidant status (selenium, Vit. C & E)
  - o Inadequate body fat
  - o Excessive body fat, especially central fat
  - o Extreme levels of exercise
  - o High alcohol intake
  - o Celiac disease(related to altered action of androgens, delayed sexual maturation, amenorrhea, miscarriages)
- Endocrine disorders (e.g Hypothyroidism)
- Structural abnormality of the respiratory system
- Chromosomal abnormalities in sperm and eggs
- Severe psychological stress
- Infection (STI)
- Diabetes, cancer and other disorders
- Some Medications

Factors Related to Altered Fertility in Women

- Recent oral contraceptives use (within 2 months)
- Anorexia nervosa, bulimia nervosa
- Vegan diets
- Age > 35 yrs
- Metabolic syndrome
- Pelvic Inflammatory disease (PID)
- Endometriosis
- Polycystic ovary syndrome
- Poor iron stores

Factors Related to Altered Fertility in Men

- Inadequate zinc status
- Heavy metal exposure(lead, mercury)
- Halogens exposure

- Sperm defects
- Steroid abuse
- High intake of soy foods

Functions of Nutrients in Pre-conception

Antioxidants: Vitamin E, Vitamin E, Vitamin C, beta-carotene and selenium

Antioxidants are needed to protect cells of the reproductive system eggs and sperm from free radicals, which can damage sperm cell DNA.

In women, free radicals can damage the egg and interfere with implantation.

Zinc status and fertility in men:

Zinc has the following functions in male fertility:

- Reducing oxidative stress
- Sperm maturation
- Testosterone synthesis

Low zinc status is related to lower sperm quality, lower sperm concentration, and abnormal sperm shapes.

Zinc supplementation alone or combined with Vitamin C and E has been found to improve sperm quality.

Preconception Iron status, Fertility and pregnancy Outcomes:

Iron deficiency prior to pregnancy increases the risk of iron-deficiency anemia during pregnancy.

Infants born to such women will also have low iron stores.

Iron deficiency before pregnancy is also related to increased cases of preterm delivery.

Women who intend to conceive should build their iron stores before pregnancy. It is easier and more efficient.

Alcohol and Fertility:

Alcohol consumption before and during pregnancy is harmful to the foetus and has been associated with foetal abnormalities. It affects fertility by interfering with estrogen and testosterone levels, testicular function and disrupting the menstrual cycle.

Alcohol consumption of over 10 drinks per week has been related to about 66% reduction in probability of conception.

Consumption of 7 or more drinks per week has been associated with a doubling the risk of infertility in women over the age of 30.

Contraceptive Use and Nutritional Status

There are different types of birth control products for women used today. They include injections, implants, oral contraceptives and patches. They have various side effects, which include nutritional side effects such as: elevated blood lipids, glucose intolerance, micronutrient deficiencies, weight gain e.t.c.

Nutrition-Related Effects of Contraceptives		
Oral Contraceptives	***Contraceptive Implants***	***Contraceptive Injections (Depo-Provera)***
• Increased blood levels of HDL • Increased triglycerides and LDL • Increased risk of blood clots, cervical cancer and cardiovascular disease • Decreased blood levels of Vitamin B12 and B6 • Increased blood levels of copper • Contraceptive Implants: • Weight gain • Increased blood levels of HDL • Increased triglycerides and LDL • Increased risk of blood clots, cervical cancer and cardiovascular disease • Decreased blood levels of Vitamin B12 and B6 • Increased blood levels of copper	• Weight Gain	• Weight gain • Increased blood levels of LDL cholesterol • Increased insulin levels • Decreased blood levels of HDL cholesterol • Decreased bone density

Importance of Pre-Conception Care

- Optimal nutrition before conception ensures the woman begins the pregnancy with a good store of nutrients in her tissues so that the needs of the fetus can be met without affecting her health.
- Adequate nutritional stores are also required to support optimal development and maintenance of the foetus. Deficiencies of nutrients e.g. Folate, iron, calcium and Vitamin D during the preconception period can have detrimental effects on the growing embryo.
- Reduces risk of complications during delivery.
- Improves pregnancy outcomes.
- Reduces infant and maternal mortality.

9.3.3.3 Self-Assessment

1. Discuss the nutrition-related effects of contraceptives
2. Discuss effect of malnutrition on fertility
3. Which one of the following nutrients is not an antioxidant?
   A. Vitamin C
   B. Vitamin E
   C. Iron
   D. Selenium

4. Which one of the following is not a nutritional factor associated with altered fertility?
   A. Recent oral contraceptives use
   B. Anorexia nervosa, bulimia nervosa
   C. Vegan diets
   D. Poor iron stores
5. Indicate whether the following statements are true or false about pre-conception nutrition?
   A. In women, free radicals can damage the egg and interfere with implantation.
   B. Low zinc status is related to lower sperm quality, lower sperm concentration, and abnormal sperm shapes.
   C. Alcohol consumption before and during pregnancy is harmful to the foetus and has been associated with foetal abnormalities

9.3.3.4 Tools, Equipment, Supplies and Materials

- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.3.5 References

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9.3.4 Learning Outcome 3: Demonstrate knowledge in nutrition during Pregnancy Learning Activities

9.3.4.1 Learning Activities

Learning Activities	Special instructions
i) Identify terminologies during pregnancy	➢ Define terminologies related to pregnancy
ii) Identify the ***stages of pregnancy*** and describe their nutrition implications	➢ Demonstrate knowledge of the stages of pregnancy
iii) Identified and describe complications during each stage of pregnancy	➢ Manage nutrition-related complications in pregnancy
iv) Identify and describe nutrition needs during pregnancy	➢ Calculate individual nutrient needs in pregnancy
v) Identify and describe prenatal care services and other interventions for pregnant women	➢ Advice on prenatal care services ➢ Demonstrate knowledge of WHO/ UNICEF policies and guidelines on prenatal care services and interventions

9.3.4.2 Information sheet

Definitions

Preterm: An infant born before 37 weeks are over.

Prenatal care: Health care provided for a pregnant woman until delivery.

Gestational diabetes: Glucose intolerance in pregnant women who have are not diabetic.

Nutrition in Pregnancy

Pregnancy outcome is significantly affected by nutritional status of the mother, before and during pregnancy. Her body should be capable of conception, carrying the pregnancy to term and successful delivery, all which depend on food intake and utilization. During pregnancy, the mother has increased energy and nutrient needs to support growth and development of the foetus and support maternal tissue.

Nutritional deficiencies during this critical stage in the lifespan can cause harmful effects on the foetus or cause complications during pregnancy and/or delivery.

Pregnant women should therefore be keen to furnish their bodies with the required energy and nutrients throughout the pregnancy.

Physiological Changes that Occur During Pregnancy

During pregnancy many changes occur in the body of a pregnant woman and cause more changes of all the mothers' body systems. They also influence nutrition requirements and their use in the body.

Altered metabolism:

- The BMR increases by the fourth month of gestation and increases 15-20% above normal level by term.
- This increase reflects increased oxygen demand of the fetus and maternal tissues therefore the calorie requirement also increases. In addition to increased metabolic rates, the metabolism of nutrients is also altered.
- Fat becomes the major source of maternal fuel
- Decrease in insulin efficiency particularly at the later part of pregnancy as a compensatory mechanism to increase glucose availability thus gestational diabetes. (resolves after birth).

Weight gain:

- Women may lose weight in the first trimester due to vomiting and nausea. Adequate weight gain is essential for foetal growth and the desired weight gain is based upon pre-pregnancy weight using BMI. On average a healthy well-nourished woman should gain approximately 12-15 kg. Underweight are advised to gain more to avoid:
    - o Preterm
    - o Low birth weight
    - o Small for gestational age babies.

Recommended Pregnancy Weight Gain by BMI

Pregnancy state (if pregnancy weight was):	Recommended weight gain in kg
Normal	11.5-16.0
Underweight	12.5-18.0
Overweight	7-11.5
Obese	5-9.0

Change in Blood Volume:

There is an increase total blood plasma volume of approximately 33% above the normal level and may increase to 50% by the end of pregnancy.

This increase enables the blood to circulate through the placenta to carry nutrients to the foetus and also to remove the metabolic wastes. The increase in blood plasma exceeds increase in RBC's resulting to hemodilution or physiologic anemia of pregnancy. This occurs during the 2nd and 3rd trimester when there is the largest rise in blood plasma volume. The concentration of albumin and most nutrients is also lower during pregnancy due to hemodilution. Minor edema may occur but considered normal if not accompanied by hypertension and proteinuria.

Gastro Intestinal Changes:

Increased progesterone production slows the gastro intestinal motility.

There is a slowed passage of food through the GIT, which enhances absorption of nutrients

Decreased motility and crowding of the abdomen with foetus causes Esophageal reflux, and therefore heart burn and constipation.

Intestinal secretions e.g. HCI are decreased, reducing gastric acidity and reducing iron and calcium absorption.

Renal Changes:

Renal flow increases by 75% and glomerular filtration rate by 50% . Glucose, amino acids and water soluble vitamins may be excreted at a higher rate. The kidney is not able to adjust completely and as a result the nutrients to be absorbed are excreted. The ability to excrete H2O is lowered and therefore presence of mild edema.

Hormonal changes:

There's increased secretion of hormones which ensure maintenance of pregnancy and prepare the mother for development of fetus .These include:

- Progesterone
- Estrogen
- Lactogen
- Prolactin
- Oxytocin.

Changes in hormones influences nutrients requirement because different hormones perform different functions during pregnancy.

Stages of Pregnancy

A normal pregnancy lasts between 38 – 40 weeks and is divided into 3 periods referred to as trimesters.

1st trimester:

Foetal development starts at this trimester with the fertilization of an ovum by a sperm, forming a zygote (a fertilized ovum).

During the week after fertilization, the fertilized egg grows into a microscopic ball of cells (blastocyst), which implants on the wall of the uterus.

It then develops into an embryo, attached to a placenta and surrounded by fluid-filled membranes

This implantation triggers a series of hormonal and physical changes in the mother's body.

The first trimester is marked by rapid changes for both the mother and the baby.

The baby's brain, spinal cord and other organs begin to form, and baby's heart begins to beat.

Baby's fingers and toes even begin to take shape.

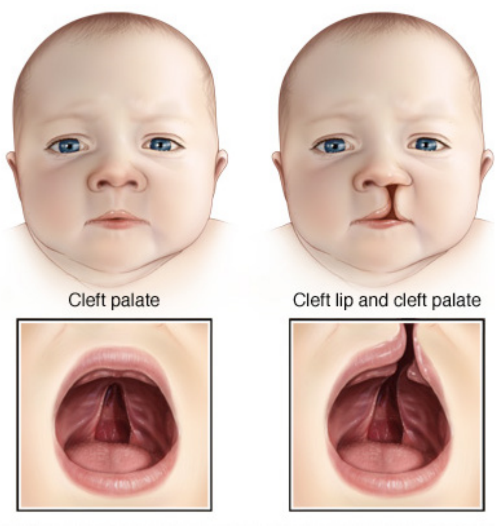
This is the beginning of the critical period of development and any injury caused by nutritional deficiencies, medication, drug abuse, radiation, trauma and other factors can interfere with the specific phases of growth in progress.

It is a time of intense rapid cell division and events scheduled for this time can only occur then and not later.

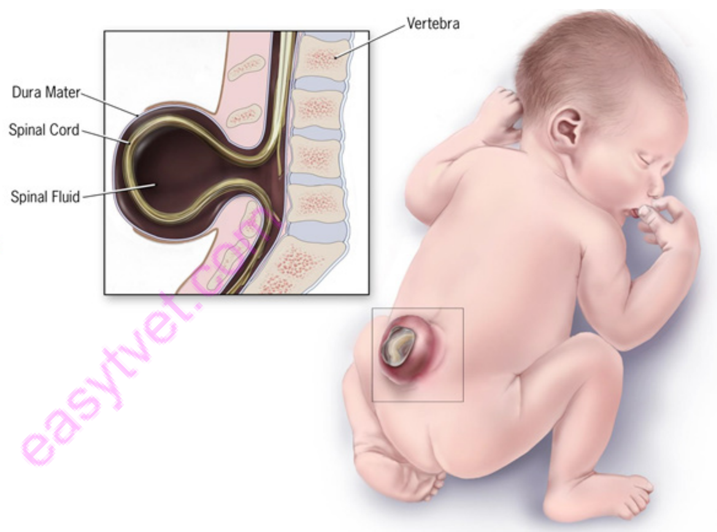
At the end of the 8th week after fertilization, the embryo is considered a fetus.

In this trimester, nutrient deficiency can cause defects such as cleft palate, missing limbs and neural tube defects. This can produce major defects in the CNS causing serious disabilities and even infant death.

Neural tube defects include Spina bifida, which is characterized by incomplete closure of the spinal column. It is also accompanied by varied abnormalities and is associated with Folate deficiency.



Cleft lip and palate



Spina bifida

2nd Trimester:

During this trimester the fetus has arms, hands, fingers, feet and the toes.

It also has ears and also begins to form the tooth sockets in its jaw.

The developing organs continue to grow and mature and at this stage the heartbeat can be felt.

Most of the bones are distinct throughout the body and the foetus starts looking like an infant.

The fetus can suck their thumb and kick at this stage.

3rd Trimester:

The seventh, eighth, and ninth months are the third and final trimester of pregnancy.

Babies weigh about 2 1/4 pounds by the start of the third trimester.

They can blink their eyes which now have lashes.

Their wrinkled skin is starting to smooth out as they put on baby fat.

They're also developing fingernails, toenails, and hair and adding billions of neurons to their brain. The baby will spend his or her final weeks putting on weight.

At full term, the average baby is more than 19 inches long and weighs nearly 7 pounds

Complications during Pregnancy

1. Nausea and vomiting

Pregnant women may experience nausea and vomiting in the first trimester. Sensitivity to food appearance, texture and smell is blamed on hormonal changes in pregnancy. This leads to loss of nutrients and they need to compensate by consuming extra nutrients and calories. Severe vomiting may lead to dehydration, which is harmful to the mother and the foetus.

How to manage Nausea and Vomiting:

- Eat dry toast or crackers
- Arise slowly
- Chew gum
- Eat small, frequent meals
- Avoid foods with offensive odors
- When nauseated, do not drink water, milk, coffee or tea

2. Constipation

Pregnant women may also experience constipation. Hormones that support pregnancy alter intestinal muscle tone and increases food transit time. Also, the growing foetus exerts pressure on the intestinal organs. These two changes cause pregnant women to experience constipation, which causes bloating and abdominal discomfort.

Constipation can be relieved by;

- Eating foods high in fiber (fruits, vegetables and whole-grain cereals)
- Exercise regularly
- Drink at least 8 glasses of liquids a day
- Respond promptly to the urge to defecate
- Use laxatives only as prescribed by a physician

3. Heart burn

Heartburn results from relaxation of intestinal muscles, including the lower esophageal sphincter, allowing stomach acid to flow back into the esophagus. The growing foetus also exerts pressure on the stomach, forcing its contents into the esophagus. This causes a burning sensation.

Constipation may be relieved by:

- Eating small, frequent meals
- Drinks liquids between meals
- Avoid spicy or greasy foods
- Chew food thoroughly
- Sit up while eating; elevate the head while sleeping
- Wait an hour after eating before lying down or exercising

4. Gestational Diabetes

1 in 14 pregnant women who does not have diabetes develops gestational diabetes, a glucose intolerance that develops during pregnancy. It is characterized by high blood glucose levels. The condition resolves after pregnancy but some women develop Type 2 diabetes, especially if they're overweight. With appropriate nutritional care and adequate follow up, harmful effects can be prevented.

The most common consequences of gestational diabetes are complications during labor and delivery and a high infant birth weight.

Birth defects associated with gestational diabetes include;

- Heart damage
- Limb deformities
- Neural tube defects.

Diet and moderate exercise may control gestational diabetes, but if blood glucose fails to normalize, insulin or other drugs may be used.

Women with gestational diabetes are advised to limit weight gain and maintain normal blood glucose levels.

5. Pre-eclampsia:

Condition characterized by high blood pressure, proteinuria and fluid retention. The edema seen in preeclampsia is whole-body fluid retention, different from normal localized edema that develops in pregnancy.

The placenta may separate from the uterus, leading to premature birth.

Pre-eclampsia often occurs after 20 weeks gestation.

6. Pre-term delivery:

Preterm birth is when a baby is born too early, before 37 weeks of pregnancy have been completed. The infants are born with various complications such as poor lung development.

Preterm may be caused by factors such as preeclampsia, chronic medical conditions, drug abuse, multiple gestation, and abnormal rupture of the uterus.

Nutrient Needs during Pregnancy

Protein and Energy Needs in Pregnancy

State	Trimester/ Period	Energy requirements	Protein requirements
Pregnancy	First trimester	36-40kcal/kg/day	0.8-1.0g/kg/d
		+150kcal/day	+0.7g/day
	Second trimester	+300kcal/day	+3.3g/day
	Third trimester	+300kcal/day	6g/day
Adolescent in pregnancy		40-43 kcal/kg/d	1.5g/kg/day add extra as per the trimester
Lactation	First 6mths then decrease gradually	+505kcal/day	+17.5g/day for the first 6mths of lactation +13g/day for next six months and 11g/day thereafter
	*Underweight women	+675kcal/day	+21g/day

Micronutrient requirement in pregnancy

Nutrient	Adult women	Pregnant women	Lactating mothers
Vitamin A (μg RE)	500	800	850
Vitamin D (μg)	5	5	5
Vitamin E (mg α-TE)	8	10	12
Vitamin K (μg)	65	55	55
Vitamin C (mg)	45	55	95
Vitamin B_1 (mg)	1.1	1.4	1.5
Vitamin B_2 (mg)	1.1	1.4	1.6
Niacin (mg NE)	14	18	17
Vitamin B_6 (mg)	1.3	1.9	2.0
Folate (μg)	400	600	500
Vitamin (B_{12})	2.4	2.6	2.8
Calcium (mg)	1000	1200	1000
Phosphorus (mg)	800	1200	1200
Magnesium (mg)	280	320	355
Iron (mg)	15	30	15
Zinc (mg)	12	15	19
Iodine (μg)	150	200	200
Selenium (μg)	26	30	42

Prenatal Care Services

WHO estimates that over two-thirds of pregnant women in Africa (69 percent) have at least one Ante Natal Care (ANC) contact during pregnancy.

Essential interventions in ANC include:

- Identification and management of obstetric complications such as pre-eclampsia,
- Tetanus immunization
- Intermittent preventive treatment for malaria during pregnancy (IPTp)
- Identification and management of infections including HIV, syphilis and other sexually transmitted infections (STIs Importance of prenatal care).

ANC is also an opportunity to promote the use of skilled attendance at birth and healthy behaviors such as breastfeeding, early postnatal care, and family planning for optimal pregnancy spacing.

Components of ANC

- Registration
- History taking
- Obstetric examination
- Clinical service / treating minor ailments
- Health education
- Immunization

9.3.4.3 Self-Assessment

1. Identify physiological changes that take place during pregnancy
2. Identify the components of ANC
3. Discuss the nutritional management of heart burn in pregnancy
4. The following are consequences of poor weight gain during pregnancy except:
   A. Preterm delivery
   B. Low birth weight
   C. Neuro tube defects
   D. Small for gestational age babies
5. ____ is a condition characterized by high blood pressure, proteinuria and fluid retention
   A. Gestational diabetes B. Pre-eclampsia
   C. Placenta Previa D. Intrauterine growth retardation

6. Which one of the following is a component of Antenatal Care
   A. Registration
   B. Obstetric examination
   C. Health education
   D. All the above
7. Which one of the following is not advisable for pregnant mothers experiencing heart burn?
   A. Eating small, frequent meals
   B. Drinks liquids with meals
   C. Avoid spicy or greasy foods
   D. Sit up while eating; elevate the head while sleeping
8. Which of the following is not true about gestational diabetes?
   A. All pregnant women suffer from gestational diabetes
   B. The condition resolves after pregnancy
   C. Some women develop Type 2 diabetes after gestational diabetes, especially if they're overweight.
   D. With appropriate nutritional care and adequate follow up, harmful effects can be prevented.

9.3.4.4 Tools, Equipment, Supplies and Materials

- Food models
- Charts
- Manuals
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.4.5 References

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9.3.5 Learning Outcome 4: Demonstrate knowledge in nutrition during Lactation

9.3.5.1 Learning Activities

Learning Activities	Special instructions
i) Identify terminologies during lactation as per the existing policies and guideline	➢ Define terminologies used in lactation
ii) Identify and describe postnatal care services and other interventions for lactating women as per WHO/UNICEF policies and guidelines	➢ Provide nutrition education ➢ Teach food hygiene and safety ➢ Provide support for lactating mothers
iii) Identified and describe breast feeding indicators and strategies as per WHO/ UNICEF policies and guidelines	➢ Demonstrate knowledge of WHO/UNICEF guidelines on breastfeeding
iv) Identify and describe nutrition needs during lactation as per the RDAs for macro and micronutrients	➢ Calculate nutrition requirements during lactation

9.3.5.1 Information sheet

Definitions

Exclusive breastfeeding: Feeding an infant with nothing but breast milk for the first six months of life, except ORS, drops and syrups (vitamins, minerals and medicines).

Colostrum: The first type of mil produced by the mammary glands after birth, which is usually rich in antibodies

Human milk is the perfect food for infants until the age of six months. It contains adequate energy and proteins needed to support growth and development at this crucial stage in the lifespan.

Other liquids or foods can introduce source of infection and contamination, can also lower the quantity of the nutrients and may also cause a premature disruption of milk production.

The Milk Let- Down Reflex

It is an important brain-breast connection referred to as the let-down reflex is necessary. Suckling by the infant sends signal to the mother's brain which then sends a signal to the pituitary glands.

The anterior pituitary secretes the hormone prolactin which stimulates the synthesis of milk in the breast.

The posterior pituitary produces the hormone oxytocin, which causes contraction of the smooth muscle cells that are in the alveoli and ducts of the mammary glands. This causes the milk ducts to contract so that milk is releases and ejected from the breast.

This process can be inhibited by tension, nervousness and fatigue.

Once lactation is established, milk production continues with suckling several times a day. When suckling stops, milk production diminishes.

Components of Breast Milk

1. **Carbohydrates**

Breast milk contains carbohydrates. The main being lactose, which provides over 40% of calories

Importance of lactose in breastmilk:

- Facilitates absorption of Ca & Mg
- Favors the absorption & retention of nitrogen
- Increases the acidic environment in the intestines, which stimulates the growth of gut bacteria.
- Provides galactose, important for nerve sheath synthesis.(brain development)

2. **Proteins:**

The amount of protein in breastmilk is less than in cows' milk, but this quantity is beneficial because it places less stress on the infant's immature kidneys to excrete urea, the major byproduct of protein metabolism. Much of the protein in breastmilk is whey protein, which is efficiently digested and absorbed. Approximately 60-80% of all protein in human milk is whey protein.

3. **Lipids:**

Breast milk provides approximately 50-58% of total calories in cow milk, yet the lipids in human milk are easily digested because of fat-digesting enzymes contained in breast milk. It contains essential fatty acids, such as linoleic acid & linolenic acid as well as their longer chain derivatives arachidonic acid and DHA. DHA is the most abundant fatty acid in the brain & is also present in the retina of the eye, contributing to neural and visual development.

4. **Vitamins:**

All vitamins needed for growth and health of infant are supplied in breast milk. However, some vitamin content in breast milk varies with the mother's diet. E.g Vitamin D

Human milk contains enough Vitamin A &Vitamin B6

5. **Minerals**

Breast milk contains enough minerals to support adequate growth &development. These minerals are in just enough amounts, and so cannot burden the immature infant kidneys.

Babies are born with a reserve of iron, which comes from their mother's blood while they are in the womb. For the first 6 months of life, breastfed babies will get what they need from their mother's milk. Although human milk is low in Iron, 50% is absorbed.

Zinc absorption is better from breast milk than cow's milk.

Breast milk is low in sodium compared to cow's milk.

Cow's milk contains as much Ca, 6 times as much Phosphorous, two times as much Flourine & 3 times as much Sodium as breast milk.

Variables Affecting Breast Milk Composition

The composition of breast milk constantly changes due to:

1. **Stage of lactation (colostrum, transitional milk, mature milk)**

Colostrum:

It is higher in proteins, minerals and Sodium than mature milk. It is however lower in sugar, fat and calories. Colostrum is rich in antibodies and anti-infective factors that protect infants against various gastro intestinal infections.

Transitional Milk:

Colostrum begins to change to transitional milk about the 3^{rd} – 6^{th} day after delivery and at this stage protein decreases while carbohydrates and fat increases.

Mature Milk:

By the 10^{th} day the mature milk is stable.

2. **Maternal diet**

The content of some minerals, total fat and cholesterol is not significantly affected by maternal diet. The content of other nutrients e.g. calcium are maintained at the expense of maternal tissues when maternal intake is inadequate.

The vitamin content declines as a result of inadequate maternal intake especially the Vitamin B, A, C and D.

3. **Duration of the Feed**

Foremilk is significantly lower in fat than hind milk. The increase in fat content is a physiological mechanism designed to provide satiety and also to signal the infant to stop feeding.

Mothers are encouraged to breastfeed the infant for longer so they benefit from the richer hind milk.

Advantages of Breastfeeding

- Breast milk contains all the nutrients needed by infant & in correct proportions to promote optimal growth.
- Contains immunological factors found in colostrum which contribute antibodies which help infants fight infection.
- Provides a sense of security for the child (bonding)
- There's less risk of contamination because breast milk isn't exposed to the external environment.
- Reduces the likelihood of allergic reactions since there are no foreign substances being introduced
- Helps the uterus to contract

- Reduces the risk of developing breast cancer
- Delays ovulation, when suckling is consistent; it is a birth control method.
- Saves money; economical
- Helps conserve iron stores
- Helps mother go back to pre-conception weight (fat accumulated is used)

Contraindications of Breastfeeding

- Mothers who have active untreated tuberculosis
- Mother is taking some medication that can pass through breast milk and adversely affect the infant e.g TB medication, chemotherapy drugs
- When the infant has diseases such as galactocaemia; cannot metabolize galactose or Phenylketonuria (PKU)-when infant cannot handle the amount of phenylalanine found in breast milk.

Nutritional Needs during Lactation

- During lactation nursing mothers tend to feel thirstier, owing to the fact that part of their water consumption is utilized by the body for the formation of milk. Increase water intake by one quarter per day to provide a total of 2.5 to 3 quarters per day
- Increase calorie consumption to about 2500 calories per day
- Encourage consumption of healthy foods rich in nutrients
- Encourage lactating mothers to eat more protein rich foods
- Provide small frequent meals
- Avoid smoking tobacco and consumption of alcohol
- Consult a physician/doctor before taking any kind of medication
- Provide folic acid and iron supplements

	Acceptable micronutrients distribution range (AMDR)		
Nutrients (unit of measure/day)	Adult women	Pregnancy	Lactation
Vitamin A (mcg)	400-600	500-700	800-1,000
Vitamin B6 (mg)	1.1-1.3	1.6-1.9	1.7-2
Vitamin B12 (mcg)	2-2.4	2.2-2.6	2.4-2.8
Vitamin C (mg)	60-85	70-100	90-130
Thiamin (mg)	0.9-1.1	1.2-1.4	1.2-1.4
Riboflavin (mg)	1.1-1.3	1.4-1.7	1.5-1.8
Niacin (mg)	14-18	17-22	17-22
Folic acid (mcg)	320-400	520-600	450-500
Vitamin D (mcg)	10-15	10-15	10-15
Vitamin E (mg)	12	12	15
Vitamin K (mcg)	140	140	140
Calcium (mg)	800-1,000	800-1,000	800-1,000
Phosphorus (mg)	580-700	580-700	580-700
Magnesium (mg)	170-240	170-240	170-240
Iron (mg)	10-18	22-27	8-11
Zinc (mg)	7-8	9-11	10-13
Copper (mg)	0.7-0.9	0.9-1.2	1.2-1.6
Selenium (mcg)	45-55	45-55	59-70
Iodine (mcg)	150	220	290

Micronutrient Requirement in Lactation

Practices Incompatible with Lactation

1. **Caffeine:**

   Should be restricted or used in moderation because it is passed to the baby in breast milk. It causes the baby to be irritable and wakeful; too much interferes with bioavailability of iron from breast milk

2. **Alcohol:**

   May alter the flavor of breast milk and cause infant to reject breast milk

   Infants metabolize alcohol inefficiently and even lower doses have enough potential to suppress their feeding behavior.

   Alcohol may also reduce breast milk production by inhibiting oxytocin

3. **Some Medication:**

   Some medicines are contraindicated, either because they suppress lactation or because they are secreted into breast milk and can harm the infant. Mother should consult before taking any drug, including herbal supplements

4. **Illicit drugs:**

   Drug abuse poses harm to the physical & emotional health of the mother and the infant. Breast milk can deliver high doses of illicit drugs to cause irritability, tremors, hallucinations & even death in infants

5. **Smoking:**

   Smoking reduces breast milk volume and nicotine affects the smell and flavor of breast milk.

9.3.5.3 Self-Assessment

1. Discuss the nutritional composition of breast milk
2. Outline the importance of colostrum
3. Discuss the variable that affect the composition of breast milk
4. Indicate whether the following statements are true or false
   A. The milk let-down reflex can be inhibited by tension, nervousness and fatigue
   B. The amount of protein in breastmilk is less than in cows' milk
   C. Babies are born with a reserve of iron that lasts them 9 months
   D. Mothers who have active untreated tuberculosis should not breastfeed
   E. Caffeine can be taken liberally during lactation as it does not affect the baby

9.3.5.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO policies and guidelines
- MOH policies and guidelines
- Skills lab

- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.5.5 References

WHO. (1995). The World Health Organization's infant feeding recommendation. Wkly Epidemiol Rec, 70(17), 119-120.

Brown, J. E. (2016). *Nutrition through the life cycle*. Cengage Learning.

9.3.6 Learning Outcome 5: Demonstrate knowledge in nutrition during Infancy (0-24 months)

9.3.6.1 Learning Activities

Learning Activities	Special instructions
i) Identify nutrition related terminologies in infancy	➢ Define terminologies related to infancy
ii) Describe nutrition requirements for infants 0-6 months/breast feeding indicators	➢ Identify breastfeeding indicators
iii) Describe breast feeding in vulnerable situations and in the context of HIV and AIDS	➢ Demonstrate knowledge of breastfeeding in vulnerable groups and HIV/AIDS
iv) Identify and describe initiatives to promote good breast feeding practices	➢ Identify good breastfeeding practices ➢ Guide mothers on proper breastfeeding practices
v) Identify and describe nutrition requirements and need of infants 0-6 months	➢ Determine nutritional requirements of infants
vi) Describe nutrition requirements and feeding of infants 9 months to 11 months	➢ Calculate nutrition requirements and feeding of infants 9 months ➢ Demonstrate knowledge of complementary feeding
vii) Describe nutrition requirements and feeding of infants 12 months to 24 months as per MOH, WHO/UNICEF policies and guidelines	➢ Determine nutrition requirements and feeding of infant 12 months to 24 months

9.3.6.2 Information sheet

Infant: A baby between 0 and 1 year old

Complementary feeding: Type of feeding given to infants at 6 months when breast milk alone is no longer sufficient to meet the nutritional needs.

Nutrition during the 1st year of life has long term consequences which affect health throughout life.

Growth, development & maturation occur more rapidly than any other time and adequate feeding achieves normal physical & mental development.

Nutritional deficiency effects on the infant's health will depend on when the deficiency occurs and how long it lasts. If deficiency occurs within the critical period, the consequences may be permanent.

The success of early child feeding depends on:

- The choice of feeding method
- The timing
- Pattern of introducing solid foods

Developmental Milestones in Infancy

- Infants lose weight during the 1st few days of life but the birth weight is usually regained by the 7th-10th days of life; body water decreases throughout infancy.
- They double their birth weight by the time they're 4-6 months and triple by 1yr.
- By the end of the 1st year, the growth rate slows considerably.
- They increase their length by 50% during the 1st year of life
- Total body fat increases rapidly for the first 9 months after which the rate of fat gain tappers off for the rest of the childhood.
- The newborn has a functional but physiologically immature kidney- that increases in size and the stomach capacity increases from 10-20Mls at birth to 200mls by 1yr
- Although gastric secretion of pepsin remains low (during the first 3 months) the enzymatic activity is sufficient to digest the milk protein the infant ingests normally
- Lactase activity reaches adult levels by birth whereas pancreatic amylase remains low for the 1st 6 months. (If an infant is fed on starch earlier, increased activity of salivary amylase & digestion in the colon may compensate for the low pancreatic amylase)

Infant Feeding Options

- Breastfeeding
- Infant formula
- Wet nursing
- Heat-treated animal milk
- Milk banks (breast milk)

Nutrition Requirements for Infants

The nutrient needs of the infants are determined by:

- The rate of growth
- Energy expended in activity
- Basal metabolic needs
- The interaction of nutrients consumed

Nutritional Requirements of Infants

Energy requirements:

Age	Energy Requirement per Day
0-3 months	**100-120kcal/kg**
3-6 months	**110-115kcal/kg**
6-12 months	**90-110 kcal/kg**

Careful monitoring of energy & nutrient intakes should be done in the event of weightt reduction, failure to gain weight, weight loss or failing growth, which could signify malnutrition or undetected disease.

Protein

2g-2.2 g/kg body weight is adequate for tissue growth. Proteins should provide 30-40% of calories per day. This is adequately provided in breast milk

Requirements are based on the composition of human milk, with the assumption that breast milk is 100% utilised and that breast milk is adequate for the first 6 months.

In the 2nd 6 months of life, the diet should be supplemented with high quality proteins.

Inadequate intake of proteins can result from:

- excessive dilution of milk formula
- deprivation due to poverty
- food allergies
- Extreme vegetarian food patterns.

Carbohydrates

Should supply 30-60% of energy intake

37 % of the calories in breast milk and 40-50% of calories in commercial formula are derived from lactose

Fluid

Requirements are determined by the amount of losses from the skin, lungs, faeces and urine and a small amount needed for growth.

Human milk supplies water in amounts adequate under ordinary conditions, but additional water may be necessary if the weather is hot & humid or due to other losses like diarrhea.

Breastfeeding in HIV/ AIDS

The most appropriate infant feeding option for an HIV-infected mother should continue to depend on her individual circumstances, including her health status and the local situation, but should take greater consideration of the health services available and the counselling and support she is likely to receive.

Exclusive breastfeeding is recommended for HIV-infected women for the first six months of life unless replacement feeding is acceptable, feasible, affordable, sustainable and safe for them and their infants before that time.

When replacement feeding is acceptable, feasible, affordable, sustainable and safe, avoidance of all breastfeeding by HIV-infected women is recommended.

At six months, if replacement feeding is still not acceptable, feasible, affordable, sustainable and safe, continuation of breastfeeding with additional complementary foods is recommended, while the mother and baby continue to be regularly assessed. All breastfeeding should stop once a nutritionally adequate and safe diet without breast milk can be provided.

Whatever the feeding decision, health services should follow up all HIV exposed infants, and continue to offer infant feeding counselling and support, particularly at key points when feeding decisions may be reconsidered, such as the time of early infant diagnosis and at six months of age

Breastfeeding mothers of infants and young children who are known to be HIV infected should be strongly encouraged to continue breastfeeding.

Initiatives to Promote Good Breastfeeding Practices

The World Health Organization (WHO) recommends the following steps to successful breastfeeding:

Critical Management Procedures

1.
    a) Comply fully with the International Code of Marketing of Breast-milk Substitutes and relevant World Health Assembly resolutions.
    b) Have a written infant feeding policy that is routinely communicated to staff and parents.
    c) Establish ongoing monitoring and data-management systems.
2. Ensure that staff has sufficient knowledge, competence and skills to support breastfeeding.

Key Clinical Practices

3. Discuss the importance and management of breastfeeding with pregnant women and their families.
4. Facilitate immediate and uninterrupted skin-to-skin contact and support mothers to initiate breastfeeding as soon as possible after birth.
5. Support mothers to initiate and maintain breastfeeding and manage common difficulties.
6. Do not provide breastfed newborns any food or fluids other than breast milk, unless medically indicated.
7. Enable mothers and their infants to remain together and to practise rooming-in 24 hours a day.

8. Support mothers to recognize and respond to their infants' cues for feeding.
9. Counsel mothers on the use and risks of feeding bottles, teats and pacifiers.
10. Coordinate discharge so that parents and their infants have timely access to ongoing support and care.

Substantial evidence has indicated that following the Ten Steps improves breastfeeding rates significantly. The steps are to be implemented by facilities providing maternity and newborn services.

Complementary Feeding

Exclusive breastfeeding is recommended for the 1st 6 months of an infant's life. At 6 months, other foods should be introduced to meet increased energy needs and supply adequate nutrients necessary for optimal growth and development at this crucial stage. Complementary feeding should not replace breast feeding. Breast milk remains the primary source of nutrition for the infant.

Guiding Principles for Appropriate Complementary Feeding

- Introduce one type of food at a time and monitor for any allergic reactions for between 2-7 days
- Vary the textures so that the child can get used to variety of food textures
- Meal time environment should be free from distractions
- Start with small serving sizes and increase amount gradually
- Start with feeding two times a day and increase the frequency as tolerated
- Progress from pureed food to mashed then to soft textured food
- Ensure baby is ready for solid foods before introducing any.

Physical Signs That Infant Is Ready For Solid Foods:

- Baby can support his neck or sit up well without support.
- Baby has lost the tongue-thrust reflex; does not automatically push solids out of his mouth with his tongue.
- Baby is ready and willing to chew.
- Baby is developing a pincer grasp, where he picks up food or other objects between thumb and forefinger.
- Baby is eager to participate in mealtime and may try to grab food and put it in his mouth.

Infants should be kept away from the following foods, seeing as they pose health and safety risk:

- Sticky foods e.g. Jelly, chewing gum; could easily choke
- Raw vegetables; risk of contamination, choking

- Honey- contains spores of bacterium, clostridium botulinum which causes botulism.
- Hard and crunchy foods e.g pop corn
- Nuts and seeds

9.3.6.3 *Self-Assessment*

1. List the infant feeding options
2. Discuss the nutritional requirements in infancy
3. Outline the advantages of breastfeeding
4. The following are signs that a baby is ready for solid foods except:
   A. Baby can support his neck or sit up well without support.
   B. Baby has lost the tongue-thrust reflex;
   C. Baby is developing a pincer grasp,
   D. Baby is eager cries a lot
5. Indicate whether the following statements are true or false about infant feeding:
   A. Honey should be used to sweeten baby food
   B. Breastfeeding should stop as soon complementary feeding starts
   C. In exclusive breastfeeding, the child is given breast milk and water for six complete months
   D. Infants should be fed raw vegetable to prevent constipation

9.3.6.4 *Tools, Equipment, Supplies and Materials*

- Textbooks
- Food models
- MOH. WHO/UNICEF Policy and guidelines
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education

- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.6.5 References

Brown, J. E. (2016). Nutrition through the life cycle. Cengage Learning.

World Health Organization. (2018). Ten steps to successful breastfeeding (revised 2018). *Retrieved April*, *30*, 2018.

World Health Organization. (2009). Infant and young child feeding: model chapter for textbooks for medical students and allied health professionals.

9.3.7 Learning Outcome 6: Demonstrate knowledge in nutrition for preschoolers (25-59 months)

9.3.7.1 Learning Activities

Learning Activities	Special instructions
i) Identify nutrition related terminologies for pre-schoolers	➢ Define terminologies related to nutrition for pre-schoolers
ii) Describe developmental milestones for pre-schoolers	➢ Describe developmental milestones for pre-schoolers
iii) Identify and describe nutrition vulnerability for pre-schoolers	➢ Identify vulnerable children among pre-schoolers
iv) Identify and describe nutrition requirements for pre-school children	➢ Calculate nutritional requirements of pre-schoolers

9.3.7.2 Information sheet

Growth is slow but steady at this stage. There is a constant increase in food intake and the child is more active. Height and weight vary greatly due to genetic and environmental influences

In spite of relatively slow growth nutrition plays an important role in:

- Furnishing the energy requirements for the vigorous activities during this age
- Enhance resistance to infection
- Provides building materials for growth
- Provide adequate nutrients stores that assist in adolescent growth.

Factors that influence feeding habits in preschoolers & school-going children include:

- **Family environment/parental influence**: the parents have the last chance to influence food choices for their children. They do this by controlling the availability of different food.
- **Family type and status:** The family's socioeconomic status determines food availability and utilization in the household. Those who are poor will be more vulnerable to multiple stresses including poor nutritional status and this can be due to lack of money for food and poor child care
- **Media:** Pre-schoolers are generally influenced by media especially advertisement and this influences the food preferences of a child. TV & internet access can also encourage inactivity, passive use of leisure time and snacking and all these can result to obesity.

- **Illness/diseases**: ill children have increased nutrient needs and limited food intake. Bacterial or acute viral infections take a short time but require an increase in intake of fluid, proteins. Chronic conditions like asthma and congenital heart diseases may make it difficult to feed. Children will therefore have to adjust to amount of food recommended.

Nutritional Requirements

Age	RDA Calories	RDA proteins
0-3 months	100-120kcl/kg	2.2g/kg
3-6 months	110-115kcl/kg	2.2g/kg
6-12 months	90-110kcl/kg	2.0g/kg
1-3 years	100-105kcl/kg	1.8g/kg
4-5 years	85-100kcl/kg	1.5g/kg

Energy and protein requirements for pre-schoolers

Nutrient	1-3yrs	4-6yrs	7-9yrs
Energy (kcal)	1300	1800	2400
Protein (g)	16	24	28
Vitamin A (μg RE)	400	500	700
Vitamin D (μg)	5	5	5
Vitamin E (mg α-TE)	6	7	7
Vitamin K (μg)	15	20	25
Vitamin C (mg)	30	30	35
Vitamin B_1 (mg)	0.5	0.6	0.9
Vitamin B_2 (mg)	0.5	0.6	0.9
Niacin (mg NE)	6	8	12
Vitamin B_6 (mg)	0.5	0.6	1.0
Folate (μgaffe/day)	160	200	300
Vitamin (B_{12})	0.9	1.2	1.8
Calcium (mg)	500	600	700
Phosphorus (mg)	800	800	800
Magnesium (mg)	60	70	100
Iron (mg)	10	10	10
Zinc (mg)	10	10	10
Iodine (μg)	75	110	100
Selenium (μg)	17	21	21

Micronutrient needs of pre-schoolers

9.3.7.3 Self-Assessment

1. Identify factors that determine feeding habits of preschoolers
2. Describe the developmental milestones for pre-schoolers
3. Which one of the following is not a role of nutrition for pre-schoolers?

A. Furnishing the energy requirements for the vigorous activities during this age

B. Enhance resistance to infection

C. Provide adequate nutrients stores that assist in adolescent growth.

D. All the above

4. Indicate whether the following statements are true about nutrition for pre-schoolers:

A. Growth in this stage is faster than during infancy

B. Ill children may have increased nutrient needs

C. Good feeding habits should begin to be inculcated at pre-school age

D. There is a high risk of child obesity if a pre-schooler is not physically active

9.3.7.4 Tools, Equipment, Supplies and Materials

- Manuals
- Food models
- Charts
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.7.5 References

1. Roberts, S., & Heyman, M. B. (2011). *Feeding your child for lifelong health: birth through age six*. Bantam.

2. Rowell, K., & McGlothlin, J. (2015). *Helping your child with extreme picky eating: A step-by-step guide for overcoming selective eating, food aversion, and feeding disorders*. New Harbinger Publications.

3. Haddad, L., Bhatterai, S., Immink, M., & Kumar, S. (1996). *Managing interactions between household food security and preschooler health*. Intl Food Policy Res Inst.

9.3.8 Learning Outcome 7: Demonstrate knowledge in nutrition for pre-adolescents (6years-12 years)

9.3.8.1 Learning Activities

Learning Activities	Special instructions
i) Identify nutrition related terminologies for pre-adolescents	
ii) Describe developmental milestones	➢ Identify pre-adolescent developmental milestones ➢ Determine nutrition vulnerabilities for pre-adolescents
iii) Identify and describe Nutrition vulnerabilities for pre-adolescents	➢ Identify vulnerable pre-adolescents
iv) Identify and describe nutrition requirements for pre-adolescents	➢ Demonstrate knowledge of pre-adolescent nutritional requirements

9.3.8.2 Information Sheet

Children at this age are often school-going children and so their nutritional requirements will differ from preschoolers. They are more active and actively growing and developing. Their bodies therefore need to be furnished with adequate energy and nutrients.

Pre-adolescents rarely develop severe malnutrition because:

- They are growing more slowly
- They can eat more food at one meal since their stomach capacity has increased
- They are more resistant to many infections
- They can demand for food when hungry
- They are able to get a share of the family meal since they feed faster.
- In the rural setting they collect and eat some wild fruits.

However, undernutrition can still occur if:

- The child was under nourished when they were younger
- If the child is a poor eater
- If there are restrictions; religion, allergies
- When there are parasite infections
- When they consume a lot of low nutritive value snacks

Common nutrition problems for these children include:

- Overweight & obesity
- Anaemia
- Poor dental health
- Allergies
- Parasite infestation
- Protein Energy Malnutrition (PEM)

Nutrition Requirements for Pre-adolescents

Nutrient	1-3yrs	4-6yrs	7-9yrs
Energy (kcal)	1300	1800	2400
Protein (g)	16	24	28
Vitamin A (μg RE)	400	500	700
Vitamin D (μg)	5	5	5
Vitamin E (mg α-TE)	6	7	7
Vitamin K (μg)	15	20	25
Vitamin C (mg)	30	30	35
Vitamin B_1 (mg)	0.5	0.6	0.9
Vitamin B_2 (mg)	0.5	0.6	0.9
Niacin (mg NE)	6	8	12
Vitamin B_6 (mg)	0.5	0.6	1.0
Folate (μgaffe/day)	160	200	300
Vitamin (B_{12})	0.9	1.2	1.8
Calcium (mg)	500	600	700
Phosphorus (mg)	800	800	800
Magnesium (mg)	60	70	100
Iron (mg)	10	10	10
Zinc (mg)	10	10	10
Iodine (μg)	75	110	100
Selenium (μg)	17	21	21

Micronutrient requirement for pre-adolescents

9.3.8.3 Self-Assessment

1. Discuss the nutritional requirement of pre-adolescents
2. The following nutritional and health problems are common in pre-adolescents except:
   A. Anaemia
   B. Poor dental health
   C. Protein Energy Malnutrition (PEM)
   D. Type 2 diabetes

3. Indicate whether the following statements are true or false about pre-adolescent nutrition:
   A. They can eat more food at one meal since their stomach capacity has increased
   B. They are less resistant to many infections than the pre-schoolers
   C. A pre-adolescent child is at risk of malnutrition if they were under nourished when they were younger

9.3.8.4 Tools, Equipment, Supplies and Materials

1. Food charts
2. Food models
3. Food samples
4. Text books
5. Nutrition care manuals
6. Text books
7. Computers with internet
8. Library and resource centre
9. WHO guidelines
10. MOH policies and guidelines
11. Ministry of Education
12. Skills lab
13. LCD projectors, video clips, charts and other teaching aids
14. Invitation of competent expertise

9.3.7.5 References

Brown, J. E. (2016). Nutrition through the life cycle. Cengage Learning.

Centers for Disease Control and Prevention. (2015). Childhood nutrition facts.

9.3.9 Learning Outcome 8: Demonstrate knowledge in nutrition for adolescents (13years-19 years)

9.3.9.1 Learning Activities

Learning Activities	Special instructions
i) Identify nutrition related terminologies for adolescents	➢ Define related terminologies
ii) Describe developmental changes in adolescence resource materials	➢ Identify developmental changes in boys and girls
iii) Identify and describe nutrition vulnerabilities for adolescents are	➢ Identify vulnerable adolescents
iv) Identify and describe nutrition requirements for adolescents	➢ Determine nutritional requirements of adolescents
v) Identify and describe factors influencing dietary practices and food choices	➢ Demonstrate knowledge of factors influencing dietary practices and food choices of adolescents

9.3.9.2 Information Sheet

Definition

Adolescence; a period of transition from childhood to adulthood and is accompanied by a series of psychological, physical, biochemical and even physiological changes

Menarche: Onset of menstruation

The progress changes in adolescence are characterized by an orderly sequence but there are variations between sexes and even between individuals in timing, intensity of changes and deviation of the process.

Body Changes in Adolescence	
Boys	**Girls**
• Increase in size and strength of muscles	• Onset of menarche
• Voice changes	• Breast enlargement
• Broadening of chest	• More fat deposit compared to muscle mass in boys
• Appearance of pubic hair	• Less bone growth compared to boys

• Increase in sweat production& development of body odor	• Appearance of pubic hair
• Rapid height acquisition (“growth spurt”)	

Nutrients Requirements

They are higher than at any other time with exception of pregnancy and lactation. Nutrient needs will vary depending on :

- the rate of growth
- body size
- physical activity

Adolescents 10-18yrs		
Nutrient	**Male**	**Female**
Energy (kcal)	2500	2150
Protein (g)	0.9	0.9
Vitamin A (µg RE)	600	600
Vitamin D (µg)	5	5
Vitamin E (mg α-TE)	10	7.5
Vitamin K (µg)	35-65	35-65
Vitamin C (mg)	40	40
Vitamin B_1 (mg)	1.2	1.1
Vitamin B_2 (mg)	1.3	1.0
Niacin (mg NE)	16	16
Vitamin B_6 (mg)	1.3	1.2
Folate (µgDFE/day)	400	400
Vitamin (B_{12})	2.4	2.4
Calcium (mg)	1300	1300
Phosphorus (mg)	1200	1200
Magnesium (mg)	250	250
Iron (mg)	12	15
Zinc (mg)	15	12
Iodine (µg)	110	100
Selenium (µg)	34	26

Adolescence nutrition requirements

Factors Influencing Food Intake in Adolescents

- Body image
- Family
- Peers
- Media e.g.TV, magazine, social media
- Family financial status
- Nutrition knowledge

Nutritional & Health Problems Common in Adolescence

- Anemia
- Eating disorders such as Anorexia nervosa
- Complications of early pregnancy
- Obesity

Anorexia nervosa

- o An eating disorder involving a physiological loss or denial of appetite and self starvation related to a distorted ideas on body image.
- o People suffering from this disorder think they are 'fat' and have intense fear for obesity.
- o Can be caused by pressure to maintain a certain weight, look attractive or competent on a job or
- o Seeking acceptance from peers.

Effects of Anorexia Nervosa

- Lowered body temperature because of loss of fat insulation
- Slower BMR due to a reduction in synthesis of thyroid hormone.
- Decreased heart rate due to the slower metabolism; this leads to fatigue and fainting
- Leads to iron deficiency anaemia
- Leads to a low white blood cell count and leads to risk of or rise in infections
- Loss of hair
- Leads to constipation

Bulimia Nervosa

- Eating disorder in which large quantities of food is eaten at one time (binge eating) and then purged from the body by vomiting or use of laxatives and other means
- It is seen in older adolescents who seek to maintain a normal weight.

- It's also characterized by strict dieting, taking diuretics and hyper gymnasia to retain normal weight & body shape.
- People with this disorder are difficult to identify because they keep their purge behavior secret and their symptoms are not obvious.
- Leads to loss of menstrual periods (amenorrhea)

Effects of Bulimia Nervosa

- Iron deficiency anemia
- Can alter body temperature
- Lower immunity because of inadequate intake
- Lead to constipation due to overuse of laxatives
- Dehydration and electrolyte imbalance
- Repeated exposure of teeth to acids in vomiting cause demineralization making the teeth painful and sensitive to acid heat and cold. This may eventually lead to teeth decay, erosion of tooth and cause teeth to fall out.
- It can cause gastric dilation with an increased risk of rapture and this can cause death.

9.3.9.3 Self-Assessment

1. Discuss the nutritional requirements in adolescents
2. Which one of the following is not true about anorexia nervosa?
   A. Anorexics have a distorted perception of their weight where they think they are overweight
   B. It is often caused by the need to fit into societal and peer expectations
   C. It can lead to amenorrhea
   D. Anorexics are able to keep a normal weight
3. Which one of the following is not a sign of adolescence in girls?
   A. Onset of menarche
   B. Breast enlargement
   C. Chest broadens
   D. Appearance of pubic hair
4. Which one of the following is not a common nutritional & health problems in Adolescence
   A. Anemia
   B. Eating disorders such as Anorexia nervosa

C. Complications of ageing

D. Obesity

5. Which one of the following is not a factor that determines food intake in adolescents:

A. Body image

B. Sarcopenia

C. Peers

D. Media

6. The following are factors that determine nutrient intake in adolescents except:

A. The rate of growth

B. Body size

C. Self esteem

D. Physical activity

9.3.9.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.9.5 References

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9.3.10 Learning Outcome 9: Demonstrate knowledge in nutrition for adults (20years-60 years)

9.3.10.1 Learning Activities

Learning Activities	Special instructions
i) Identify nutrition related terminologies in adulthood	➢ Define terminology related to adulthood
ii) Identify and describe nutrition vulnerabilities and habits with nutrition implication	➢ Identify vulnerable adults
iii) Describe nutrition requirements for early adulthood (20-40 years)	➢ Determine nutritional requirements of early adulthood (20-40 years)
iv) Describe nutrition requirements for mid adulthood (40 years-60 years)	➢ Calculate nutritional requirements for mid-adulthood (20-40 years)

9.3.10.2 Information Sheet

Definitions

Adulthood: the period in the human lifespan in which full physical and intellectual maturity have been attained. Adulthood is commonly thought of as beginning at age 20 or 21 years.

In psychology, adulthood is defined as a period of optimum mental functioning when the individual's intellectual, emotional, and social capabilities are at their peak to meet the demands of **career, marriage, and children.**

Stages of Adulthood

- Early adulthood – 20s to 30s
- Middle adulthood - 40s to 50s
- Older adulthood - 60s to 70s
- Oldest adulthood - 80s and 90s

In early adulthood our physical abilities are at their peak, including muscle strength, sensory abilities, and cardiac functioning. The aging process also begins during early adulthood and is characterized by changes in skin, vision, and reproductive capability.

Aging speeds up during middle adulthood and is characterized by:

- Decline in vision
- Hearing
- Immune-system functioning
- End of reproductive capability for women, known as menopause.

Since majority of growth and development is complete at adulthood, the objectives of nutrition change to:

- Maintaining good health and an active lifestyle
- Preventing diet-related diseases, such as cardiovascular disease, hypertension and Type 2 diabetes.

Nutritional Requirements

Growth is no longer energy demanding in adulthood and basal metabolic rate (BMR) is relatively constant among population groups of a given age and gender.

Habitual physical activity and body weight are the main determinants for the diversity in energy requirements for adult population with different lifestyles. Women bear children during these years. For women, the recommended dietary allowance for energy is 2200 kcal daily and for men, 2900 kcal.

Recommended Kilocalorie Intake For Adults With Different Nutrition Status.

BMI	SEDENTARY	MODERATE	ACTIVE
Overweight	20 – 25 kcal/kg	25-30 kcal/kg	30-35 kcal/kg
Normal	25-30 kcal/kg	30-35 kcal/kg	35-40 kcal/kg
Underweight	30-35 kcal/kg	35-40 kcal/kg	40-45kcal/kg

Source: WHO/FAO (2002)

- Carbohydrates; 45%-65% of kcals
- Protein; 10%-35%
- Total fat; 20%-35%

Nutrient	Adult women	Adult men
Vitamin A (μg RE)	500	600
Vitamin D (μg)	5 (19-50) 10 (50+)	5 (19-50) 10 (50+)
Vitamin E (mg α-TE)	7.5	10
Vitamin K (μg)	55	65
Vitamin C (mg)	45	45
Vitamin B_1 (mg)	1.1	1.2
Vitamin B_2 (mg)	1.1	1.3
Niacin (mg NE)	14	16
Vitamin B_6 (mg)	1.3(19-50) 1.7 (50+)	1.3 (19-50) 1.5 (50+)
Folate (μg)	400	400
Vitamin (B_{12})	2.4	2.4
Calcium (mg)	1000	1000
Phosphorus (mg)	800	800
Magnesium (mg)	220	260
Iron (mg)	15	29
Zinc (mg)	12	14
Iodine (μg)	110	130
Selenium (μg)	26	34

Mineral and Vitamins Requirement for adults FAO/WHO (2001)

Factors Influencing Dietary intake in Adults

- Biological determinants such as hunger, appetite, and taste
- Economic determinants such as cost, income, availability
- Physical determinants such as access,
- Social determinants such as culture, family, peers and meal patterns
- Psychological determinants such as mood, stress and guilt
- Attitudes, beliefs and knowledge about food

Common Nutrition and Health Problems in Adulthood

- Overweight and obesity
- Alcoholism
- Mental illnesses e.g depression
- Communicable diseases
- Chronic Non-communicable diseases e.g Cardiovascular diseases (like heart attacks and stroke), Cancer, Chronic respiratory diseases (such as chronic obstructed pulmonary disease and asthma) Diabetes.

9.3.10.3 Self-Assessment

1. Outline the stages of adulthood
2. Discuss the nutritional requirements in adulthood
3. Identify factors that influence food choice in adulthood
4. Indicate whether the following statements are true or false about adult nutrition:
   A. Growth is energy demanding in adulthood
   B. Basal metabolic rate (BMR) is relatively constant among population groups of a given age and gender.
   C. Women of menopausal age are at risk of osteoporosis
   D. The main objectives of nutrition in adulthood are maintaining good health and an active lifestyle and preventing diet-related diseases
   E. Habitual physical activity and body weight are the main determinants for the diversity in energy requirements for adult population with different lifestyles

9.3.10.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.10.5 References

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9.3.11 Learning Outcome 10: Demonstrate knowledge in nutrition for older persons/geriatric nutrition (60years and above)

9.3.11.1 Learning Activities

Learning Activities	Special instructions
i) Identified nutrition related terminologies for older persons	➢ Define terminologies related to nutrition in old age
ii) Identify, describe and demonstrate nutrition assessment for the older persons	➢ Conduct nutrition assessment for elderly people
iii) Describe physiological, psychosocial and economic changes for older persons	➢ Determine physiological, psychosocial and economic changes for older persons.
iv) Describe and demonstrate meal planning for the older person	➢ Plan meals for older persons
v) Identify and describe nutrition requirements for the older persons	➢ Determine nutritional requirements of elderly people
vi) Identify and describe nutrient drug interactions for the older persons	➢ Interpret interactions between drugs and nutrients
vii) Identify and describe interventions for the older persons in Kenya	➢ Apply existing interventions for older persons in Kenya

9.3.11.2 Information sheet

Elderly persons are one of the groups of people who are vulnerable to malnutrition. Aging may affect their food access and utilization, which determines their nutritional status and health. An in-depth understanding of the process of ageing and its effects on an individual's life is helpful in meal planning for elderly people.

The elderly are classified into:

Young old	65 -75 years
Old old	75 – 85 years
Oldest old	> 85 years

Factors that Determine Nutritional Needs of Elderly People

- Existing health problem
- Individual level of activity,
- Energy expenditure and caloric requirement

- Ability to access, prepare, ingest and digest food
- Personal food preferences
- Medication

As people age, they experience several changes that influence their nutrition and health status. These changes include:

a) Psychosocial Changes:

Ageing persons may experience psychological problems such as depression, memory impairment, loneliness and social isolation.

All of these may affect appetite and therefore they may not meet their nutritional requirements.

b) Physiological Changes

As the ageing process continues body composition changes as fat replaces muscle, known as sarcopenia. Because of decline in lean body mass, BMR declines by 5% and so the total Kcal needs drop. Body water also decreases along with a decline in lean body mass.

c) Gastrointestinal Changes

Gastrointestinal changes in the elderly include:

- Digestive hormones and enzymes decrease
- Lactase production decreases thus lactose is not digested.
- Intestinal mucosa deteriorates
- Hypochlorhydria , which affects protein digestion
- Pernicious anemia due to impaired vitamin B12 absorption.
- Gastric emptying time increases.
- Constipation also becomes a common problem because of increase in gastric emptying time due to overuse of laxatives, less fluids and inactivity.

d) Musculoskeletal Changes:

There is a progressive drop in bone mass which starts when people are in middle adulthood.

It accelerates in women during menopause making the skeleton more vulnerable to fractures and osteoporosis. Adequate intake of calcium and vitamin D is recommended to help keep the bones intact.

e) Decrease in sense of taste and smell

Also a common problem among the elderly

Use stronger seasoning to make food tastier, substitute some foods with others, change preparation methods.

f) Dental changes:

Some experience total loss of teeth while others, teeth might be painful due to gum diseases. This affects diet/nutrient intake. They can wear dentures, modify the consistency of food e.g. pureed, depending with elderly nutrient needs.

g) Loss of sense of thirst:

This is due to diminished activity of ADH and aldosterone. Therefore total body water is likely to reduce and they become dehydrated. Recommendation is 1ml/kcal (approx. 2liters/day).

h) Cardiovascular changes

There's increase in blood pressure especially women over 80years. Increase in serum cholesterol mostly in overweight. Organs decline in function e.g. liver, kidney, pancreas etc

i) Immune system changes

Immune system declines or operates less efficiently with age thus lessens ability to fight infections. Provide enough protein, vitamin C, Zinc etc.

Nutritional Requirements for the Elderly

Energy: Requirements reduce with age by about 5% per decade.

Proteins: Needs are the same as those of other adults or may increase due to lower absorption and chronic diseases.

RDA is 0.8 g/kg bd wt.

Fats: Reduce fat to less than 30% total Kcal/day

Vitamin D: The elderly shl'd consume Vitamin D fortified foods which provide significant Vitamin D.

Calcium: The recommendations for Vitamin D & Calcium are higher for older people. Requirement is 1200-1500mg/day

Iron: They're likely to suffer from iron-deficiency anaemia due to low dietary intake, chronic blood loss from diseases, poor iron absorption due to reduced stomach acid secretion and antacid use.

Indicators of Poor Nutrition Among the Elderly

- Significant weight loss , greater than 4% in one year.
- Low BMI or high BMI
- Significant change in functional status as measured by activities in daily living
- Anorexia
- Significant decrease in food intake
- Significant changes in cognitive function
- Significant medical and social life events

Nutrients for Which the Elderly May need Supplementation

- Calcium
- Vitamin B12
- Zinc
- Vitamin C

Interventions for Older Persons in Kenya

The National Policy for Older Persons and Ageing was enacted by Parliament in February 2009. It recognizes older persons as significant members of the society. Their rights must be respected, protected and promoted. The policy addresses the unique challenges faced by older persons in the population.

The Constitution (2010), in the Bill of Rights recognize the rights of older persons. It states that the state shall take measures to ensure the rights of older persons are recognized and:

a) To fully participate in the affairs of the society
b) To pursue their personal development
c) To live dignity and respect and be free from abuse
d) To receive reasonable care and assistance from their families and the State

The National Policy for Older Persons and Ageing seeks to:

a) Facilitate the provision of reasonable care and assistance to Older Persons by family and the state;
b) Promote collaboration and partnerships among key stakeholders for the effective implementation of this policy;
c) Promote the participation of Older Persons in development processes;
d) Enhance and facilitate Older Persons to pursue their personal development;
e) Create a favourable environment that enables Older Persons to live in dignity;
f) Protect the Older Persons from abuse

Other legal frameworks that provides for the welfare of the elderly are;

- The National Hospital Insurance Fund (NHIF) Act
- Pensions Act
- The National Social Security Fund (NSSF) Act
- Kenya Vision 2030

9.3.11.3 Self-Assessment

1. Identify changes that occur for the elderly and how they affect nutrition
2. Discuss the existing interventions for the elderly in Kenya
3. The following are nutrients for which the elderly may need supplementation except:

   A. Calcium

   B. Vitamin B12

   C. Zinc

   D. Vitamin B1
4. Which one of the following is a gastrointestinal change seen in older adults?

   A. Osteoporosis

   B. Depression

   C. Alcohol abuse

   D. Intestinal mucosa deteriorates
5. The following are indicators of poor nutrition in the elderly except:

   A. Significant weight loss , greater than 4% in one year.

   B. Anorexia

   C. Significant increase in food intake

   D. Significant changes in cognitive function
6. Loss of sense of thirst in the elderly is due to diminished activity of ______

   A. Oestrogen and antidiuretic hormone

   B. Adrenaline and oestrogen

   C. Antidiuretic hormone and aldosterone

   D. Adrenaline and aldosterone

7. Supplementation with ____ may help increase the sense of taste in elderly persons.
   A. Calcium
   B. Zinc
   C. Vitamin C
   D. Niacin

9.3.11.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- Text books
- Nutrition care manuals
- Text books
- Computers with internet
- Library and resource centre
- WHO guidelines
- MOH policies and guidelines
- Skills lab
- LCD projectors, video clips, charts and other teaching aids
- Invitation of competent expertise

9.3.11.5 References

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CHAPTER 10:

APPLY PRINCIPLES OF HUMAN NUTRITION

10.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to manage nutrition and dietetic services it includes: classifying different nutrients, demonstrate understanding of food metabolism, demonstrate understanding of the role of nutrition in disease occurrence and management, identifying factors that place client at nutritional risk and undertaking nutrition monitoring.

10.2 Performance Standard

By the end of this unit of learning/competency, the trainee should demonstrate ability to classify different nutrients and their metabolism based on nutritional composition and resource materials; relate the role of nutrition in disease occurrence and management as per nutritional standard requirement; provide dietary management in metabolic disorders in line with standard operating procedures (SOPs) and design systems that would help in nutrition monitoring a per SOPs and existing policies and guidelines.

10.3 Learning Outcomes

10.3.1 List of the Learning Outcomes

i. Classify different nutrients

ii. Demonstrate understanding of food metabolism

iii. Understand role of nutrition in disease occurrence and management

iv. Identify factors that place client at nutritional risk

v. Undertake nutrition monitoring

10.3.2 Learning Outcome 1: Classify different nutrients

10.3.2.1 Learning Activities

Learning outcome	Specific instructions
i) Determine nutrient needs • Review factors that influence nutritional requirements	➢ Calculate individual nutrient requirements
ii) Assess macro and micro nutrients	➢ Distinguish between micronutrients and macronutrients ➢ Identify sources of micronutrients and macronutrients ➢ Calculate energy composition of the macronutrients
iii) Categorize types of Macro and micro nutrients Review • Types of macronutrients • Types of micronutrients	➢ Apply knowledge of the macronutrients and micronutrients in meal planning ➢ Use macronutrients and micronutrients in diet therapy
iv) Determine concepts and basic principles of nutrition and dietetics as per nutritional standards	➢ Apply the basic principles of nutrition in meal planning for diet therapy
v) Determine energy levels of different foods as per client needs and standard nutritional requirement • Review factors that influence energy requirements	➢ Calculate energy levels of different foods ➢ Classify foods by energy composition

10.3.2.2 Information Sheet

Definitions

1. **Nutrition**: a process by which food and drink is taken, digested, absorbed, and used by the body for physical activity, growth, development, and health.
2. **Nutrients:** nourishing substances needed by the body for physical activity, growth, development, and health.
3. **Essential nutrients:** Nutrients that cannot be synthesized by the body and must be consumed through food.

4. **Macronutrients:** Nutrients that the body requires in large quantities and provide energy to the body. They are: Carbohydrates, fats, and proteins.
5. **Micronutrients**: nutrients needed by the body in very small amounts. They are: vitamins and minerals.
6. **Balanced or nutritious diet:** a combination of foods from different food groups that, when eaten, provides the energy and nutrients the body needs in the right amounts and quality to maintain health, growth, and development.
7. **Calorie**: a unit of energy yielded from food in the body

Essential Nutrients and their functions

The body must be provided with all nutrients to maintain the functions of the various systems. Nutrients perform key functions in the body, and failure to maintain a balance in their consumption leads to physiological problems, as seen in malnutrition.

Nutrients are categorized into:

- Carbohydrates (CHO)
- Fats (lipids)
- Proteins
- Vitamins
- Minerals
- Water

The six nutrients are further classified into organic and inorganic, depending on their chemical composition. Carbohydrates, fats (lipids), proteins and vitamins are organic nutrients because they contain carbon. The organic nutrients must be broken down before the body can be able to utilize them.

The minerals and water are classified as inorganic nutrients. They are easily utilized because they are consumed in their simplest form, except for water.

The essential Nutrients and their Functions

Organic Nutrients	Function
Carbohydrates	Provide energy
Fats	Provide energy
Proteins	Build and repair body tissues
	Provide energy
Vitamins	Regulate body processes
Inorganic Nutrients	**Function**
Minerals	Regulate body processes
Water	Regulate body processes

Macronutrients

These are nutrients which are required in large quantities in the body and they include carbohydrates, proteins and lipids

- **Carbohydrates**

  These include starches, fibre, and sugars and are the primary source of energy in most diets, fuelling physical activity and basic body functions.

  Grains/cereals (e.g., rice, millet, maize, sorghum, wheat), roots (cassava, potatoes), and starchy fruits and vegetables are rich in energy from carbohydrates. Whole grains contain the entire grain. They are richer in nutrients and fibre and a healthier choice than refined grains, which lose fibre, vitamins, and minerals in the milling process. Whole grains should be at least half of the grains consumed. Some refined grains are 'enriched' after being milled, to replace some lost nutrients, or 'fortified' to include additional nutrients. This does not replace lost fibre.

  If purchasing refined grains, consumers should select 'enriched' and/ or 'fortified' grains. Although sweet foods such as sugar, jam, cakes, and drinks are a source of carbohydrates, they should be consumed minimally because they do not provide any other nutrients and may increase risk of overweight.

- **Fats (lipids)**

  Fats are a concentrated source of energy. They also build body cells, support brain development of infants, help body processes, and facilitate the absorption and use of fat-soluble vitamins A, D, E, and K.

  They are derived from both animal and plant sources.

  Saturated fatty acids are solid at room temperature and include animal fats (butter, lard, tallow, ghee) and tropical oils (palm, coconut, palm kernel).

  Trans fats are also solid at room temperature and include partially hydrogenated vegetable oils (margarine, shortening). Consumption of saturated fats and trans fats increases risk of heart disease. Unsaturated fatty acids are liquid at room temperature. These include monounsaturated and polyunsaturated fats and are found in vegetable oils such as sunflower, corn, soybean, canola, and olive oils. Replacing saturated fats with unsaturated fats lowers risk of heart disease.

- **Proteins**

  These are body-building foods and are required for growth and development, maintenance and repair of tissues, production of enzymes, and formation of certain hormones.

  Rich plant sources of protein include beans and lentils. Animal sources include meat, fish, poultry, dairy products, and eggs.

Micronutrients

These are required by the body in small quantities and they include vitamins and minerals.

a. Vitamins

There are two categories of vitamins:

i. **Fat-soluble vitamins:** They are stored by the body and require dietary fat to be absorbed. They include vitamins A, D, E, and K. Fat-soluble vitamins are necessary for development and maintenance of body tissues and their functions, e.g., eyes (vitamin A), bones (vitamin D), muscles, blood clotting (vitamin K), protection of cells (vitamin E), synthesis of enzymes, and absorption of essential nutrients. Dietary sources of fat-soluble vitamins include:

- **Vitamin A:** Sources include: red and orange fruits and vegetables (e.g., carrots, peppers, pumpkin, mango, papaya), dark green leafy vegetables (e.g., sukuma wiki), liver, fish, and fortified dairy products, margarine, and oils
- **Vitamin D:** Sources include: fortified dairy products, oily fish. The body also synthesizes vitamin D through exposure to the sun
- **Vitamin E:** Sources include: vegetable oils, nuts, and seeds
- **Vitamin K:** Sources include: green leafy vegetables and vegetable oils

ii. **Water-soluble vitamins**: They are not stored in the body and must be consumed regularly. They include vitamins C (ascorbic acid), B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), and B12 (cobalamin), as well as pantothenic acid and folic acid. Their functions include releasing energy, supporting utilisation of macronutrients, and synthesizing red blood cells. Dietary sources of water-soluble vitamins include fruits, dark leafy vegetables, whole grains, meat, fish, poultry, and fortified cereals, specifically:

- **Vitamin C**: citrus fruits, red pepper, and other plant sources
- **Thiamine:** whole grains, legumes, liver, enriched flours
- **Riboflavin**: liver, eggs, legumes, dark green vegetables, whole grains, enriched flours
- **Niacin:** peanuts, whole grains, enriched flours, liver, fish, poultry
- **Vitamin B6:** whole grains and cereals, legumes, dark leafy greens, pork, poultry, and beef
- **Vitamin B-12:** animal-source foods such as liver, kidney, eggs, milk, fish
- **Folic acid:** dark leafy greens, whole grains, meat, fish, legumes, citrus fruit

b. Minerals

They contribute to a variety of body processes, including growth, development, water balance, and neurological processes. Although minerals are present in many foods, they are more easily absorbed from some foods than from others. Essential minerals include the following:

- **Iron:** essential component of blood and helps transfer oxygen to various tissues. Dietary sources include red meat, fish, poultry (easily absorbed), legumes, leafy green vegetables (less easily absorbed, but absorption increases if eaten with animal-source iron or vitamin C).
- **Calcium**: a key component of bones and teeth and is needed for a strong skeleton. Dietary sources include dairy products (most easily absorbed) and leafy greens (not well absorbed).
- **Iodine**: important for thyroid function and for mental development of children. The most important dietary source is iodised salt.
- **Zinc**: enhances and strengthens the immune system, helps wounds heal, facilitates digestion, and is an important component of skeletal muscle. Dietary sources include beef, seafood, liver, nuts, beans, and whole grains.
- Other minerals include: chromium, copper, fluoride, magnesium, manganese, molybdenum, nickel, potassium, phosphorus, sodium, and selenium.

Water

Water is plays an important role in many body functions such as circulation, digestion, absorption, excretion and other body processes. Our bodies lose water through urination, sweating and in the form of humidity in breathing.

For optimum body function, our bodies must maintain a balance between water intake and water loss. If water losses exceed water intake, one suffers from dehydration.Sources of water include water itself, fruits and vegetables, beverages etc.

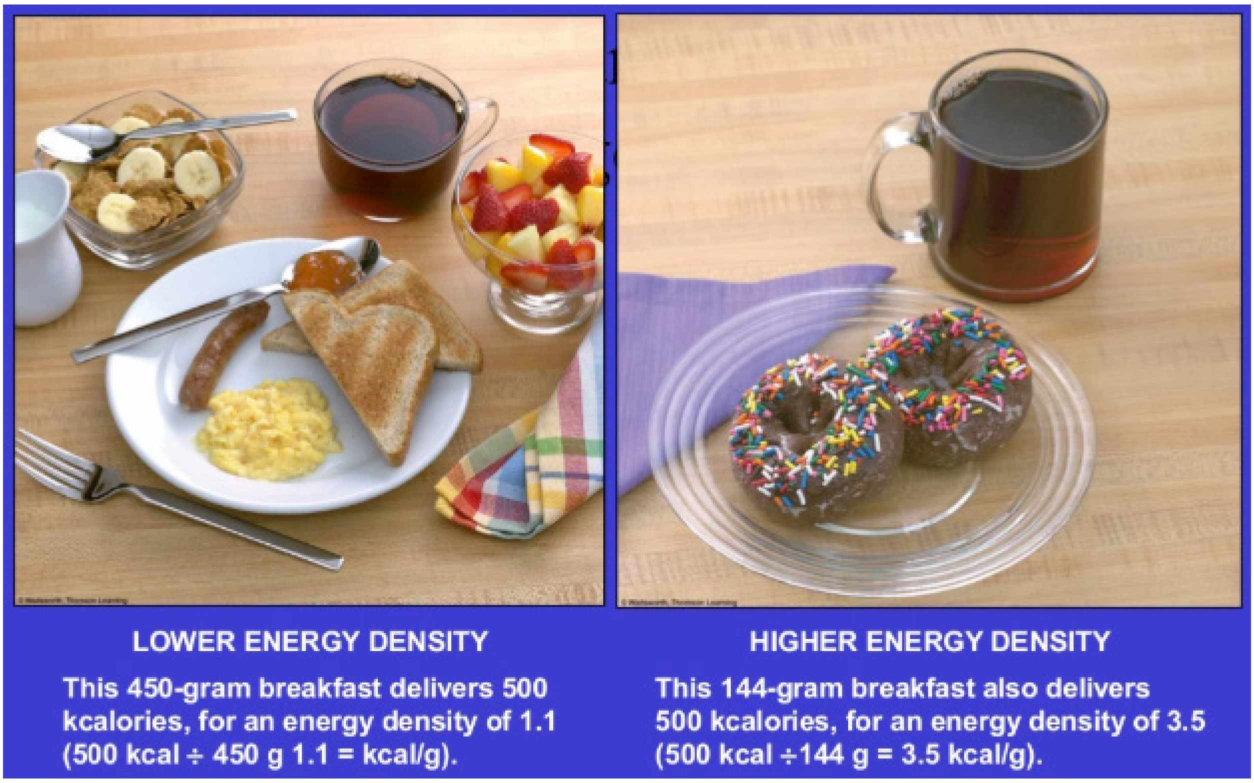
Energy measurement

Calorie is a unit of energy that food provides the body.

1 Kilocalorie (Kcal) = 1000 calories

The energy value, also known as caloric density of a food is the amount of calories it contains. Foods vary in caloric density as follows:

Carbohydrates	4kcal/g
Protein	4kcal/g
Fat	9kcal/g



Energy Density of two Breakfast Options Compared

10.3.2.3 Self-Assessment

1. List the six classes of nutrients
2. Identify one function of the following nutrients:
   A. Zinc
   B. Vitamin C
   C. Vitamin A
3. Indicate the amount of energy yielded from the following :
   A. 50 g of protein
   B. 300g of carbohydrate
   C. 40g of fat
4. Which one of the following is not a macronutrient?
   A. Fat
   B. Zinc
   C. Carbohydrates
   D. Proteins

5. Which one of the following is a water soluble vitamin?
   A. Vitamin K
   B. Vitamin D
   C. Vitamin C
   D. Vitamin E
6. _________ is important for thyroid function
   A. Calcium
   B. Vitamin D
   C. Iodine
   D. Vitamin C
7. _______ are nutrients that cannot be synthesized by the body and must be consumed through food.
   A. Micronutrients
   B. Macronutrients
   C. Supplements
   D. Essential nutrients
8. The following are energy giving nutrients except
   A. Protein
   B. Fat
   C. Vitamin D
   D. Carbohydrates

10.3.2.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- Stationery
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise

- Computers with internet
- Library and resource centre

10.3.2.5 References

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10.3.3 Learning Outcome 2: Demonstrate understanding of food metabolism

10.3.3.1 Learning Activities

Learning outcome	Specific instructions
i) Describe Digestion in the GIT	➢ Draw and label the GIT ➢ Apply knowledge of digestion in disease management ➢ Consider factors that affect digestion and absorption of the micronutrients and micronutrients
ii) Determine GIT sites of secretions and absorption	➢ Educate on sites of secretions in the digestive system ➢ Apply knowledge of secretion sites in disease management
iii) Explain factors affecting digestion, absorption and utilization.	➢ Consider factors affecting digestion, absorption and utilization ➢ Plan a diet for diseases that affect digestion, absorption and utilization
iv) Explain factors affecting bioavailability of macro and micro nutrients.	➢ Enhance bioavailability of macro and micro nutrients
v) Assess factors that hinder metabolism • Define metabolism • Review types of metabolic reactions	➢ Enhance metabolism through diet

10.3.3.2 Information Sheet

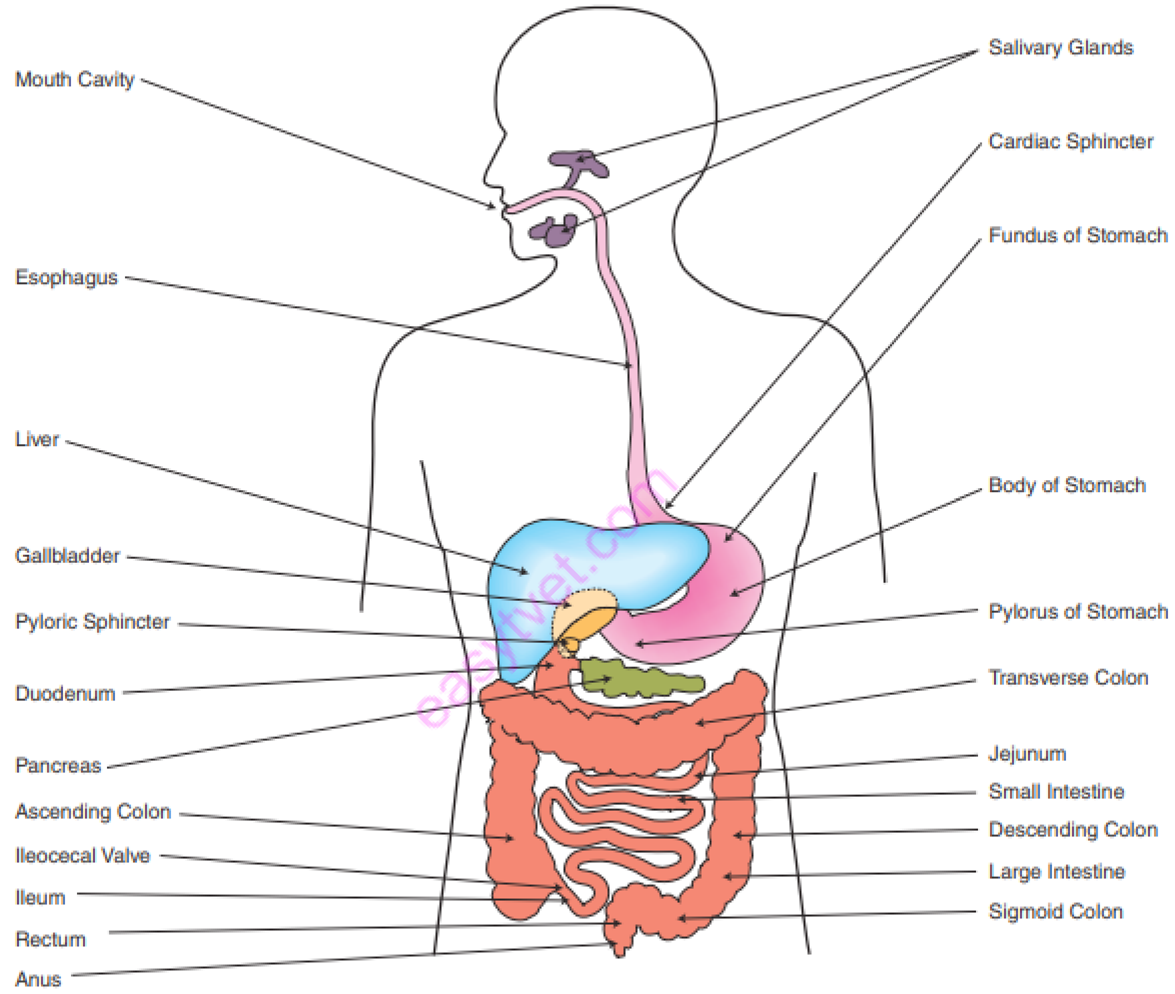
Definitions

- **Digestion:** the process whereby food is broken down into smaller parts, chemically changed, and moved through the gastrointestinal system
- **Absorption:** passage of nutrients into the blood or lymphatic system
- **Bioavailability:** refers to the proportion of a nutrient that is absorbed from the diet and used for normal body functions

- **Metabolism:** the sum total of chemical processes that occur in the body
- **Peristalsis:** a rhythmic contraction of the muscular walls of the tract.

Digestion

The gastrointestinal tract is a system that ingests digests, absorbs food and rids the body of waste matter in food. It is made up of several organs and structures which transform whole food into absorbable and useful substances. It starts in the moth and ends at the anus.



The digestive system

There are two types of action during digestion;

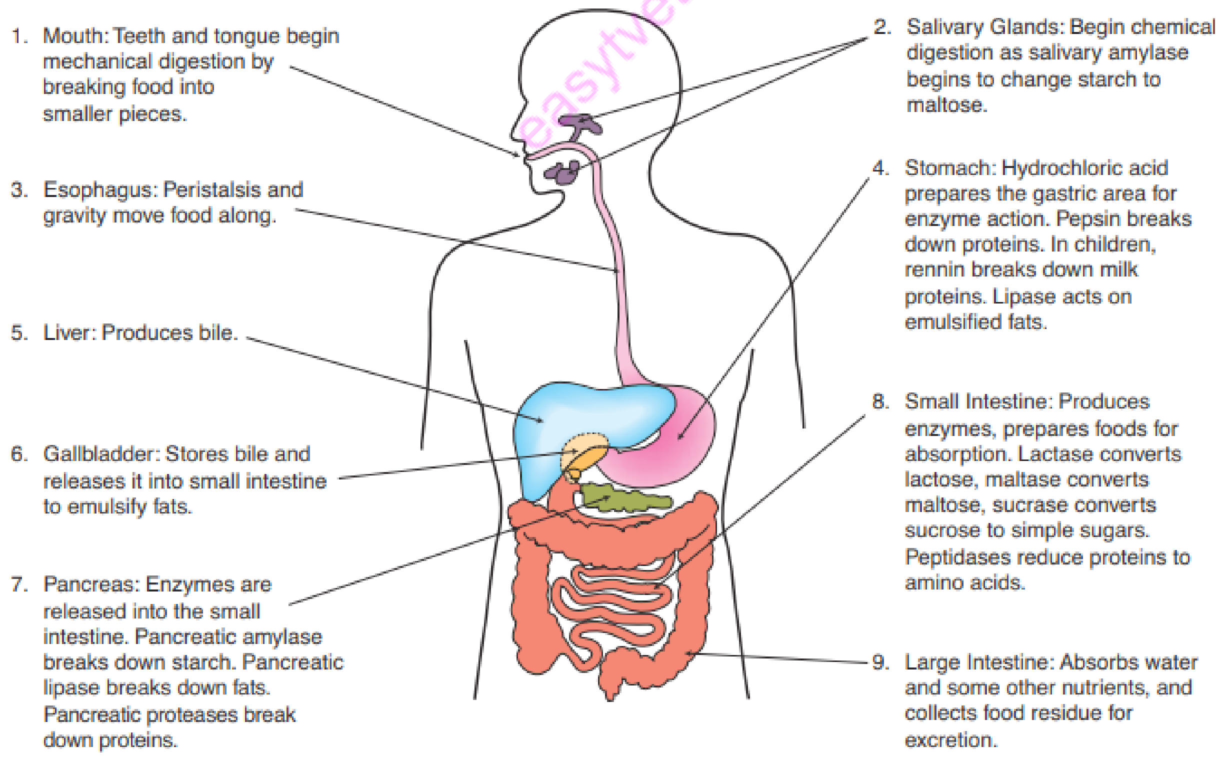
i) Mechanical digestion: Food is mechanically broken down into smaller pieces by teeth and moved through the oesophagus through peristalsis.

ii) Chemical digestion: Chemical reactions involving digestive enzymes and water help break down food into absorbable molecules. Such enzymes include salivary enzymes, pancreatic enzymes, intestinal enzymes as well as gastric enzymes

Enzymes and foods acted upon

Source	Enzyme	Food Acted Upon
Mouth	Salivary amylase	Starch
Stomach	Pepsin	Proteins
	Rennin	Proteins in milk
	Gastric lipase	Emulsified fat
Small intestines	Pancreatic amylase	Starch
	Pancreatic proteases (trypsin, chymotrypsin, carboxypeptidases)	Proteins
	Pancreatic lipase (steapsin)	Fats
	Lactase	Lactose
	Maltase	Maltose
	Sucrase	Sucrose
	Peptidases	Proteins

Basic functions of the digestive system



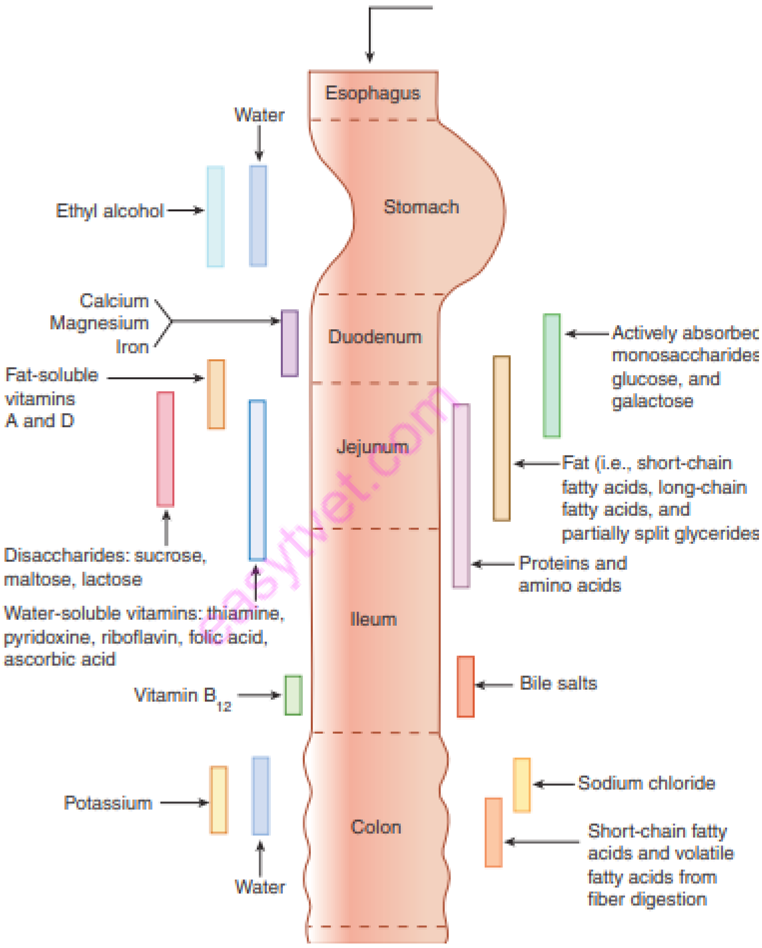
Basic Functions of the digestive system

Absorption

Absorption takes place when food has been broken down through a combination of mechanical and chemical digestion. The smaller molecules are then utilised for various purposes in the body. Carbohydrates are absorbed in the form of glucose, fructose and galactose, proteins are absorbed in the form of amino acids, while fats are absorbed as fatty acids and glycerol.

Absorption mainly takes place in the small intestines, although the mouth, the stomach and large intestines also play a significant role.

Nutrients are absorbed at different sites in the body as shown in the following figure.



Absorption sites in the GIT

Factors affecting digestion and absorption

- **Psychological influences**: The psychological status of an individual has a significant effect on the rate of digestion and absorption. For example, short term stress can lead to diarrhoea and stomach ache.
- **Chemical influences:** Types of food differ in physical and chemical properties and this determines the rate of reaction with digestive secretions and the rate of absorption too.

- **The stomach content**: The volume of a feed has a significant influence on the rate of digestion and absorption. Food consumed on an empty stomach has more contact with digestive enzymes and therefore the rate of digestion is higher than when one is fuller
- **Drugs:** Certain medications have a direct effect on the digestive system and therefore affect the rate of digestion and absorption. For example, antacid medication reduce acidity and therefore may lower the rate of absorption of calcium, magnesium and Vitamin B12. Diuretics may cause one to lose excess water and water soluble nutrients, which can put one at risk of deficiency.
- **Bacterial influences:** When harmful bacteria are allowed to populate the digestive tract, they may wreak havoc, leading to inflammation and peptic wounds. Bacteria may also produce excessive gas, causing bloating and abdominal discomfort.

Metabolism

Food that is absorbed enters the body cells, where it is processed to produce energy. This is metabolism. Some nutrients provide more energy than others, owing to their differences in chemical composition. Metabolism involves changes which either use or generate energy. These changes are categorised into:

Anabolic changes: These are reactions in which small molecules are used to create larger molecules. This process requires energy. Examples include; synthesis of glycogen, triglycerides and proteins.

Catabolic changes: These reactions involve the breakdown of complex compounds to yield simple ones. Catabolic reactions release energy. Examples of such reactions in the body include; breakdown of glycogen to yield glucose, breakdown of triglycerides and protein.

Metabolic reactions require enzymes and coenzymes to facilitate their action. Enzymes are protein compounds that facilitate chemical reactions in the body. Coenzymes on the other hand facilitate enzyme activity.

Factors Which Influence Metabolism Rate

- Body size
- Age
- Sex
- Climate
- Nature of the work
- Individual activity

Bioavailability of nutrients

Bioavailability is the rate at which a nutrient is absorbed and used by the body. Bioavailability determines the supply of nutrients in the body and thus has an important effect on individual nutritional status and health.

Nutrient bioavailability varies depending on various factors. Macronutrients generally have a high bioavailability, as high as more than 90%. Micronutrients on the other hand have a widely varying bioavailability.

Bioavailability of a nutrient may be influenced by the following factors in the metabolic pathway:

- How a nutrient is released from the physicochemical dietary matrix
- Effects of digestive enzymes in the digestive system
- Binding and uptake by the intestinal mucosa
- Movement across the gut wall to the blood or lymphatic circulation
- Systemic distribution
- Nutrient deposition or storage
- Metabolic and functional use
- Excretion in urine an faecal matter

How Inhibitors Reduce Bioavailability

a. Binding the nutrient: The nutrient changes its form and thus is not recognised by the uptake systems in the intestinal cells

b. The inhibitor may render the nutrient insoluble and therefore unavailable for absorption

c. Competing for the same uptake system. For example, pulses, whole grains, nuts and seeds are high in phytic acid which bind minerals such as zinc and calcium, making them unavailable for absorption

   Calcium interferes with the absorption of non-heme iron by blocking the surface of absorptive cells in the intestines, therefore reducing bioavailability

10.3.3.3 Self-Assessment

1. Define digestion
2. Identify one function of the following parts of the digestive system:
   a. Gall bladder
   b. Pancreas
3. Discuss the factors that influence digestion and absorption

4. Match the following enzymes with the organ that produces them

ENZYME	SOURCE
1. Salivary amylase	
2. Pepsin	
3. Rennin	
4. Gastric lipase	
5. Pancreatic amylase	
6. Pancreatic proteases	
7. Pancreatic lipase	
8. Lactase	
9. Maltase	
10. Sucrase	
11. Peptidases	

10.3.3.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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10.3.4 Learning Outcome 3: Understand role of nutrition in disease occurrence and management

10.3.4.1 Learning Activities

Learning Outcome	Specific instructions
i. Assess Prevalence of nutrition implications in disease occurrence	• Consider the relationship between malnutrition and disease • Identify common micro and macronutrient deficiencies.
ii. Evaluate client's nutrition assessment a. Review types of nutrition assessment	• Conduct nutrition assessment on client
iii. Determine dietary management in metabolic disorders and malnutrition a. Review types of metabolic disorders	• Guide clients on appropriate amount of nutrients to consume depending on their nutrition needs
iv. Explore Nutritional support a. Review types of nutritional support	• Provide nutritional support as per client requirement • Choose appropriate nutritional support as per client requirements • Justify choice of nutritional support for client

10.3.4.2 Information Sheet

Definitions

Malnutrition: A physiological condition that results from deficiency, excess or imbalance of nutrient intake

Nutritional status: The state of health of an individual as influenced by food intake

Nutrition Assessment: An evaluation of objective and objective data to establish a person's nutritional status. The outcomes of an assessment lead to a plan for nutritional care to maintain and improve health status.

Types of Nutrition Assessment

- **Anthropometric assessment:** Measures the body's physical dimensions such as weight, height, Mid Upper Arm Circumference (MUAC), head circumference, waist circumference. These measurements are affected by nutrient intake and utilization and are a pointer to nutritional status.
- **Biochemical or laboratory assessment:** This method analyzes nutrient metabolites in blood, urine, feces and a variety of other components in blood and other tissues.

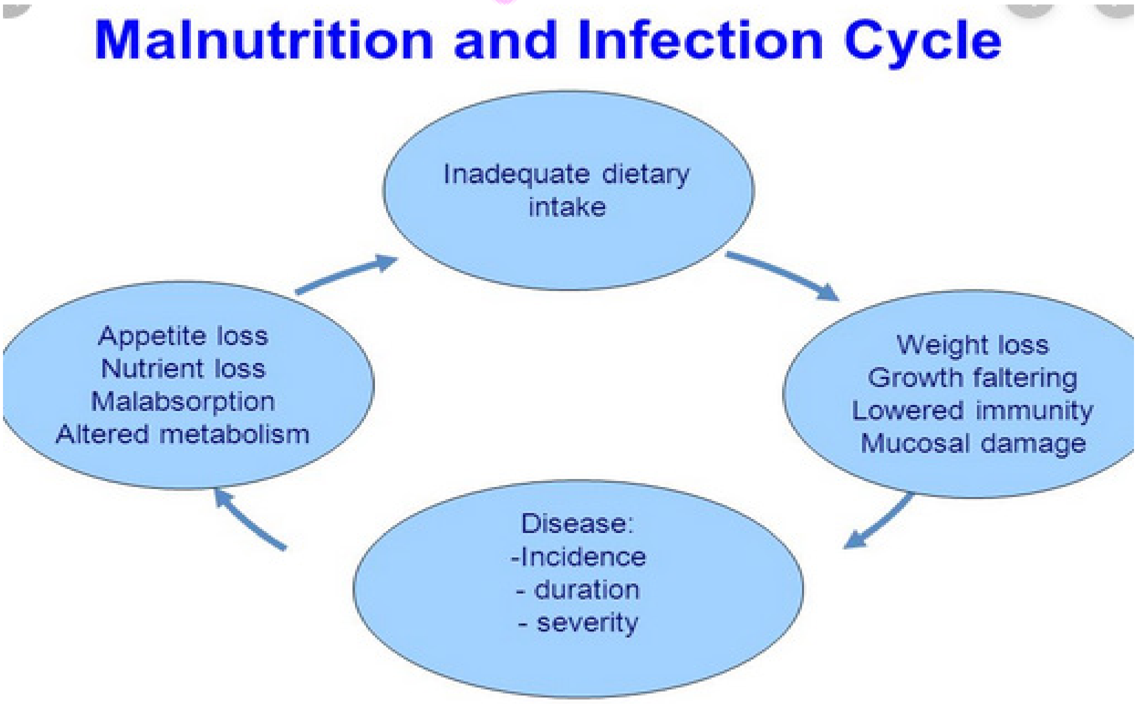
These components are an indicator of nutritional status. Examples include serum tests for lipids, albumin, hemoglobin level, urine test for sugar, blood; stool examination for intestinal parasites.

- **Clinical assessment**: This method includes reviewing the medical history and conducting a physical examination to detect signs and symptoms of malnutrition. Observations made include enlargement of salivary glands , loss of tooth enamel, loss of subcutaneous fat,
- **Dietary assessment**: This is dietary intake data which is used in conjunction with anthropometric, biochemical and clinical data to determine client nutritional status. There are various techniques of measuring diet. They are:
    - o 24 hours dietary recall
    - o Food frequency questionnaire
    - o Dietary history
    - o Food diary /record
    - o Food balance sheets

Malnutrition and Disease

Malnutrition increases susceptibility to infection. Infection on the other hand contributes to malnutrition. Dietary inadequacy leads to weight loss, impaired immunity, mucosal damage, pathogenic invasion and interferes with growth and development in children.

Disease worsens malnutrition through reduced nutrient intake, increased requirement and nutrient loss through vomiting and diarrhea. These complications further impair the body's defense mechanism and the vicious cycle of malnutrition and infection continues



Malnutrition and Infection Cycle

Common Nutritional Deficiencies

Macronutrient Deficiencies:

1. **Carbohydrates**

Carbohydrates are the body's main energy source. They are broken down into their simple form, the monosaccahrides. Functions of carbohydrates include:

- Source of energy
- Necessary for utilization of other nutrients
- Sugar enhances flavor of food as an additive
- Fibre provides bulk in diet

Deficiency of carbohydrates causes:

- Use of fat and protein as fuel source leading to weight loss
- Marasmus
- Mood swings
- Ketosis

2. **Proteins**

The building blocks of proteins are amino acids. Proteins are needed for the following functions:

Growth and development

- Repair and maintenance of body tissues
- Maintaining
- Synthesis of body compounds such as hormones, antibodies, enzymes
- Used for energy supply in the absence of carbohydrates and fats

The RDA for proteins is 0.8g/kg body weight. Individual protein requirement is determined by various factors such as age, physiological status, disease e.t.c

Consequences of Protein Deficiency

- Kwashiokor
- Poor growth and development in children
- Low birth weight
- Still birth
- Wasting/loss of weight
- Anaemia
- Susceptibility to infection
- Fluid imbalance

- Premature birth
- Mental deficiency

3. Fats

Fats are broken down into fatty acids and glycerol, which are then utilized for various purposes in the body. When consumed in excess, fat can cause cardiovascular diseases such as heart attack, stroke, atherosclerosis heart failure e.t..c

Functions of fat include:

- Provide a concentrated source of energy
- Form the structures of cell membranes(phospholipids)
- An insulator; helps regulate body temperature
- Protects the vital body organs e.g. kidney, liver and the heart.
- Essential for absorption of fat soluble vitamins
- Cholesterol is essential for synthesis of bile, hormones & Vitamin D.

Consequences of fat /lipid deficiency

- Deficiency in fat-soluble vitamins
- Cognitive deficiency in children
- Poor vision

4. Water

Water is considered a macronutrient because it is required in considerably high amounts, although it does not contribute to energy.

Functions of water include:

- It is an essential component of body fluids e.g blood and lymph
- Moisture is necessary for the normal functioning of every organ in the body.
- Water is the universal medium in which the various chemical changes of the body take place.
- As a carrier, water aids in digestion, absorption, circulation and excretion.
- Waste products are transported in the blood in watery solution and eliminated by the kidneys.
- Maintains blood volume
- It is essential in the regulation of body temperature.
- Lubrication of joints and viscera in the abdominal cavity

Insufficient water intake leads to dehydration, which can lead to death. Dehydration occurs when water loss exceeds water intake. Signs of dehydration:

- Thirst
- Loss of appetite
- Decreased blood volume
- Decreased urination
- Impaired physical performance
- Impaired temperature regulation
- Muscle spasms(involuntary contraction)
- Increased pulse and increased respiration
- Rate
- End in death if not corrected.

Micronutrient Deficiency

Vitamins

Vitamin	Consequences of deficiency
Fat-soluble vitamins	
Vitamin A	- Keratomalacia - Night blindness
Vitamin D	- Rickets - Osteomalacia
Vitamin E	
Vitamin K	- Hemorrhage
Water-soluble vitamins	
Vitamin C	- Scurvy
Vitamin B1	- Beriberi
Vitamin B2	- Ariboflavinosis
Vitamin B3	- Pellagra
Vitamin B5	- Digestive and neurological disturbances
Vitamin B6	- Anemia, Smooth tongue, - Central nervous system disturbances
Vitamin B7	- Skin rash - Hair loss - Neurological disturbances
Vitamin B9	- Anaemia - Neurological disturbances - Birth defects in newborns

Vitamin B12	- Anaemia - Nerve damage and paralysis

10.3.4.3 Self-Assessment

1. Discuss types of nutrition assessment
2. Outline the functions of water
3. Identify five signs and symptoms of dehydration
4. Which one of the following is not an anthropometric assessment?
   A. Weight
   B. Height
   C. Oedema
   D. Mid Upper Arm Circumference (MUAC)
5. The following are types of dietary assessment except:
   A. Food frequency questionnaire
   B. Dietary history
   C. Food balance sheets
   D. Food security assessment
6. Which one of the following is caused by protein deficiency ?
   A. Deficiency in fat-soluble vitamins
   B. Mood swings
   C. Ketosis
   D. Kwashiokor
7. Deficiency in Vitamin D causes
   A. Scurvy
   B. Marasmus
   C. Rickets
   D. Night blindness
8. Which one of the following is not part of clinical assessment?
   A. Enlargement of salivary glands
   B. Head circumference
   C. Loss of tooth enamel
   D. Loss of subcutaneous fat

10.3.4.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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10.3.5 Learning outcome 4: Identify factors that place client at nutritional risk

10.3.5.1 Learning Activities

Learning activity	Specific instructions
i) Report problems which may affect the client's ability to eat or drink to the dietitian and/or other relevant health professional • Review nutrition related complications	• Identify nutrition related problems experienced by clients • Document nutrition related problems experienced by clients • Manage problems which may affect client's ability to eat or drink
ii) Document and report client food intake	• Carry out nutritional screening • Record client's food intake • Address emerging issues that affect food intake
iii) Provide feedback about changes to nutrition support requirements to catering/food services	• Collaborate with the interdisciplinary healthcare team
iv) Inform client of the dietary recommendation	• Establish rapport with client • Educate client on their individual dietary needs • Justify the need for dietary modification

10.3.5.1 Information Sheet

Definitions

Nutrition screening: a process used to identify nutritional problems and risk factors

Nutrition status: a measurement of the extent to which an individual's physiologic need for nutrients is being met

Nutrition risk can be assessed in populations by evaluating such factors as food intake, income, functional status, socialization, acute and chronic illness, and use of medications. This is because these factors pose a great risk to the nutritional status of individuals.

An individual's nutrition status reflects the degree to which physiologic needs for nutrients are being met. Nutrient intake depends on actual food consumption, which is influenced by factors such as economic situation, earing behavior, emotional climate, cultural influences, effects of various disease states on appetite, and the ability to consume and absorb adequate nutrients.

There are several factors that influence nutrient intake including physiologic stressors such as:

- Infection
- Acute or chronic disease processes,
- Fever, or trauma;
- Body maintenance and well-being;
- Normal anabolic states of growth such as pregnancy or rehabilitation;
- Psychological stress.

Persons at nutritional risk can be identified on the basis of screening information that is routinely obtained at the time of admission to a hospital or nursing home or after returning to home-based care. Information obtained in the nutrition assessment is used to design an individual nutrition care plan.

Nutrition risk factors

Category	Factors
Food and nutrient intake patterns	- Calorie and protein intake greater or less than that required for age and activity level - Vitamin and mineral intake greater or less than that required for age - Swallowing difficulties - Gastrointestinal disturbances - Unusual food habits (e.g., pica) - Impaired cognitive function or depression - Nothing by mouth for more than 3 days - Inability or unwillingness to consume food - Increase or decrease in activities of daily living - Misuse of supplements - Inadequate transitional feeding, tube feeding or parenteral nutrition, or both - Bowel irregularity (e.g., constipation, diarrhea) - Restricted diet - Feeding limitations

Psychological and social facrors	- Language barriers - Cultural or religious factors - Emotional disturbances associated with feeding difficulties (e.g., depression) - Limited resources for food preparation or obtaining food and supplies - Alcohol or drug addiction - Limited or low income - Lack of or inability to communicate needs - Limited use or understanding of community resources
Physical conditions	Extreme age: adults older than 80 years, premature infants, very young children Pregnancy: adolescent, closely spaced, or three or more pregnancies

Nutrition screening precedes the nutrition care process. The purpose of a nutrition screen is to quickly identify individuals who are malnourished or at nutritional risk and determine whether a more detailed assessment is warranted. Regardless of the information gathered, the goal of screening is to identify individuals who are at nutritional risk, those likely to become at nutritional risk, and those who are likely to get into nutritional risk.

Nutrition in Collaboration with Other Disciplines in Healthcare

A nutritionist must be able to work with members of the medical care team for effective delivery of services. Collaboration ensures effective teamwork and eases communication between professionals. The different professions learn with, from and about each other with the objective of improving quality of care.

Inter-professional Roles of a Nutritionist:

- Directly communicates with the healthcare team about the patient's health status
- Share knowledge with other members of the health team
- Keeps in touch with the current scientific advancements in the field of medicine and nutrition; should therefore attend conferences, seminars and other related meetings.
- Work as policy makers to improve guidelines.

10.3.5.3 Self-Assessment

1. Outline factors that influence food choice
2. Outline the inter-professional roles of a nutritionist
3. Categorise the following risk factors as *Food and nutrient intake factors, psychological and social factors or physical conditions*
    a. Nothing by mouth for more than 3 days
    b. Inability or unwillingness to consume food
    c. Limited resources for food preparation or obtaining food and supplies
    d. Alcohol or drug addiction
    e. Extreme age: adults older than 80 years, premature infants, very young children
    f. Pregnancy
    g. Adolescent
    h. Closely spaced, or three or more pregnancies
    i. Increase or decrease in activities of daily living
    j. Misuse of supplements
    k. Inadequate transitional feeding, tube feeding or parenteral nutrition, or both
    l. Limited or low income
    m. Lack of or inability to communicate needs

10.3.5.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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10.3.6 Learning Outcome 5: Undertake nutrition monitoring

10.3.6.1 Learning Activities

Learning outcome	Specific activity
I. Identify the nutrition status of clients a. Review types of nutrition assessment	• Carry out anthropometric assessment to determine nutritional status • Interpret biochemical outcomes • Conduct clinical assessment • Conduct dietary assessment
II. Follow Systems designed by a dietitian to monitor client nutritional status	• Conduct follow up on client • Record client progress
III. Evaluate progress of client nutritional status that is reported to the dietitian, and/or other health professional	• Compare client nutritional status and goals of nutrition care • Record client progress • Identify discrepancies from the ideal

10.3.6.2 Information Sheet

Definitions

- **Monitoring:** an ongoing review of nutrition intervention outcomes to assess the process of achievement of the goals set at planning. It assesses progress by measuring pre-determined indicators.

- **Evaluation:** Evaluation is the systematic process of assessing the relevance, effectiveness, efficiency and impact of a nutrition intervention against set goals. The outcome helps to make the decision to discharge the client or to modify the care plan.

Types of Monitoring;

- **Process monitoring:** Assesses the 'how' of nutrition intervention. It queries the flow of activities towards the set goals while noting discrepancies
- **Impact monitoring:** assesses the impact of the nutrition intervention. Impact monitoring focuses on changes such as behaviour change and change in nutrition indicators of interest.

Importance of Monitoring in Nutrition Care

- Helps in decision making on the continued interventions
- To determine programme strengths and weaknesses
- To assess resource utilization
- Used to measure programme outcomes
- To review strategies
- To observe the trends of the programme
- It helps the nutritionist to improve their effectiveness and efficiency in addressing nutrition problems

Types of Evaluation:

- **Context evaluation**: Context evaluation is concerned with the assessment of existing information of the funding agency, the target group and the general programme environment.
- **Formative evaluation**: This is the day to day running of the programme towards acquisition of short term objectives therefore assess programme input, output or services and the general events in the programme environment
- **Impact evaluation**: Determine the ultimate effect on the beneficiaries in the long term. It is concerned with ultimate programme indicators.

Importance of Evaluation:

- Provide useful information for other ongoing or future interventions
- To provide useful information to the interdisciplinary medical care team
- To determine whether the intervention was successful or not

10.3.6.3 Self-Assessment

1. Discuss the two types of monitoring
2. Outline the importance of monitoring
3. Outline the importance of evaluation
4. _____ is an ongoing review of nutrition intervention outcomes to assess the process of achievement of the goals set at planning. It assesses progress by measuring pre-determined indicators.

   A. Monitoring　　B. Evaluation

   C. Assessment　　D. Situation analysis

5. Indicate whether the following statements are true or false about evaluation:
    A. Context evaluation is concerned with the assessment of existing information of the funding agency, the target group and the general programme environment.
    B. Formative evaluation determines the ultimate effect on the beneficiaries in the long term. It is concerned with ultimate programme indicators.
    C. Impact evaluation examines the day to day running of the programme towards acquisition of short term objectives therefore assess programme input, output or services and the general events in the programme environment

10.3.6.4 Tools, Equipment, Supplies and Materials

- Food charts
- Food models
- Food samples
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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CHAPTER 11:

CONDUCT NUTRITION CARE PROCESS

11.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to examine client nutrition status. It includes carrying out nutrition assessment, conduct nutrition diagnosis, conduct nutrition interventions, and conduct nutrition monitoring and conducting nutrition evaluation.

11.2 Performance Standard

By the end of this learning unit/competency, the trainee should be able to apply the nutrition care process based on the expectations and priorities of individuals group and population; carry out nutrition assessment as per resource materials, user needs, policies and guidelines; develop a nutrition diagnosis in collaboration with other health workers based on the results of nutrition assessment and resource material; conduct prescriptions for nutrition interventions as per WHO/MOH policies and guidelines; conduct evaluation of the entire care process based on the intervention plan and WHO policies and guidelines; and, audit the entire nutrition care process based on resource materials and policies and guidelines.

11.3 Learning Outcomes

11.3.1 List of the Learning Outcomes

1. Carry out nutrition assessment
2. Conduct nutrition diagnosis
3. Conduct prescriptions for nutrition interventions
4. Conduct monitoring and dietary assessment
5. Conduct evaluation for the entire nutrition care process.

11.3.2 Learning Outcome 1: Carry out nutrition assessment

11.3.2.1 Learning Activities

Learning activity	Special instruction
i) Determine anthropometric methods and tools	➢ Collect and document data on dietary intake using relevant tools as per organizational procedure ➢ Examine eating patterns e.g. number of meals, kind, amount, where is eaten, religious and cultural restriction, ability to feed self.
ii) Identify, interpret and evaluate biochemical assessments	➢ Identify the data that would lead into a possible nutritional diagnosis ➢ Collect clinical evidence of a nutrient deficiency ➢ Recommend further testing if a nutrition problem is not identified
iii) Identify and determine clinical and physical assessments • Review doctor's/ paramedical worker's notes	➢ Organize and cluster assessment data to identify a nutrition diagnosis ➢ Review data collected for factors that affect nutritional and health status ➢ Avoid working in isolation and collaborate with the medical team
iv) Conduct dietary assessment	➢ Collect and document data on dietary intake using relevant tools as per organizational procedure ➢ Collect clinical evidence of a nutrient deficiency ➢ Identify the data that would lead into a possible nutritional diagnosis ➢ Review the clustered data against the standards to identify similar signs or symptoms ➢ Recommend further testing if a nutrition problem is not identified
v) Conduct socio-economic evaluation	➢ Examine eating patterns e.g. number of meals, kind, amount, where is eaten, religious and cultural restriction ➢ Obtain history from guardians, for persons who cannot express themselves well such as young children, elderly or mentally challenged ➢ Obtain patients history through face to face interviews, reading patients file, referral notes. ➢ Use the patient's file determine patient's history and profile

vi)	Perform functionality assessment	➢ Identify the patient/client ➢ Create a conducive environment ➢ Establish a rapport with the client ➢ View work place procedure manual ➢ Conduct tests or procedures to aid in evaluation ➢ Review the client's ability to feed self ➢ Perform handgrip assessment ➢ Perform exercise tolerance ➢ Support patient on nutritional needs

11.3.2.2 Information Sheet

Definitions

- **Undernutrition**: condition that results when insufficient food is consumed over an extended period of time
- **Overnutrition:** pathological state resulting from the consumption of excessive quantity of food over an extended time
- **Dietary data:** information related to food and dietary supplements intake that will allow for accurate and reliable nutrient intake estimation
- **Data sources**: Organized assessment data that is clustered for comparison with defining characteristics of suspected diagnoses as listed in diagnosis reference sheets.
- **Demographic status of patient**: refers to Socioeconomic characteristics of a population expressed statistically, such as age, sex, education level, income level, marital status, occupation, religion, birth rate, death rate, average size of a family, average age at marriage. For example a census is a collection of the demographic factors associated with every member of a population.
- **Patient socioeconomic status**: Socioeconomic status is the social standing or class of an individual or group. It is often measured as a combination of education, income and occupation
- **Functional assessment**: these are tests are used to assess the degree of alteration in physiological functions which could lead to impaired nutritional status
- **Hand-grip strength**: the measure of the maximum static force that a hand can squeeze using a dynamometer
- **Exercise tolerance**: refers to the exercise capacity of a client as measured by their ability to endure exercise as well as the maximum workload achieved during the exercise period
- **Ambulation:** is defined as moving a patient from one place to another

Nutrition assessment

A nutritionist/dietician as a health practitioner should use different methods of nutritional assessment to assess the nutritional status of children, mothers and other adults.

Nutritional assessment is the interpretation of anthropometric, biochemical (laboratory), clinical and dietary data to determine whether a person or groups of people are well nourished or malnourished (over-nourished or under-nourished). Nutrition assessment is discussed in details in chapter 25 (Nutrition assessment and surveillance) of this learning guide.

Categories of Nutrition Assessment Data

How do nutrition/dietetics professionals determine where to obtain nutrition assessment data?

1. Anthropometric measurements
   - Include height/length, weight, body mass index (BMI), mid upper arm circumference, skin fold thickness growth rate, and rate of weight change. In young children, head circumference and chest circumference are also measured to assess patterns of growth and development and deviation from average size
2. Food and Nutrition related history
   - Food intake, nutrition and health awareness and management, physical activity and exercise, and food availability
3. Biochemical data, medical tests and procedures
   - Include laboratory data (e.g., electrolytes, glucose, lipid panel, and gastric emptying time).
   - Laboratory investigations to be done to exclude the underlying cause including routine examination of stool, urine, blood and x- rays.
   - Estimation of HB, serum proteins, enzymes, blood level of nutrients like vitamins, iron, amino acid, etc. to be done whenever indicated.
   - Assessment of associated problems like tuberculosis, mal-absorption syndrome, any infection or infestations should be made to find out the probable cause of nutritional deficiency.
4. Nutrition-focused physical findings
   - Include oral health, general physical appearance, muscle and subcutaneous fat wasting
   - Clinical examination of the client is done to assess deficiency signs and associated problems.
5. Client history
   - Include medication and supplement history, social history, medical/health history, and personal history.

Nutrition care indicators

Clearly defined markers – measureable

- Food and nutrient intake
- Medication use
- Growth and body composition
- Food and nutrition related knowledge
- Attitudes and behaviors
- Food access
- Physical activity
- Anthropometric data
- Laboratory values
- Physical findings (observed or reported)
- Personal and family medical history, social factors

Types of data to collect

i) Nutritional adequacy

ii) Health status (physical and clinical conditions, anthropometric and biochemical measurements, physiologic and disease status)

iii) Eating patterns

iv) Usual weight

v) Changes in appetite, taste, smell, chewing, swallowing

vi) Recent surgery, trauma, burns, infection

vii) Family history and chronic illness: (e.g. obesity, GI disorder, Diabetes Mellitus, Hypertension(HTN), Cancer)

viii) Nausea, vomiting, diarrhoea, constipation

ix) Food allergies or intolerance

x) Medication and/or supplements

xi) Self-care behaviours: meal preparation; environment during meal time

xii) Exercise and activity patterns

Additional history for infants and children

a) Gestational nutrition: infant birth weight, any delay in physical or mental growth

b) Infant breastfed or bottle fed

c) Child's willingness to eat what is prepared

d) Overweight and obesity risk factor

Additional history for adolescent

a) Present weight

b) What they feel about their Weight

c) Use of anabolic steroid or other agent to increase muscle size

d) Overweight and obesity risk factor (amount, time, where, type, skipped meals..)

e) Age first started menstruating (for girls).

Additional history for pregnant women

a) Number of pregnancies. (how many, problems, vitamins or supplements taken)

b) Food preferences when pregnant. (preferred, avoid, crave any particular foods)

Additional history for geriatrics

a) **A**ny diet differences from when you were in your 40s and 50s? (why, what factor affect: note physiologic or psychological changes or socioeconomic changes)

Components of nutrition assessment process

- Review data collected for factors that affect nutritional and health status
- Cluster individual data elements to identify a nutrition diagnosis as described in the nutrition diagnosis reference sheets
- Identify standards for data comparison

Data sources

The client's assessment data can be obtained from the following sources;

i) Screening or referral form

ii) Patient/client interview

iii) Medical or health records

iv) Observation and measurements

v) Consultation with caregivers and family

vi) Community based surveys

vii) Statistical reports

viii) Administrative data sets

ix) Epidemiological studies

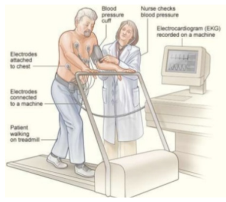
Nutrition assessment components

- Conducting a dietary intake review for factors that affect health conditions and influence nutrition risk
- Evaluate disease and health condition for nutrition-related consequences
- Evaluation of, functional, psychological and behavioural factors related to food access, selection, preparation, physical activity, and understanding of health condition
- Evaluation of knowledge, potential for changing behaviours, and readiness to learn
- Identifying standards by which data will be compared
- Identifying possible problem areas for making nutrition diagnoses

Functional assessment

Nutrient deficiencies sometimes impair physiological functions

- Tests or procedures may be conducted to aid evaluation
- Examples: skin's response to antigens; hand-grip strength; and exercise tolerance

Functional assessment	Test	Procedure/Content	Expected values	Resources
Handgrip strength index	Handgrip Strength The purpose of this test is to measure the maximum isometric strength of the hand and forearm muscles.	The client should hold the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer is adjusted if required - the base should rest on the first metacarpal (heel of palm), while the handle should rest on middle of the four fingers. When ready the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 5 seconds. No other body movement is allowed.	Men= 48 and above Women=26 and above	Video on how a dynamometer works https://www.youtube.com/watch?v=-jmWNKUek3o
Exercise tolerance	Cardiovascular or aerobic exercises, such as walking, jogging, cycling, rowing, dancing, and water aerobics	Metabolic equivalents MET (Metabolic Equivalent Term) 1 MET= basal aerobic oxygen consumption to stay alive Exercise intolerance can be objectively quantified using semiquantitative assessments, and surveys and quantitative methods, including timed walking tests (6 minute walk distance) and graded exercise treadmill or bicycle exercise tests.		

		Cardiopulmonary exercise testing on a treadmill or a bicycle ergometer provides the most accurate, reliable, and reproducible assessments of exercise tolerance, and yields multiple important outcomes, including METS, exercise time, exercise workload, blood pressure and heart rate responses, and rate-pressure product.		
Ability to self-feed		The 'Eating-feeding continuum' consists of four major stages: independent eating, assisted eating, assisted feeding and dependent feeding. In the literature 'independent eating' and 'self-feeding' are terms that are loosely defined and often used indiscriminately to include truly independent eating and assisted independent eating. A patient can remain independent and self-feed even if he or she cannot cook, shop or clear away. A good example of this would be the individual who needs a Meals-on- Wheels service. Independent eating skills can be defined as a series of independent activities which include: - The desire for food and fluid - The ability to recognize food - The motivation to seek out, select and bring home food		
		- The ability to prepare food and drinks by cutting, chopping, mixing, cooking and serving a meal or snack Useful eating aids should include padded cutlery, two-handled beakers, uni-valvular straws, rubber placemats, eggcups with a suction base, plate guards and tilting teapots.		

Ambulation		Once a patient is assessed as safe to ambulate, determine if assistance from additional health care providers or assistive devices is required		Vedio on assessment for ambulation https://www.youtube.com/watch?v=X_qucAc9hmo Vedio on Gait cycle and gait analysis https://www.youtube.com/watch?v=1u6d1CX7o9c
Wheel chair bound		If dealing with a disability that reduces the mobility, nutrition plays a vital role in keeping the client healthy. Proper nutrition will help the client to avoid pressure sores, type 2 diabetes and urinary tract infections. Ensure the client is having sufficient and nutritious meals daily.		

Clinically significant metabolic Equivalents for Maximum Exercise

1 MET:	Resting
2 METS	Level walking at 2mph
4 METs	Level walking at 2mph
<5 METs	Poor prognosis; peak cost of basic activities of daily living
10 METs	Prognosis with medical therapy as good as coronary bypass surgery; unlikely to exhibit significant nuclear perfusion defect
13 METs	Excellent prognosis regardless of other exercise responses
18 METs	Elite endurance athletes
20 METs	World class athletes

Categories of cut-offs of physical activity e.g. sedentary, light activity, moderate activity, high activity and highly active.

	Relative intensity		Absolute intensity (METs) in different age groups[a]			
	$VO_{2\ max}$ (%)	HR_{max} (%)	Young (20–39 years)	Middle-aged (40–64 years)	Old (65–79 years)	Very old (>80 years)
Light	25–44	30–49	3.0–4.7	2.5–4.4	2.0–3.5	1.26–2.2
Moderate	45–59	50–69	4.8–7.1	4.5–5.9	3.6–4.7	2.3–2.95
Hard	60–84	70–89	7.2–10.1	6.0–8.4	4.8–6.7	3.0–4.25
Very hard	≥85	≥90	≥10.2	≥8.5	≥6.8	≥4.25
Maximum[b]	100	100	12.0	10.0	8.0	5

Adapted from: Physical Activity and Health: A Report from the Surgeon General (1996).
[a] Absolute intensity values are approximate mean values for healthy men and usually 1–2 metabolic energy turnover units (METs) lower in women.
[b] Maximum values are approximate values achieved during maximum exercise.
$VO_{2\ max}$: maximum oxygen uptake; HR_{max}: maximum heart rate.

Establishing patient's Demographic and socio economic status;

Patient assessment is perhaps the most practical method of obtaining an overview of the nutritional status of a given patient. Poverty, housing, health, disease, cultural and ethnic differences, food supply, and community health programs, to name a few major factors, affect the patient's nutritional levels. Gathering existing data on these and other factors will help determine whether the patient's nutritional resources are adequate, what groups are potentially at high nutritional risk, and how well the patient's nutritional and related health needs are being met by? Existing curative and preventive health programs.

In effect, a patients demographic and socio economic assessment paints a picture of the his general health and the factors influencing the way the patient live. To do this, demographic, epidemiologic, cultural and geographic data must all be utilized by the nutritionist. The patient's entire health-care capabilities-including medical, educational, and social welfare as well as nutritional-must be surveyed.

Patient's assessment relies primarily on existing sources of information. These may include vital statistics, hospital records and patient's own history.

Histories taken during assessment

1. **Medical history**

Medical history provides much insight into nutrition-related problems.

The client should be assessed on the following;

- Main complaint
- Present and past illnesses
- Current health status
- Gastrointestinal problems like abdominal pain/cramping, diarrhea, nausea & vomiting
- Bowel movement patterns

- Increased metabolic needs
- Increased nutritional losses
- Allergies
- Presence of opportunistic infections
- Past or present surgeries
- Alcohol and drug use
- Family history of disease and concurrent medical problems/chronic diseases (e.g. hypertension, diabetes, cancer, malaria)
- Examination for physical conditions
- Recent significant weight loss

The medical profile of the client should also be examined with regards to the medications taken and their side effects. The negative effects of food intake or malabsorption of nutrients should be addressed appropriately.

2. **Social history**

Social aspects of the medical history may also influence nutrition status (e.g., information relating to socioeconomic status, the individual's ability to buy food independently, whether the person is living or eating alone, physical or mental handicaps, smoking, or drug or alcohol addiction. In older adults, confusion caused by environmental changes, unsuitable housing conditions, lack of socialization at meals, psychological problems, or poverty may add to the risks. In order to meet the needs of diverse groups of clients, knowledge of various cultures is critical during the interviewing process. Factors that affect a person's cultural values include;

- religious beliefs
- rituals
- symbols
- language
- dietary practices
- education
- communication style
- views on health, wellness, and illness
- racial identity

Rapport establishment with clients of different cultures is important for positive outcomes.

3. **Medication history**

Gathering of medication history is a very important part of nutrition assessment because food/nutrients and drugs interact in many ways that may affect nutrition status and drug therapy effectiveness. The geriatrics, the chronically ill, those who have a history of inadequate nutritional intake, or are receiving multiple drugs for a period are prone to drug-induced nutritional deficiencies. The effectiveness of drug therapy can also be altered by specific foods and the timing of food and meal consumption. Use of herbal products may also affect the effects of medications.

4. **Nutrition/Diet history**

During nutrition/diet history assessment, the problems need to be evaluated include; anorexia, loss of the sense of taste (ageusia), diminished or distorted taste (dysgeusia), of smell (anosmia loss), excessive alcohol intake, poor-fitting dentures, food faddism, mastication or swallowing problems, frequent meals away from home, adverse food and drug interactions, dietary cultural or religious restrictions, an inability to eat for more than 7 to 10 days, intravenous fluid therapy for more than 5 days, or feeding dependence can lead to inadequate nutrient intake and nutritional inadequacy.

Alternative nutrition therapies, including use of mega doses of vitamins and minerals, various herbs, macrobiotic diets, probiotics, and amino acid supplements, must be addressed because they have an effect on the individual's nutritional and overall health care

Output of nutrition assessment

Results of nutrition assessment;

- Lead to appropriate initial determination that a nutrition diagnosis/problem exists
- If a nutrition diagnosis can be made, the Nutritionist labels the problem and creates a PES (Problem, Etiology, Signs/Symptoms) statement in Step 2 of the Nutrition Care Process
- If a nutrition problem is not identified, further information or testing may be necessary to make a determination
- If the assessment indicates that no nutrition problem currently exists that warrants a nutrition intervention, the term "No nutrition diagnosis at this time (NO-1.1)" may be documented

Critical thinking during assessment

When determining medical condition, it is very critical to;

- Determine appropriate data to collect
- Observe for verbal and non-verbal cues that can guide and prompt affective interviewing methods
- Determine the need for additional information
- Select assessment tools and procedures that match the situation
- Apply assessment tools in valid and reliable ways
- Distinguish relevant from irrelevant data
- Distinguish important from unimportant data
- Validate the data

- Organize and categorize the validated data in a meaningful framework that relates to nutrition related problems

Documentation of assessment data

Documentation is an ongoing process that is expected to support the four (4) steps in the Nutrition Care Process. For the documentation of the assessment to meet the quality standards, it should have relevance, accuracy, and timeliness.

Other information that would further describe quality assessment documentation include:

- Date and time of assessment
- Relevant data collected and comparison with reference standards
- Subject's perceptions, values, and motivation related to presenting problems
- Changes in subject's level of understanding, food-related behaviours, and other clinical outcomes for appropriate follow-up
- Reason for discharge/discontinuation if appropriate

Case study

Arianna was a healthy 16-year-old girl who was so happy to return to school this year. This is her junior year of high school, and she has been looking forward to attending the junior senior prom with Mike. Arianna is very active in cheerleading, Photo Club, gymnastics, and swimming. She has decided to join the Prom Committee this year so she can help plan the best prom that Wayne High has ever seen. Arianna has begun to look for prom dresses knowing that she will need to be saving every cent she can to afford the most perfect dress. Arianna has decided that she would like to lose a few extra pounds before the prom and decides to go on a strict diet. Arianna's friends have noticed that the once perky, playful superstar of the swimming team has been losing her "shine." She has dull, limp hair, which is a total change from the full head of shiny, bouncy black hair. Arianna has developed a complexion problem and has started using all kinds of acne products. Her skin is very oily and feels dirty all the time. Arianna's friends also noticed that she is not as pleasant as before, and Arianna has started to lose lots of her friends. Arianna's friend Ruth contacted Arianna's mother and told her of her concerns. Arianna's mother agreed that she had also noticed the changes and would take Arianna to the doctor.

a. Identify three changes in Arianna to suggest that she was getting into trouble.

b. What information would be important to share with the physician?

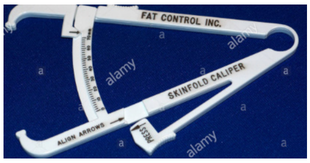
c. In which category of nutritional assessment would you list Arianna's observations?

d. Which observation would you consider significant enough to cause concern?

11.3.2.3 Self-Assessment

1. Define the following terms;
    A. Data sources
    B. Overnutrition
    C. Differential diagnosis
    D. Ambulation
2. Dietary data is ___________________
    A. Organized assessment data that is clustered for comparison with defining characteristics of suspected diagnoses.
    B. Investigation or analysis of the cause or nature of a condition, situation or problem.
    C. information related to food and dietary supplements intake that will allow for accurate and reliable nutrient intake estimation
    D. Pre-defined criteria (signs and symptoms) to which the current situation can be compared.
3. Screening forms, community based surveys, epidemiological studies and statistical reports are all classified under;
    A. Medical history
    B. Social history
    C. Nutrition care indicators
    D. Data sources
4. Client history include all of the following (indicate true/false against each answer)
    a. Supplement history
    b. Medical history
    c. Health history
    d. None of the above
5. Identify the components of the nutrition diagnosis reference sheets
6. Describe the rapid screening methods and tools used to determine underlying medical condition
7. Explain the laboratory methods used to determine deficiencies
8. State the data sources used in determining underlying medical condition
9. Describe the stages of Feeding eating continuum assessment
10. Independent eating skills can be defined as a series of independent activities. Explain these activities
11. Explain how you will meet the nutritional needs of a patient who is wheel chair bound and cannot self-feed

11.3.2.4 Equipment and Materials

Microtoise 	Stadiometers 	Calipers 
Dynamometer 	Height Boards 	Weighing scales/Beam balance 
Adult MUAC tapes 	Color-coded measuring tapes 	Salter scale 
Children MUAC tapes 	Length boards 	

Materials and resources

1. Computers with internet
2. Library and resource Centre
3. WHO guidelines
4. MOH policies and guidelines
5. Skills lab
6. LCDs, video clips, charts and other teaching aids
7. Invitation of competent expertise

11.3.2.5 References

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11.3.3 Learning Outcome 2: Conduct nutrition diagnosis

11.3.3.1 Learning Activities

<table>
<tr><th>Learning activity</th><th>Special instruction</th></tr>
<tr><td>i) Determine underlying medical condition of the client
• Carry out diagnostic procedures
• Carry out differential diagnosis</td><td>➢ Carry out rapid screening methods like MUAC and BMI
➢ Conduct diagnostic/biochemical examinations
➢ Organize and cluster assessment data to identify a nutrition diagnosis
➢ Review data collected for factors that affect nutritional and health status
➢ Collaborate with the medical team</td></tr>
<tr><td>ii) Label and classify nutrition problems of client
• Identify standards for data comparison</td><td>➢ Review the clustered data against the standards to identify similar signs or symptoms
➢ Classify the nutrition problems into the various domains
o Intake domain
o Clinical domain
o Behavioral-environmental domain</td></tr>
<tr><td>iii) Identify and describe etiology of conditions
• Examine client intrinsic factors
• Examine client extrinsic factors are assessed
• Determine client Iatrogenic causes
• Consider doctor's prescription</td><td>➢ Observe clues of possible inadequate intake compared to the established reference standards
➢ Classify the causes of the various nutrition problems
➢ Document any medical disease(s)/ condition(s) that the client may be having as per the medical notes
➢ Document the family history of the patient as pertaining the current health status</td></tr>
<tr><td>iv) Identify and describe signs and symptoms
• Check signs and symptoms
• Consider the doctor's prescription</td><td>➢ Review medical diagnosis
➢ Identify and document the defining characteristics that the nutritionist/dietitian can treat independently based on the intake domain</td></tr>
</table>

v) Determine nutrition diagnosis • Consider the results of anthropometric measurements, biochemical, clinical signs and symptoms, dietary, socio-economic and functional assessments.	➢ Cluster the nutrition problems, causes and defining characteristics ➢ Develop nutrition diagnosis statement (PES statement) ➢ Document nutritional diagnosis as per work place procedures

11.3.3.2 Information Sheet

Definitions

- **Nutrition problem**: "actual problems related to intake of energy, nutrients, fluids, bioactive substances through oral diet or nutrition support (enteral or parenteral nutrition)
- **Nutrient:** components of food that help to nourish the body e.g. carbohydrates, proteins, vitamins, lipids (fats), minerals and water
- **Imbalance:** pathological state resulting from disproportion among essential nutrients with or without the absolute deficiency of any nutrient
- **Specific deficiency**: pathological state resulting from relative or absolute lack of specific nutrients
- **Diagnosis:** the act of identifying a disease or condition from its signs and symptoms
- **Differential diagnosis**: the process of weighing the probability of one disease versus that of other diseases possibly accounting for a patient's illness by considering shared signs and symptoms.
- **Diagnostic procedure**: is an examination to identify a client's specific signs and symptoms in order determine a condition, disease or illness.
- **Etiology**: factors that contribute to the cause or existence of a particular problem
- **Client intrinsic factors**: factors that originate from within the client which may cause a nutritional problem
- **Client extrinsic factors**: factors that originate outside of the client and their control
- **Drug-nutrient interaction**: an alteration of kinetics or dynamics of a drug or a nutritional element, or a compromise in nutritional status as a result of the addition of a drug
- **Signs**: are observable changes (objective data) in the patient/client or groups health status
- **Symptoms:** changes that the patient/client/group feels and expresses verbally (subjective data) to the dietitians professional

- **Nutrition diagnosis**: a food and nutrition professional's identification and labelling of an existing nutrition problem that the food and nutrition professional is responsible for treating independently.
    - o It also refers to the identification and descriptive labeling of an actual occurrence of a nutrition problem that dietetics professionals are responsible for treating independently

Nutrition diagnosis

- It is a new concept for dietetics profession which is the missing link between nutrition assessment and nutrition intervention
- It involves identification and descriptive labeling of an actual occurrence of a nutrition problem that dietetics professionals are responsible for treating independently

Diagnosis involves investigation or analysis of the cause or nature of a condition, situation or problem. A medical diagnosis describes a disease or pathology of organs. Interventions for medical diagnosis may take several forms such as medications, surgery and other therapeutic approaches and may incorporate nutrition intervention.

Diagnosis implies;

- Pre-defined list of conditions
- Pre-defined criteria (signs and symptoms) to which the current situation can be compared.

NUTRITIONAL PROBLEMS

Nutrition problems are alterations in the patient's nutritional status. The problem may already exist, or may be at risk of occurring. This will call for screening tests for malnutrition and other nutrition conditions and interpretation of screening results.

A nutritional deficiency occurs when the body doesn't absorb or get food from the necessary amount of a nutrient. Deficiencies can lead to a variety of health problems. These can include digestion problems, skin disorders, stunted or defective bone growth, and even dementia.

Assessment of dietary intake details the history of dietary patterns, specific food consumed, quality and adequacy in relation of nutrient value.

Types of nutrition problems

There are two main types;

i) Under nutrition

ii) Over nutrition

They include the following categories;

- Undernutrition
- Overnutrition
- Specific deficiencies
- imbalances
- Chronic diseases
- Eating disorders

Domains of nutrition problems

Nutritional problems are categorized into three main domains;

i. Intake Domain – Involves actual problems related to excessive or inadequate intake compared to requirements (actual or estimated).

   Diagnostic labels include:

   - o Impaired (nutrient utilization…)
   - o Altered (GI function…)
   - o Inadequate/excessive (calorie intake…)
   - o Inappropriate (intake of types of carbohydrate)
   - o Swallowing difficulty

   It is composed into five (5) categories;

   a) Energy balance
   b) Oral diet or nutrition support intake (EN &PN)
   c) Fluid intake
   d) Bioactive substance
   e) Nutrients

ii. Clinical Domain –nutrition problems that are related to medical or physical conditions. It includes problems in swallowing, chewing, digestion, absorption, and maintaining appropriate weight. They are medical or physical conditions that are abnormal. It is composed of three categories:

   a) Functional balance: change in physical or mechanical functioning with nutritional consequences
   b) Biochemical balance: change in capacity to metabolize nutrients as a result of medications, surgery, or as indicated by altered lab values
   c) Weight balance: chronic weight or changed weight status when compared with usual or desired body weight

iii. Behavioral-Environmental Domain – problems that are related to knowledge, attitudes/beliefs, physical environment or access to food, and food safety. It is composed of three categories;

a) Knowledge and beliefs

b) Physical activity, balance and function

c) Food safety and access

To accurately identify a nutritional problem, the question to ask is, "Can the nutritionist/Dietitian resolve or improve the nutrition diagnosis?" The American Dieticians Academy advises focus on the intake domain as it is more specific to the roles of the nutritionist/dietician.

Methods of collecting current dietary intake information

24-hour recall: is a guided interview in which an individual recounts all of the foods and beverages consumed in the past 24 hours or during the previous day

Food frequency questionnaire: a survey of food routinely consumed

Food diaries: a detailed log (record of events) of food eaten during a specified time period, usually several days

Direct observation: achieved by observing food intake of the individual directly in a facility

Diagnostic procedures

This include biochemical analysis/Laboratory tests: Laboratory methods are used to determine deficiencies in;

- o Serum protein, particularly albumin level;
- o The blood-forming nutrients: iron, folacin, vitamin B6, and vitamin B12;
- o Water-soluble vitamins: thiamine, riboflavin, niacin, and vitamin C;
- o The fat-soluble vitamins: A, D, E, and K;
- o Minerals: iron, iodine and other trace elements;
- o Levels of blood lipids such as cholesterol and triglycerides, glucose and various enzymes which are implicated in heart disease, diabetes, and other chronic diseases.

Laboratory studies are important because they can detect preclinical nutritional deficiencies and can be used to confirm subjective finding;

- Glucose: plasma glucose level.
    - Normal (60-110 mg/dl), HBA1C

- Haemoglobin: To detect iron deficiency anaemia .(Male:14-18) (Female:12-16)
    - Increase Dehydration.
    - Decrease anaemia.
- Haematocrit : measure cell volume also an indicator of iron status (Male: 37% -49%) (Female :36%to46%)
    - Low value indicate insufficient haemoglobin formation.
- Cholesterol: To evaluate fat metabolism and to assess risk for cardiovascular disease. Normal (120-200), 200 -239 moderate risk, 240 or more high risk.
- Triglycerides: used to screen for hyperlipidaemia and to determine the risk of Coronary artery disease. Normal (< 150mg /dl).
- Serum proteins, Serum albumin: to measure of visceral protein status, Albumin is a better indicator of long-term protein status. Normal (3.5-5.5 g/dl)
    - Low serum albumin level occur with protein calorie malnutrition, altered hydration status, decrease liver function.
- Serum transferrin: Iron transport protein, more sensitive indicator of visceral protein status than albumen.
    - Serum transferrin = (0.8* total iron binding capacity) -43 Normal result (170-250 mg/dl)

Nutrition Diagnosis Reference Sheets

A reference sheet should be available for each nutrition diagnosis. Each reference sheet contains four (4) components;

a) Problem or Nutrition Diagnosis Label

b) Definition of the Nutrition Diagnosis Label

c) Etiology (cause/contributing risk factors)

d) Signs/Symptoms (defining characteristics)

Etiology

Etiology is a factor gathered during the nutrition assessment that contributes to the existence or the maintenance of pathophysiological, psychosocial, situational, developmental, cultural, and/or environmental problems. Identifying the etiology leads to selection of the nutrition intervention aimed at resolving the underlying cause of the nutrition problem. A nutritionist/ dietitian is expected to determine if this is the “root cause” for the problem. If addressing the etiology will not resolve the problem, can the Nutritionist/dietician intervention lessen the signs and symptoms?

Etiologies are grouped by the type of cause or contributing risk factor.

- Beliefs-Attitudes
- Cultural

- Knowledge
- Physical Function
- Physiologic
- Social-Personal
- Treatment

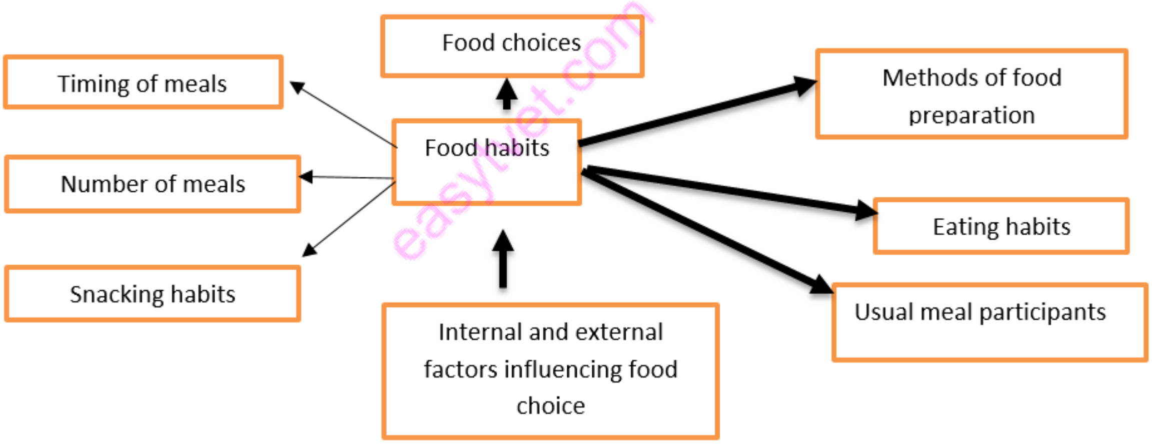
For the following, the category alone may be the cause or contributing risk factor of the nutrition diagnosis

- Access
- Behavior

Internal and external factors influencing food choice

Food habits are seen to provide an important signal of group identity as they influence eating times and number of meal, food preparation methods and meal participants, portion sizes and ways of eating (See Figure below)

Main components of food habits within group



Internal factors determining food choices

The main factors that underpin the drive to eat are physiological and psychological. These are classified as internal biological responses which influence food choice.

Psychological influences may modify or override the physiological need for food e.g. binge eating, or refusal to eat as a result of depression.

Internal factors cannot be separated from the external environment that will have shaped the setting in which these responses have developed e.g. dietary restraint is likely to have developed as a response to a cultural norm for slimness in women; perceptions and preferences for foods may then be shaped by this norm, and become a behavior influencing food choice.

Main physiological and psychological factors believed to have a role in the internal control of food choice

Factor	Expression	Comments
Physiological factors		
Hunger	Need to eat	Often determined by habit
Satiety	Stop food intake by preventing subsequent eating	May be over-ridden if presented with a variety of foods
Psychological factors		
Appetite	Desire for specific foods based on experience	Not thought to be linked to nutritional need
Aversion	Avoidance of specific foods, from (perceived) experience	May severely restrict foods
Preference	Established by frequency of exposure and early learning May also be linked to genetic differences in taste sensitivities	Set specific taste thresholds e.g. to sugar; salt; also resistance to new tastes (neophobia) Reinforced by positive outcomes (e.g. increased alertness)
Emotions (mood and stress)	Specific foods associated with positive and negative emotions	May lead to comfort eating, or food refusal as a weapon
Personality traits	Sensitivity to external and internal cues affecting food intake	May be important in believe about ability to control body weight

Nutritionists/ dieticians should know that recognition of the existence of internal and external factors in food choices is of great importance and that they should allow client's control over their food choice.

If a client losses control of their food choice, their appetite may reduce which may be the problem in institutions where menus are centrally determined. Patients who are prescribed modified diets may also experience a loss of control with consequently poor adherence to the diet.

External factors determining food choices

These factors are determined by the social and cultural context and they also affect both development and persistence of internal factors, as well as food available.

Factor	Description
1) Culture	– Defines what is acceptable as food – Confers and reinforces identity and belonging – May identify subgroups for whom certain foods are acceptable – May be overt (staple food, most popular food) or subtle (seasonings used and methods of cooking)
2) Religion	– Determines the broad context of food choice (rules) – Prohibitions exists on different types of meat, methods of slaughter, cooking methods and food combinations – Rules may also cover periods of fasting, rituals and festivals
3) Ethical decisions	– The way food is produced may affect food choices – Concerns about rearing animals for food and environmentally damaging methods of agriculture – Supporters may alter their food choices to match their ethical principles, choosing organically produced food, becoming vegan or vegetarian
4) Economic factors	– Access of food in terms of money or goods for exchange influences food choice – Clients in higher economic class can obtain a greater variety of food – Clients on a low income have limited opportunity to exercise alternative food choices. May be due to poor availability of food in their locality, inadequate money to buy food or both.
5) Social norms	– Acceptable behavior within an individuals social circle in relation to food strongly influences food choice – Revolves around peer pressure and reinforces expectations about food – May perpetuate food choices along gender lines, – Social norms may also determine the status of foods whereby some foods are perceived as more prestigious and therefore used to impress others.
6) Education/health awareness	– Originates form external environment and determines engagement with food and nutrition issues and the degree to which health issues influence food choice. – Experiences many barriers that interfere with food choices – The recognition of risk from an unhealthy diet, its relevance to the individual and the ability to act on this by food choices are key prerequisites.
7) Media and advertising	– Provide information about some foods, usually those that have been processed or manufactured and possibly less nutritionally desirable with higher higher levels of fat, salt, and sugar. – Exposure to food advertisements increases awareness and demand for the product.

Social and cultural factors have a great influence on food choice, even when consumers are not conscious of this. These modify or override physiological and psychological factors, and can have both positive and negative consequences on total food intake.

Intrinsic and extrinsic factors impact

Intrinsic factors include nutritional risk factors that influence nutritional status and place an individual at increased risk for poor nutrition Intrinsic factors include medications, economic status/lacking enough money for food, genetics, age, gender and having an illness or condition (comorbidities) that causes a diet change.

When considered in relation to nutrition, these factors are at least partly responsible for differences between individuals in:

- Absorption of food
- Metabolism
- Enzyme digestion
- Biosynthesis
- Catabolism
- Transport across cell membranes
- Uptake by cell receptors
- Storage
- Excretion

The host-related factors can be further subdivided into intestinal and systemic factors. Reductions in the secretion of hydrochloric acid, gastric acid, and/or intrinsic factor, together with alterations in the permeability of the intestinal mucosa, are all examples of intestinal factors that can markedly influence the absorption of certain nutrients, but that are often ignored when setting dietary requirements. Systemic factors that should also be considered include nutrient status of the host, age, sex, ethnicity, genotype, and physiological state (e.g., pregnancy or lactation), and chronic and acute infectious disease states.

The extrinsic factors are diet-related factors that must be considered depending on the nature of the habitual diet and may include the chemical form of the nutrient and the nature of the dietary matrix, interactions between nutrients and/or organic components, and food preparation and processing practices within the country or region.

Adverse Effects of Nutrient-Drug Interactions

Some drugs may affect the absorption of nutrients, while some foods—for example, those containing caffeine—can amplify or modify the effects of certain drugs. Taking drugs with hot beverages could also make them less effective. Short- or long-term instances of nutrient-drug interactions may be life threatening. A nutrient-drug interaction may also impact the nutritional status of the body. Nutrient-drug interactions can occur with both prescription and over-the-counter medicine.

Impact of Drug-Nutrient Interaction on Nutritional Status

A drug has the capacity of interfering with a person's nutritional status. Appetite may be stimulated by a certain drug, resulting in an increase in nutrient intake due to more food being eaten. However, drugs may also cause a decrease in appetite, leading to a decrease in nutrient intake. In this case, a drug could possibly cause a nutritional deficiency. Nutritional status may also be impacted by a drug's effect on the three main nutrients: carbohydrates, fat, and protein. A drug may speed up or slow down the breakdown of these three nutrients, which are essential to the body's functioning. When a drug affects the absorption of nutrients from food into the body, less energy is available to be used by the body. The impact of the nutrient-drug interaction may vary according to the medicine taken, the dose of the medicine given, and the form taken (e.g., pill, liquid).

Avoiding drug-nutrient interactions

Drug-food interactions which are a potential threat to good nutrition should be avoided at all costs, unless the benefit expected outweighs the potential risk. Ensure the following;

- Take drugs at correct dose and frequency to reduce the severity of the side effects
- Take a gut-irritating drug with or after meals to reduce the chances of discomfort
- Drug administration and meal times may be staggered to avoid unintended interactions
- A drug likely to interact unfavorably with food may be given parenterally
- A drug causing epigastric pain may be given likewise or rectally or as a necessary
- Taking syrup or a liquid drug may prevent prolonged stay of the drug in the gastrointestinal tract hence reducing chances of interaction with food
- If taking phenelzine drug (antidepressant) abstain from eating liver

Signs and symptoms

These are the defining characteristics that serve as evidence that a problem exists

Linked to etiology by words "as evidenced by"

Identifying the etiology will lead to the selection of a nutrition intervention aimed at resolving the underlying cause of the nutrition problem whenever possible. Major and minor etiologies may result from medical, genetic, or environmental factors.

Signs are observable changes (objective data) in the patient/client or groups health status while Symptoms are changes that the patient/client/group feels and expresses verbally (subjective data) to the dietitians professional

Signs and symptoms are grouped by

- o Nutrition assessment category, and
- o Potential indicators of the specific nutrition diagnosis

Assessment of defining characteristics

General appearance: this will provide clues to overall nutritional status e.g. obese, cachetic (fat and muscle wasting), edematous etc.One should review physical assessment findings for signs of poor nutrition

Physical examination

Physical examination can help the assessor detect signs of nutrition deficiency and fluid imbalances.

Clinical signs of malnutrition: signs of malnutrition tends to appear most often in parts of the body where cells replacement occurs at rapid rate such as: eyes, hair, skin, lips, nails and tongue;

Evaluating nutritional disorders

Body system/ Region	Sign or symptom	Implications
General	Weakness and fatigue	Anemia or electrolyte imbalance
	Weight loss	Decreased calorie intake, increased calorie use, or inadequate nutrient intake or absorption
Skin, hair, and nails	• Dry, flaky skin • Dry skin with poor turgor	• Vitamin A, vitamin B-complex, or linoleic acid deficiency • Dehydration
	Rough, scaly skin with bumps	Vitamin A deficiency
	Petechiae or ecchmoses	Vitamin Cor K deficiency
	Sore that won't heal	Protein, vitamin C or zinc deficiency
	Thinning, dry hair	Protein deficiency
	Spoon-shaped, brittle, or ridged nails	Iron deficiency
Eyes	Night blindness; corneal swelling, softening, or dryness; Bitot's spots (gray triangular patches on the conjunctiva)	Vitamin A deficiency
	Red conjuctiva	Riboflavin deficiency
Throat and mouth	Cracks at the corner of the mouth Magenta tongue Beefy red tongue	Riboflavin or niacin deficiency Riboflavin deficiency Vitamin B_{12} deficiency
	Soft, spongy, bleeding gums Poor dentition	Vitamin C deficiency Overconsumption of refined sugars or acidic carbonated beverages; illicit drug use

Cardiovascular	Swollen neck (goiter)	Iodine deficiency
	Edema	Protein deficiency, thiamine deficiency
	Third and fourth heart sounds	
	Shortness of breath	
	Cough	Fluid volume deficit; anemia
	Tachycardia, murmur, hypertension	
Gastrointestinal	Ascites	Protein deficiency
Musculoskeletal	Bone pain and bow leg	Vitamin D or calcium deficiency
	Muscle wasting	Protein, carbohydrate, and fat deficiency
Neurologic	Altered mental status Ataxia	Dehydration and thiamine or vitamin B_{12} deficiency
	Paresthesia, neuropathies	Vitamin B_{12}, pyridoxine, thiamine, or niacin deficiency

Anthropometric measures

These measures evaluate growth, development, and body composition. The most common anthropometric measures include:

- Height or length
- Weight
- Arm and head circumference
- Waist circumference
- Body mass index
- Triceps skin-fold thickness
- Elbow breadth

A. **Derived weight measures**: (used to depict change in body weight)

- Body weight as a Percent ideal body weight: is the optimal weight recommended for optimal health Percent ideal body weight =current wt./ideal wt.*100 (If the result 80% -90% mild malnutrition . 70%- 80% moderate malnutrition . Less than 70% sever malnutrition) .
- Percent usual body weight :
    - o Percent usual body weight = current wt. /usual wt. *100 . (If the result 85% -95% mild malnutrition , 75%-84% moderate mal nutrition ,less than 75 % sever malnutrition)
- Recent weight change is calculated by :
    - o Usual wt. – current wt. /usual wt. *100 . (An unintentional loss of >5% of body wt. over 1 month , or > 7.5 % over 3 month , or 10 % over 6 month is clinically significant)

B. BODY MASS INDEX

The body mass index is a practical marker of optimal weight for height and indicator of obesity or under nutrition. It is calculated and interpreted as follows;

$$BMI = \frac{\text{weight (lb)} * 703}{\text{height}^2 \text{ (in}^2\text{)}}$$

OR

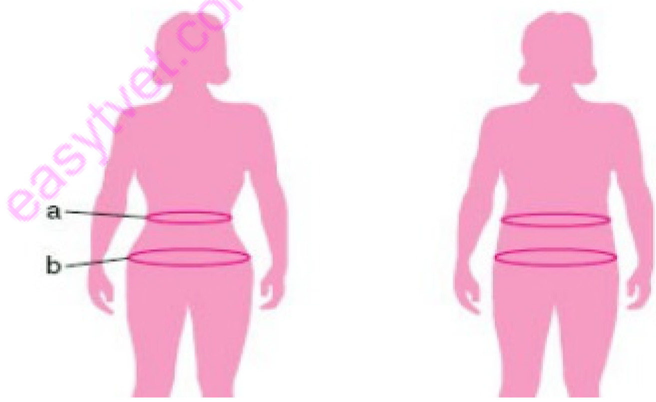
$$BMI = \frac{\text{weight (kg)}}{\text{height}^2 \text{ (m}^2\text{)}} \quad \text{(metric)}$$

BMI	Weight Status
Below 18.5	Underweight
18.5 - 24.9	Normal
25 - 29.9	Overweight
30 & Above	Obese

C. Waist-Hip ratio

This is used to assess body fat distribution and is calculate as follows;

$$WHR = \frac{\text{Waist circumference}}{\text{Hip circumference}}$$



Interpretation: 1.0 or more in men the person is obese while if the women is 0.8 or more the women is obese.

D. Skin fold thickness

These measurements provide an estimate of body fat stores or the extent of obesity or under nutrition.(biceps, subcapsular, suprailiac skinfolds).

TSF values 10 % below or above standard suggest under nutrition or over nutrition .

Table 3 - Descriptive and comparative analysis of the anthropometric variables of school-age children of both genders, classified as overweight according to the assessment period (initial, 10 and 20 years)

	Initial	10 years	20 years	Δ%
Male				
Body mass (kg)	32.02±5.62	33.48±7.34	37.14±6.43[†]	15.99
Height (cm)	130.70±9.35	133.52±10.67	138.45±9.78[†]	5.92
Biceps (mm)	6.06±1.55	8.54±9.37	9.37±3.04[†]	54.62
Triceps (mm)	11.94±2.46	13.24±3.75	14.54±5.45	21.77
Subscapular (mm)	6.22±1.10	7.62±2.17	9.90±4.47[†]	59.16
Suprailiac (mm)	6.30±2.27	9.56±5.75	11.53±5.62[†]	83.01
Mid-axillary (mm)	5.08±1.52	6.88±3.54	10.00±4.50[†]	96.85
Abdomen (mm)	8.81±4.16	14.38±8.12	18.10±7.39[†]	105.44
Calf (mm)	11.92±2.89	14.58±4.84	16.51±6.51[†]	38.50
$\overline{X}$7SF (mm)	8.05±2.03	10.68±4.56	12.83±4.25[†]	59.37
Female				
Body mass (kg)	35.07±5.73	35.19±5.90	37.48±7.70	6.87
Height (cm)	133.89±8.35	135.07±9.13	137.79±10.97	2.91
Biceps (mm)	9.24±2.79	11.12±2.81	9.93±2.99	7.46
Triceps (mm)	15.98±3.97	17.13±3.21	16.48±3.02	3.12
Subscapular (mm)	10.74±3.87	12.76±3.44	12.75±4.61	18.71
Suprailiac (mm)	11.81±4.72	16.53±4.40[*]	15.73±5.81[†]	33.19
Mid-axillary (mm)	9.06±4.47	11.81±3.14	12.42±5.08[†]	37.08
Abdomen (mm)	15.00±6.24	21.34±4.98[*]	22.30±5.81[†]	48.66
Calf (mm)	17.24±3.83	17.43±3.96	17.01±5.42	-1.33
$\overline{X}$7DC (mm)	12.72±3.66	15.44±2.87	15.23±3.63[†]	19.73

Δ% = delta percentage.
$\overline{X}$7SF = mean adiposity of the seven SFs (biceps, triceps, subscapular, suprailiac, mid-axillary, abdomen and calf).
$p < 0.01$.
[*] Initial different from 10 years.
[†] Initial different from 20 years.
[‡] 10 years different from 20 years.

E. Mid Upper Arm Circumference

MUAC estimates skeletal muscle mass and fat stores.

This method is difficult to obtain and interpret in older adult because of sagging skin, changes in fat distribution, and declining muscle mass.

F. Arm span or total arm length

Measurement arm span is useful those situation in which height is difficult to measure. (children with cerebral palsy, scoliosis or in aging person).

Nutrition Diagnosis and medical diagnosis

A nutrition diagnosis, in contrast to a medical diagnosis, is written in terms of client problem for which nutrition-related activities provide the primary intervention. It focuses on nutrition issues that may be consequences of or contribute to diseases. It also addresses behaviors that impact food choices.

Differences between nutrition diagnosis and medical diagnosis

Medical Diagnosis	Nutritional Diagnosis
• A medical diagnosis describes a disease or pathology of organs. Interventions for medical diagnosis may take several forms such as medications, surgery and other therapeutic approaches and may incorporate nutrition intervention	• Nutrition diagnosis entails the nutrition professional identifying and labeling a specific nutrition diagnosis (problem) and taking responsibility for treating it independently with a nutrition intervention, the nutrition dx is ideally resolved
Diabetes	Excessive CHO intake r/t visits to Coldstone Creamery as evidenced by diet hx and high hs blood glucose
Trauma and closed head injury	Increased energy needs r/t multiple trauma as evidenced by results of indirect calorimetry
Liver failure	Altered gastrointestinal function r/t cirrhosis of the liver as evidenced by steatorrhea and growth failure
Obesity	Excessive energy intake r/t lack of access to healthy food choices (restaurant eating) as evidenced by diet history and BMI of 35.

Anorexia nervosa	Undesirable food choices r/t history of anorexia nervosa and self-limiting behavior as evidenced by diet history and weight loss of 5 lb.

Nutrition diagnosis components

The nutrition diagnosis is expressed using nutrition diagnostic terms and the etiologies, signs, and symptoms that have been identified in the reference sheets describing each diagnosis. There are three distinct parts to a nutrition diagnostic statement:

i) The nutrition diagnosis describes alterations in a patient's/client's status. A diagnostic label may be accompanied by a descriptor such as "altered," "excessive," or "inadequate."

ii) The etiology is preceded by the words "related to."

iii) Signs/symptoms (defining characteristics) The defining characteristics are a typical cluster of signs and symptoms that provide evidence that a nutrition diagnosis exists.

- The signs and symptoms are preceded by the words "as evidenced by."
- Signs are the observations of a trained clinician.
- Symptoms are changes reported by the patient/client.

Characteristics of nutritional diagnosis statement

A well written nutrition Diagnostic Statement should be:

a) Clear and concise to avoid misinterpretation and/or confusion

b) specific so as to point towards the precise condition/problem

c) accurately related and limited to one/single problem so as to ensure that each problem is handled conclusively

d) Accurately related to one etiology

e) Based on reliable, accurate assessment data i.e. based on signs and symptoms from the assessment data

How to develop a nutrition diagnoses

- o Evaluate nutrition assessment using critical thinking
- o Identify the problem(s)
- o State them each clearly and singularly
- o Focus on those that can be treated by nutritional intervention
- o Describe the signs and symptoms
- o Explore the etiology or cause
- o Again focus on a nutrition-related cause Not medical diagnosis.

The PES statement

This is a structured sentence that is used to summarize the nutrition problem. It clarifies a specific nutrition problem and logically links the nutrition diagnosis to nutrition intervention and to monitoring and evaluation.

This statement has 3 distinct components:

P (Problem): diagnostic label, describes in a general way an alteration in the nutritional status

Words commonly used: excessive, inadequate, and inappropriate

E (Etiology) – factors that contribute to the cause or existence of a particular problem

S (Signs and Symptoms) defining characteristics obtained from the subjective and objective nutrition assessment data

This information is obtained during the nutrition assessment phase of the Nutrition Care Process. This statement has a distinct format:

- Problem related to Etiology as evidenced by Signs and Symptoms

Evaluating PES statement

P (Problem): Can the nutritionist's/dietician's resolve or improve the nutrition diagnosis? Consider the "intake" nutrition diagnosis as the one more specific to the role of the Nutritionist/ dietician.

E (Etiology): Is the etiology listed the "root cause"? Will the nutritionist's/dietician's intervention resolve or improve the problem by addressing the etiology? Can nutritionist's/ dietician's intervention at least lessen the symptoms?

S (Signs and Symptoms): Will measuring the signs and symptoms indicate if the problem is resolved or improved? Are the signs and symptoms specific enough that the Nutritionist/ dietician can monitor and document resolution or improvement of the nutrition diagnosis?

Does the nutrition assessment data support the specific nutrition diagnosis, etiology, and signs and symptoms?

Sample PES statements

1. Patient has involuntary weight loss (p) due to inadequate energy intake (E) as evidenced by eight pounds weight loss within 4 weeks (S).
2. Excessive Fat Intake (P) related to limited access to healthful options – frequent consumption of high-fat, fast-food meals (E) as evidenced by serum cholesterol level of 230 mg/dL and patient report of 10 meals per week of hamburgers and fries (S)
3. Excessive Energy Intake(P) related to unchanged dietary intake and restricted mobility while fracture heals (E) as evidenced by 5 lb weight gain during last 3 weeks due to patient report of consumption of 500 kcal/day more than estimated needs(S).

Critical thinking in nutrition diagnosis

To effectively develop a good nutrition diagnostic statement, the following should be considered;

- Finding patterns and relationships among the data and possible causes.
- Making inferences.
- Stating the problem clearly and singularly.
- Suspending judgment.
- Making interdisciplinary connections.
- Ruling in/ruling out specific diagnoses

Documentation

Documentation is an on-going process that supports all of the steps in the Nutrition Care Process. Quality documentation of the diagnosis step should be relevant, accurate, and timely. A nutrition diagnosis is the impression of nutrition/dietetics professionals at a given point in time. Therefore, as more assessment data become available, the documentation of the diagnosis may need to be revised and updated. Inclusion of the following information would further describe quality documentation of this step:

- Date and time; and
- Written statement of nutrition diagnosis.

Determination for continuation of care

Because the nutrition diagnosis step involves naming and describing the problem, the determination for continuation of care follows the nutrition diagnosis step. If a food and nutrition professional does not find a nutrition diagnosis, a patient/client may be referred back to the primary provider. If the potential exists for a nutrition diagnosis to develop, a food and nutrition professional may establish an appropriate method and interval for follow-up.

CASE STUDIES

Case study 1

Arianna was a healthy 16-year-old girl who was so happy to return to school this year. This is her junior year of high school, and she has been looking forward to attending the junior senior prom with Mike. Arianna is very active in cheerleading, Photo Club, gymnastics, and swimming. She has decided to join the Prom Committee this year so she can help plan the best prom that Wayne High has ever seen. Arianna has begun to look for prom dresses knowing that she will need to be saving every cent she can to afford the most perfect dress. Arianna has decided that she would like to lose a few extra pounds before the prom and decides to go on a strict diet. Arianna's friends have noticed that the once perky, playful superstar of the swimming team has been losing her "shine." She has dull, limp hair, which is a total change from the full head of shiny, bouncy black hair. Arianna has developed a complexion problem and has started using all kinds of acne products. Her skin is very oily and feels dirty all the time. Arianna's friends also noticed that she is not as pleasant as before, and Arianna has started to lose lots of her friends. Arianna's friend Ruth contacted Arianna's mother and told her of her concerns. Arianna's mother agreed that she had also noticed the changes and would take Arianna to the doctor.

a. What contributed to the development of the problems?

b. Draw PES statement for Arianna’s problems

<u>Case study 2</u>

Review the following cases:

Medical hx: 72 year old female admitted with decompensated CHF; heart failure team consulted; has been admitted with same dx 2x in past month; meds: Lasix and Toprol; current diet order: 2 grams sodium; has lost 5 pounds in 24 hours since admission; Output > input by 2 litres

Nutrition history: has been told to weigh herself daily but has no scale at home. Does not add salt to foods at the table. Noticed swollen face and extremities on day prior to admission. Day**// before admission ate canned soup for lunch and 3 slices of pizza for dinner; does not restrict fluids; has never received nutrition counselling

Nutrition diagnosis statements;

1. Excessive sodium intake r/t frequent use of canned soups and restaurant foods as evidenced by diet history.
2. Knowledge deficit r/t no previous nutrition education as evidenced by /*9*-+-8*frequent use of high sodium convenience foods and inability to name high sodium foods.
3. Excess fluid intake r/t dietary indiscretions as evidenced by diet history and current fluid status.
4. Self-monitoring deficit r/t lack of access to scale as evidenced by patient self-report.

<u>Case study 3</u>

Mr. T, a 45 year old man, 5ft 8 inches tall and weighing 178lb (BMI 27), is admitted to the hospital with chest pain. Mr. T gained 25 pounds over the last year. Labs: LDL 240, HDL 30, TG 350 BP 120/80.

Diet is poor, skips meals and eats large dinner meals.

PES statement: “Altered nutrition-related laboratory values (lipid profile) Related to undesirable food choices as evidenced by hyperlipidemia with elevated LDL and low HDL.

11.3.3.3 Self-Assessment

1. Define the following terms;
    a. Diagnosis
    b. Differential diagnosis
    c. Nutrition problem

   d. Etiology
   e. Client intrinsic factors
   f. Symptoms
   g. Drug-nutrient interaction

2. Intake domain of nutrition diagnosis entails________
   a. Nutrition problems that are related to medical or physical conditions
   b. Problems that are related to knowledge, attitudes/beliefs, physical environment or access to food, and food safety
   c. Actual problems related to excessive or inadequate intake compared to requirements (actual or estimated).
   d. All of the above

3. The following methods are used in collecting current dietary intake information (indicate true/false for each answer
   a. 24-hour recall
   b. Food frequency questionnaire
   c. Direct observation
   d. None of the above

4. Problem, definition of nutrition diagnosis label, etiology and signs/symptims are all components of;
   a. Nutrition diagnosis reference sheet
   b. Medical diagnosis
   c. Monitoring and evaluation
   d. Nutrition diagnosis.

5. The external factors influencing food choice include;
   a. Culture and religion
   b. Hunger and ethical decisions
   c. Personal traits and economic factors
   d. Education and aversion.

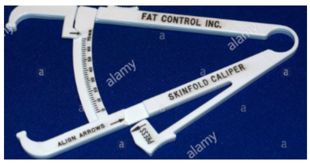
6. Describe the rapid screening methods and tools used to determine underlying medical condition.
7. Identify the diagnostic labels for the intake domain.
8. Explain why ADA recommends the use of intake domain by dietitians/nutritionists.
9. Explain the diagnostic labels for intake domain.
10. Outline the components behavioral-environmental domain.
11. Describe clinical domain of nutrition diagnosis.

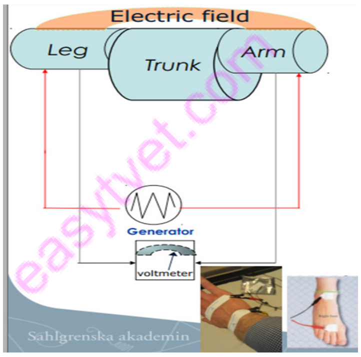
12. Discuss the client intrinsic factors that are related to nutritional problems.
13. Describe the influence of client extrinsic factors on an individual's nutritional status.
14. In which ways do food/nutrient interact positively?
15. Explain why it is difficult to use MUAC as a defining characteristic in older adults.
16. Discuss physical examination in light of the basis for signs and symptoms.

11.3.3.4 Materials

- Nutritional assessment data form
- Nutrition diagnoses reference sheets
- Stationery
- Clinical manual of 2013
- Metropolitan life insurance tables
- Computers with internet
- Library and resource Centre
- WHO guidelines
- MOH policies and guidelines
- Skills lab
- LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise

Equipment

Microtoise	Stadiometers	Calipers
		

Length boards 	Height Boards 	Weighing scales/Beam balance 
Adult MUAC tapes 	Color-coded measuring tapes 	Salter scale 
Children MUAC tapes 	Bio Impedance analysis machine 	

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11.3.4 Learning Outcome 3: Conduct prescriptions for nutrition interventions

11.3.4.1 Learning Activities

Learning activity	Special instruction
i) Prioritize and address nutrition needs • Prescribe client's daily requirements as per client conditions • Address clients' immediate nutrition needs as per the nutrition diagnosis • Supplement clients levels of micronutrients and macronutrients as per client nutrition needs	➢ Provide and consider the client's nutrition diagnosis ➢ Calculate energy requirements as per client condition ➢ Calculate client nutrient needs as per condition ➢ Provide macro and micronutrient supplement as per client' need
ii) Identify and select appropriate nutrition interventions • Define nutrition intervention plan and related strategies as per work place procedures • Identify time and frequency of care as per client nutrition needs • Identify resources required as per client nutrition needs	➢ Provide alternatives of nutrition intervention ➢ Choose suitable nutrition intervention plan as per work place procedure and with consultation with the client ➢ Plan time and frequency of nutrition care ➢ Mobilize and document resources required
iii) Design diet plans • Review client's nutritional status • Assist the client to identify self-care abilities and disabilities	➢ Review the nutrition diagnosis of the client ➢ Design a diet plan for the client putting into consideration all the assessment data ➢ Reinforce client's abilities for self-care ➢ Address client's self-care disabilities ➢ Prescribe the required self-care for the client
i) Implement designed care plans • Inform client, family and/or significant other of the implications of their admission to the health care setting • Discuss psychological, social and/or physical needs with clients • Share information regarding client nutritional status	➢ Plan the implementation with client, family and/or significant other ➢ Explain the care plan to client, family and/or significant other ➢ Highlight the financial implications of the preferred care plan ➢ Address client's fears about the designed care plan ➢ Inform client, family and/or significant other of their roles in implementing the diet plan

	➢ Address psychological, social and physical needs with the client ➢ Collaborate with the multidisciplinary team ➢ Consult relevant professionals on other factors that may affect efficacy of the care plan ➢ Record dietary modifications on relevant documents

11.3.4.2 Information Sheet

Definitions

- **Nutrition intervention:** Planned actions designed with the intent of changing nutritional related problem e.g. nutritional counselling and education, therapeutic feeding, macronutrient and micronutrient supplementation, food by prescription, supplementary feeding, enteral and parenteral nutrition.
- **Nutrition care:** It is the use of nutrition knowledge in planning meals, managing diseases and maintain health
- **Energy Intake:** the dietary energy intake that is required to meet normal needs in a healthy person of a defined age, gender weight, height, and level of physical activity
- **Recommended Dietary Allowance (RDA):** The amount of a nutrient needed to meet the requirements of almost all (97% to 98%) of the healthy population
- **Macronutrients:** Nutrients required in considerably large quantities. They are measured in grams. They are: carbohydrates, proteins and fats
- **Micronutrients:** These are nutrients required in small amounts. They are minerals and vitamins
- **Supplements:** These are food products that are intended to complement the diet
- **Calorie:** it is a unit of energy clients' get from the food and beverages they consume

Nutrition intervention

Nutrition intervention is carried out to manage the nutritional problem through counselling, education and dietary modification to meet a client's nutritional requirement.

An individual's nutritional status is assessed, after which a nutrition diagnosis is made. Once the nutrition problem has been identified, the nutritionist then considers alternative solutions to the problem.

Critical thinking helps to determine the strengths and weaknesses of each intervention. Intervention translates assessment data into strategies, activities, or interventions that will enable the patient or client to meet the established objectives. Client-driven process is key during interventions.

Interventions should be specific:

- What?
- When?
- Where?
- How?

Objectives of nutrition intervention

- Should be patient-centered
- Must be achievable
- Stated in behavioral terms, quantifiable terms
- Patient and counselor must establish goals together
    - o may involve other members of health care team
- Show what the patient will do or achieve if objectives are met

Sample objectives of nutrition intervention

Problem 1: Involuntary weight loss

Objectives:

1. Patient will stop losing weight and begin to gain weight slowly, to a target weight of 145lb
2. Patient will modify his diet to increase intake to meet calorie and protein needs

Problem 2: Inadequate protein-energy intake secondary to poor appetite

Objectives:

3. Patient will attend senior center for lunch daily to improve socialization and calorie intake
4. Patient will include nutrient-dense foods in his diet

Nutrition intervention strategies

- Prioritize nutrition diagnoses
- Consult the ADA guidelines
- Determine patient-focused expected outcomes
- Confer with family members/caregivers
- Define nutrition plan and strategies

Steps of nutrition intervention

Three main steps are followed during nutrition intervention;

1. Selecting
2. Planning
3. Implementing

I) **SELECTING**

The nutrition intervention chosen is based on the nutrition diagnosis and uses as well as team involvement, science based principles and additional research, if available. The key element is that the nutritionist improves the issue by creating a rational plan with the help of the whole family including the individual.

Nutrition intervention strategies are selected to change nutritional intake, nutritional related knowledge for behaviour or environmental conditions or access to supportive care and services

Nutrition intervention goals provide the basis for monitoring progress and measuring outcomes.

There are four domains of nutrition intervention:

1) **Nutritional counselling;** this is a supportive process characterized by collaborative counsellor- client relationship to establish food, nutrition and physical activity priorities, goals and individual action plans that acknowledge and foster responsibility for self-care to treat an existing condition
2) Nutrit**ion education**: this is a formal process to instruct a client in a skill or to impart knowledge to help client voluntarily manage or modify food, nutrition and physical activity choices and behaviour
3) **Food and nutrient provision:** this is an individualized approach for food/nutrient provision
4) **Coordination of nutrition care**; this is consultation with, referral to or coordination with nutrition care with other health care providers that can assist in treating nutrition related problems

Nutrition Counselling:

The GALIDRA approach

Galidra has proven effective in many settings and captures the essential elements of effective counseling interactions. It can be adapted as needed for other languages.

- **Greet** the client. Ask him or her to sit down and then exchange introductions to establish a comfortable atmosphere.
- **Ask** the client about his or her situation and current practices using open-ended questions and familiar language.
- **Listen** to what the client and/or caregiver say. Notice body language, use probing questions, and reflect back what the client says to make sure you understand it correctly.

- **Identify** the client's key problems and help select the most important ones to address.
- **Discuss** options, considering what is realistic and using visual materials to engage the client and/or caregiver in discussion.
- **Recommend and negotiate** a small, doable action, explaining the rationale and benefits.
- **Ask** the client to repeat what he or she understood from the discussion and what action he or she **Agrees** to try at home.
- **Make** a follow-up Appointment and ask the client to repeat the date.

Food and Nutrient Provision

There are two forms of selective feeding programmes:

- Supplementary Feeding
- Therapeutic Feeding Programmes

Supplementary feeding programmes (SFPs)

- Provide nutritious food in addition to the general ration
- Supplementary Feeding Programmes (SFPs)
- They aim to rehabilitate malnourished persons or to prevent a deterioration of nutritional status
- SFPs are short-term measures and should not be seen as a means of compensating for an inadequate general food ration.

II) PLANNING

More effort should go into planning and it should entail;

- Prioritizing the nutrition diagnoses, setting goals and defining the intervention strategy
- Arranging problems in the order of importance and urgency for the client
- Detailing the *nutrition prescription* (states patient/client's recommended dietary intake of energy, nutrients, etc.)
- Using the ADA's evidence-based practice guidelines
- Setting goals that are measurable, achievable and time-defined
    - Ideal Goals – science based values intended to control or improve specific health conditions
    - Expected Outcomes – the desired change(s) to be achieved over time as a result of nutrition intervention

III) IMPLEMENTING

This step focuses on carrying out and communicating the plan of care

Nutrition needs

Identifying nutritional problem and assessing the nutritional status of a client important in a clinical setting. With therapeutic diets we need to add or limit certain health conditions. Calories are essential for human health; all individuals require different amounts of energy each day depending on age, sex, and size and activity level.

Factors That Affect Energy Needs

- **Age:** children and teenagers need more energy due to their high metabolic rate to support growth peak
- **Sex;** male adult needs more energy due to their body composition, which is mainly muscle, compared to women who have considerably higher body fat than muscle..
- **Pregnancy and lactation:** pregnant women need more energy due to meet her own needs and also support the foetus
- **Occupation:** an individual's activity level determines their energy requirements. Physically active individuals consume more energy than individuals who lead a sedentary lifestyle.
- **Size or body weight**: a person smaller in size has a larger surface area per unit volume. Thus, the rate of heat loss is high, which leads to more energy expenditure.
- **Climate:** people living in cold countries need more energy to maintain body temperature.
- **Health:** Diseases which cause catabolism consume more energy and so ill people may require more energy than healthier persons

The numbers of calories in food informs how much potential energy they contain. The caloric content of the macronutrients is:

- 1g of CHO contains 4 Kcal
- 1g of Protein contains 4 Kcal
- 1g of fat contains 9 Kcal

Characteristics of Energy Requirements:

1. They change with increasing age between birth and maturity, in periods of growth when new tissues are being laid down.
2. Requirements are higher per unit of body weight than they are after growth has ceased
3. In mature female requirements increase during pregnancy as foetus grows, they also increase during lactation in proportion to the amount of milk produced

Basal Metabolic Rate: This is the energy required when the body is at complete rest. It is the energy that maintains all body processes when no physical activity is being carried out.

Energy for circulation and respiration constitute 60-70% of this expenditure

Factors affecting BMR

- Body size-the larger the body size the higher the BMR
- Body composition-lean body mass has higher BMR than adipose mass
- Age-energy expended per unit of body weight decreases from birth to old age
- Climate cold temperatures result in higher BMR as a compensatory mechanism
- **Disease and infection**; Disease and infection increase BMR as the body deals with the physiological stress that results. During fever BMR increase by about 7% for every 1% rise in temperature. Tumors as seen in cancer and burns on the skin also increase BMR
- **Physiological and hormonal status**: Hormonal function influences the rate at which the body consumes energy, even while at absolute rest. e.g. In endocrine gland disorder such as hyper or hypothyroidism. During pregnancy and lactation BMR increases
- **Psychological state :** Acute anxiety stimulates energy expenditure

Determining a Person's BMR:

There are two formula used to determine the BMR of a person

1.

   Men:

   Weight (kgs) x1kcal/kg body weightx24hrs

   Women: Weight (kgs) x 0.95kcals/kg body weight x 24hrs

2. Harris benedict equation (1919)

Men

REE(kcals) = 66.5+(13.75xw)+(5.0xh)-(6.7xa)

Women

REE(kcals)= 655+(9.56xw)+(1.85xh)-(4.68xa)

Where w=weight in kgs

H=height in cm

A= age in years

Physical activity level

Physical activities account for 20-40% of body energy expenditure. Amount expended depends from one person to another

For example, the amount of energy spent on physical activity depends on body size. Extra energy is expended by larger persons

When expressed as a percentage of BMR. The activity level is:

Activity level	Energy lost(%of BMR)
Sedentary	20%
Light	30%
Moderate	40%
Heavy/very active	50%

Thermic Effect of Food:

The body also burns calories every time you eat. This is referred to as the Thermic Effect of Food or the thermogenic effects of food. Digestion and processing of nutrients has a certain cost in the form of calories.

It is calculated as: 10% of (REE+ activity level)

Determining Energy Requirement:

The total daily energy requirement is commonly estimated by adding the REE and the energy required for physical activity and Thermic Effect of Food (TEF)

REE can be estimated by:

Harris benedict equation (1919)

1. Men

REE(kcals)=66.5+(13.75xw)+(5.0xh)-(6.7xa)

2. Women

REE(kcals)= 655+(9.56xw)+(1.85xh)-(4.68xa)

Where w=weight in kgs

H=height in cm

A= age in years

Example

1. Using Harris Benedict Equation, etermine the TEE for a 20 yrs old woman who is 165 cm and 55kg heavy with a light activity level

   Using Harris benedict equation

   REE(Kcals)= 655+(9.56xw)+(1.88xh)-(4.68xa)

   655+(9.56x55)+(1.88x165)-(4.68x20)

655+525.8+310.2-9.36

REE=1397.4(A)

30% OF 1397.4 = 417.7(B)

10%(A+B)= 10/100X(417.7+1397.4)=181.51

TEE=A+B+C

1397.4+417.7+181.51

1996.61

Tools Used in Determining Daily Intake

1. **Dietary reference intake (DRI)**

- This is a set of four separate reference values used to plan and evaluate diets.
- DRI estimates the nutritional requirements of healthy people
- Include separate recommendations for different groups of people of a specific age & gender
- Encompasses four sets of values: Recommended Dietary Allowance (RDAs), Estimated Average Requirement (EAR), Adequate Intake (AI) and the Upper and Lower Intake level.

2. **Daily food guide**

Daily food guide helps the planner achieve dietary adequacy, balance and variety.

Daily food guide includes most notable nutrients within each food group, the number of servings recommended, the size of servings, and the foods within each group categorized by nutrient density.

It also gives the average range of servings per day for the different food groups

Food group	Major nutrients	Servings per adult	Servings per child	One serving equivalent 1 cup/glass = 250 ml
Water		8		
General starchy foods bread, cereals and other grains	• Carbohydrates • Vitamin (B1) • Iron, • Niacin	6-11	6	• 1slice bread, • ½ cup cooked cereals, pastas or rice, ¾ to 1cup • potatoes, green bananas, • 2 small 3 inch pancakes. • 1cup ready to eat cereals
Milk and milk products	• Calcium • Riboflavin (Vit B2) • Vitamin B12, • Proteins, • fats	2-4	2	• 1 cup : o fresh milk, o fermented milk or o yoghurt

Daily Food Guide

Design diet plan

Diet planning involves prescriptions and description of modified diets such as clear liquid diets, full liquid diet, light/soft diets, high calorie diet, calorie restricted diet, high protein diet, low protein diet, sodium restricted diets, fat restricted diets, fiber restricted diets, high fiber diets, bland diets and elimination of suspect foods for allergies.

The frequency of feeding and quantities should also be determined.

1. Clear liquid diet

Description

Designed to provide fluids mainly in the form of sugar and water to prevent over-stimulating extensive digestive processes, minimize colonic residue, relieve thirst, and provide oral feedings that promote the return to the normal ingestion of food .

Provides 700 to 1,000 kcal.

Indications

The Clear Liquid Diet is indicated for the following:

- Short-term use when an acute illness or surgery causes an intolerance for foods (eg, abdominal distention, nausea, vomiting, and diarrhea)
- To temporarily restrict undigested material in the gastrointestinal tract or reintroduce foods following a period with no oral intake when poor tolerance to food , aspiration, or an anastomotic leak is anticipated
- To prepare the bowel for surgery or a gastrointestinal procedure

2. Full Liquid Diet

Description

It consists of foods that are liquid at body temperature, including gels and frozen liquids. The diet provides nourishment that is easy to consume and digest with very little stimulation to the gastrointestinal tract.

Indications:

- Used following oral surgery or plastic surgery of the face or neck area in the presence of chewing or swallowing dysfunction for acutely ill patients.
- The Full Liquid Diet has been traditionally used as a postoperative transitional diet.
- It is intended for short-term use only; therefore, attempts are not usually made to increase the variety of foods offered to provide for the total adequacy of nutrients.

3. Soft Diet

Description

It is a modified diet fit for clients with difficulty chewing or swallowing, or for those who have undergone surgery of the jaw. For the greatest variety of foods, all foods that are easily masticated are included in the diet.

Indications

- For patients who have difficulty chewing or swallowing.

4. High-protein, high-calorie diet

Description

Additional proteins and energy are added to meals or given in between meals. This increase daily energy and protein consumption.

Indications

- When individual needs for proteins and energy are increased by physiological conditions such as stress, trauma, protein loss and catabolism. This may be necessary for patients suffering from:
  - protein-energy malnutrition
  - failure to thrive
  - cancer
  - burns
  - cystic fibrosis
  - human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS)
  - chronic gastrointestinal diseases

5. Sodium-Controlled Diet

Description

This type of modified diet is intended to reduce an individual's sodium intake due to various factors. Foods naturally high in sodium as well as sodium-rich food additives are restricted. It is a commonly prescribed diet in hypertension

Indications

For management of conditions that cause fluid retention such as :

- cirrhosis of the liver with ascites
- heart failure
- hypertension
- renal disease

6. Calorie Controlled Diet

Description

The diet is modified by reducing energy intake by reducing the amount of fat and carbohydrates in the diet. Other nutrients such as proteins, vitamins and minerals are maintained at normal levels.

It is the preferred diet in weight management and other conditions in which weight management improves prognosis. It is often accompanied by physical activity and behaviour change.

In overweight and obese persons, weight loss is recommended to:

Indications

- lower blood pressure in patients with hypertension
- lower total cholesterol, low-density lipoprotein cholesterol, and triglycerides levels in patients with hyperlipidemia
- lower blood glucose levels in patients with type 2 diabetes
- prevent liver disease

7. Fat-controlled diet

Description

This diet restricts the total amount of fat in the diet, although the quality of fat is not considered.

Indications

For patients who are unable to properly digest, metabolize, and absorb fat as seen in diseases of the liver, gall bladder and the pancreas, intestinal mucosa and lymphatic system which impair fat digestion and absorption.

8. High-fiber diet

Description

A high fibre diet is characterised by increased fibre intake through consumption of fibre rich foods or supplementation with fibre.

Indications

- Cardiovascular diseases
- Diabetes Mellitus
- Weight management
- Bowel-related diseases

9. Fiber-restricted diets

Description

This type of diet reduces the amount of fibre to less than to grams per day. Foods high in fibre are eliminated from the diet while foods low in fibre such as animal products, processed grains and cereals, selected fruits and vegetable are consumed.

Indications

- To prevent the formation of an obstructing bolus when the intestinal lumen is narrowed.
- To delay intestinal transit time in conditions of diarrhea.
- To reduce (not eliminate) the fiber in the colon pre- and postoperatively.
- To allow the bowel to rest during acute exacerbation of inflammatory bowel disease, acute phases of diverticulitis, or radiation enteritis.

10. Protein-controlled diet

Description

This diet controls the quality and quantity of proteins consumed to reduce nitrogenous wastes and support healing.

Adequate non-protein energy is provided to promote protein sparing.

Indications

Applied in management of hepatic encephalopathy associated with hepatic disorders, such as:

- Hepatitis
- Cholestasis liver disease
- Cirrhosis with acute and/or chronic encephalopathy

11.3.4.3 Self-Assessment

1. Define the following terms
    A. Nutrition intervention
    B. Supplements
    C. Nutrition care
    D. Basal metabolic rate (BMR)
2. The following are strategies of nutrition intervention (indicate true/false for each)
    A. Prioritize nutrition diagnoses
    B. Consult the ADA guidelines
    C. Determine patient-focused expected outcomes
    D. None of the above

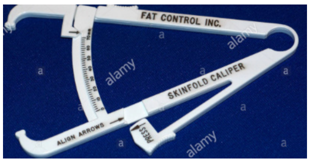
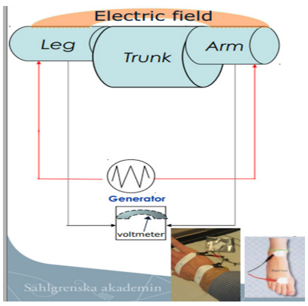
3. Prioritizing the nutrition diagnosis, setting goals and defining the intervention strategy is a component of the ____________________ step of nutrition intervention
   A. Planning
   B. Interpretation
   C. Selecting
   D. Implementing
4. The caloric content of five grams of fat is_____________________
   A. 9 Kcal
   B. 4 Kcal
   C. 20 Kcal
   D. 45 Kcal
5. Physical activities account for ____________________ of body energy expenditure
   A. 5-10%
   B. 10-30%
   C. 20-40%
   D. 30-50%
6. When an individual eats food the body burns calories which is known as________
   A. REE
   B. TEF
   C. BMR
   D. TER
7. Determine the energy requirements for
   A. 25 years old male weighing 50 kgs, height 140 cm, heavy activity level
   B. 30 year old female , weight 57kgs, height 150cm , light activity
   C. 60 year old male , weight 176.37 pounds, height 160cm ,light activity
8. Explain the 4 domains of nutrition intervention
9. Explain the factors influencing basal metabolic rate (BMR)
10. Outline the factors that influence individual energy needs

11.3.4.4 Tools, Equipment, Supplies and Materials

- Kenya National Clinical Nutrition and Dietetics Manual, MOH 2010
- Clinical manual of 2013
- Computers with internet

- Library and resource Centre
- WHO guidelines
- MOH policies and guidelines
- Skills lab
- LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise

Equipment

Microtoise 	Stadiometers 	Calipers 
Length boards 	Height Boards 	Weighing scales/Beam balance 
Adult MUAC tapes 	Color-coded measuring tapes 	Salter scale 
Children MUAC tapes 	Bio Impedance analysis machine 	

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Basic Nutrition Counselling Skill Development: A Guideline for Lifestyle Management, Kathleen D. Bauer, Carol A. Sokolik

11.3.5 Learning outcome 4: Conduct monitoring dietary assessment

11.3.5.1 Learning Activities

Learning activity	Special instruction
i) Do daily monitoring of the patients uptake and response to the interventions • Assess anthropometric measurement outcomes • Evaluate nutrition related diet history • Evaluate biochemical outcomes • Evaluate physical and clinical outcomes	➢ Consider the intervention plan, resource materials, policies and guidelines ➢ Conduct anthropometric reassessment ➢ Compare anthropometric measurements to goals of the care plan ➢ Conduct dietary assessment ➢ Compare outcome of dietary assessment to goals of the care plan ➢ Interpret biochemical outcomes ➢ Compare biochemical outcomes to goals of the care plan ➢ Conduct assessment for significant physical and clinical signs ➢ Compare physical and clinical findings to goals of nutrition care
ii) Do nutrition prescriptions and documentation	➢ Review the intervention plan against the outcomes ➢ Prescribe nutrition that could address any pending goals ➢ Document the overall outcome of nutrition care

11.3.5.2 Information Sheet

Definitions

- **Nutrition Monitoring:** pre-planned review and measurement of selected nutrition care indicators of patient/client's status relevant to the defined needs, nutrition diagnosis, nutrition intervention, and outcomes.
- **Nutrition Care Outcomes:** the results of nutrition care that are directly related to the nutrition diagnosis and the goals of the intervention plan
- **Nutrition Care Indicators:** markers that can be measured and evaluated to determine effectiveness of nutrition care

CONTENT

Nutrition Monitoring

During monitoring one determines the degree to which progress is being made and whether or not the client's goals or desired outcomes of nutrition care are being met. It means much more than merely "watching" what is happening.

It requires an active commitment to measuring and recording the appropriate outcome indicators relevant to the nutrition diagnosis' signs and symptoms.

A nutrition reassessment is needed to identify whether the nutrition-related problem still exists and evaluate the progress made toward resolving the problem.

It determines whether the patient is meeting the nutrition intervention goals or desired outcome by asking the question;

- o Is the nutrition intervention strategy working to resolve the nutrition diagnosis, its etiology, and/or signs and symptoms?

The patient's progress should be assessed by comparing specific markers or nutrition care indicators against recognized, science-based standards or baselines.

Progress should be:

- Monitored
- Measured
- Evaluated on a planned schedule

Purpose of monitoring and evaluation

- To determine whether progress made is related to the patient's nutrition intervention goals and/or desired outcomes.
- To provide evidence if the intervention is/has been effective in changing the behavior or status of the patient.
- To evaluate nutrition care outcomes.
- To create a standardized language for nutrition intervention.

Types of Monitoring;

- **Process monitoring:** Assesses the 'how' of nutrition intervention. It queries the flow of activities towards the set goals while noting discrepancies
- **Impact monitoring:** assesses the impact of the nutrition intervention. Impact monitoring focuses on changes such as behaviour change and change in nutrition indicators of interest.

Importance of Monitoring in Nutrition Care

- Helps in decision making on the continued interventions
- To determine programme strengths and weaknesses

- To assess resource utilization
- Used to measure programme outcomes
- To review strategies
- To observe the trends of the programme
- It helps the nutritionist to improve their effectiveness and efficiency in addressing nutrition problems

Data sources in nutrition monitoring and evaluation

To monitor and evaluate a patient/client's progress, the following tools may be used:

- Patient/client questionnaires
- Surveys
- Pretests and posttests
- Patient/client/family member interviews
- Anthropometric measurements
- Biochemical and medical test results
- Food and nutrition intake tools.

Relationship between monitoring, measuring and evaluation

- **Monitoring** provides findings that the nutrition intervention has impacted the patient's status positively or negatively
- **Measuring** outcomes by using data from the nutrition care indicators
- **Evaluate** patient outcomes by comparing current findings with previous status/ behavior and patient's nutritional intervention goals.

<u>Components of nutrition monitoring & evaluation</u>

1. Monitor Progress: towards the nutrition intervention/goal

- Determining that the goals and outcomes that are anticipated by the client and the dietetics professionals are indeed occurring
- Monitor, measure and evaluate on a planned schedule

2. Measure Outcomes: the appropriate nutrition care indicators

- Data is collected over time
- Nutrition, clinical and health status, patient/client centered, and health care utilization

3. Evaluate Outcomes:

- Evaluate the nutrition care indicators against appropriate standards selected during the nutrition care planning

- To determine what changes have occurred as a result of the nutrition intervention
- Comparing the current findings with the previous signs and symptoms
- Create outcomes management system
- Contribute to the body of evidence based research

Monitoring and evaluation outcomes

1. Food/Nutrition –Related History Outcomes: Food and nutrient intake, supplement intake, physical activity, food availability, etc
2. Nutrition-Focused Physical Finding Outcomes: Physical appearance, swallow function, appetite
3. Biochemical Data, Medical Tests & Procedure Outcomes: Lab data and tests
4. Anthropometric Measurement Outcomes**:** Height, weight, BMI, growth pattern, weight history
5. Nutrition care outcomes: intermediate outcomes to other broader health care outcomes
    - Acute or chronic disease: occurrence, duration, severity
    - Infections
    - Wound healing
    - Health care cost
    - Patient functional ability

Nutrition care outcome categories of monitoring and evaluation

- Determine proper indicator/measures
- Determine suitable data for comparison
- Determine the process of the clients relating to expected outcomes
- Determine why the patient outcomes are different from the expected outcomes
- Determine issues that assist or hamper improvement
- Determine how long a patient needs to be under nutrition care

Nutrition care outcome characteristics

- Represent results the nutritionist/dietician can impact
- Can be linked to nutrition intervention goals
- Are measureable with tools and resources available to the nutritionist/dietician
- Occur in a reasonable time period

Nutrition care indicators in monitoring and evaluation

- Factors that food and nutrition professionals can impact directly, such as food and nutrient intake; growth and body composition; food and nutrition-related knowledge, attitudes, and behaviors; and food access
- Laboratory values, such as HgbA1c, hematocrit, or serum cholesterol
- Functional capabilities, such as physical activity
- Patient perception of nutrition care and results of nutrition care, such as nutrition quality of life

Measurement and Evaluation of Nutrition Indicators:

- Nutrition Care Criteria – what it is compared against for example
    - o Nutrition Prescription or Goal which could be;
        - Dietary Intervention
        - Behavior change
    - o Reference Standard: select what is appropriate for intervention or goal which could be;
        - National
        - Institutional
        - Regulatory standards

Critical thinking skills for Nutrition Monitoring & Evaluation:

- Selecting appropriate indicators/measures
- Using appropriate criteria (previous status, nutrition intervention goals, or reference standards) for comparison
- Defining where patient/client is now in terms of expected outcome
- Explaining variance from expected outcomes
- Identifying factors that help/hinder progress
- Deciding between discharge or continuation of nutrition care

Nutrition monitoring and evaluation reference sheets

These reference sheets are combined with the nutrition assessment reference sheets and contain these eight components:

1. Definition of the nutrition assessment and nutrition monitoring and evaluation term
2. The nutrition assessment and nutrition monitoring and evaluation indicators
3. Measurement method or data sources recommended

4. The nutrition interventions with which the nutrition assessment and nutrition monitoring and evaluation data are used
5. The nutrition diagnoses with which the nutrition assessment and nutrition monitoring and evaluation data are used
6. The criteria for evaluation
7. The patient/client nutrition assessment and nutrition monitoring and evaluation documentation example
8. References

Documentation

Quality documentation for nutrition monitoring and evaluation includes the following:

1. Date and time of activity
2. Specific indicators measured, results, and the method for obtaining the measurement
3. Progress towards goals: Criteria to which the indicator is compared (nutrition prescription/goal or a reference standard)
4. Factors facilitating or hampering progress
5. Other positive or negative outcomes
6. Future plans for nutrition care, nutrition monitoring, and follow-up or discharge

11.3.5.3 Self-Assessment

1. Define the following terms;
   A. Nutrition care outcomes
   B. Nutrition care indicators
2. During ________ one determines the degree to which progress is being made and whether or not the client's goals or desired outcomes of nutrition care are being met
   A. Monitoring
   B. Planning
   C. Intervention
   D. Evaluation
3. ____________________ queries the flow of activities towards the set goals while noting discrepancies
   A. Impact monitoring
   B. Impact evaluation
   C. Process monitoring
   D. Process evaluation

4. The following are the components of nutrition monitoring and evaluation (indicate true/false for each answer)
    A. Prescribe outcomes
    B. Assess outcomes
    C. Measure outcomes
    D. Evaluate outcomes
5. Measurement method or data sources recommended, the nutrition interventions with which the nutrition assessment and nutrition monitoring and evaluation data are used and the nutrition diagnoses with which the nutrition assessment and nutrition monitoring and evaluation data are used are components of;
    A. Nutrition diagnosis reference sheets
    B. Nutrition evaluation reference sheets
    C. Nutrition intervention and monitoring reference sheets
    D. Nutrition monitoring and evaluation reference sheets
6. Distinguish between monitoring and evaluation
7. Outline the importance of monitoring and evaluation
8. Why is monitoring and evaluation important in nutrition care process?
9. Highlight the critical thinking skills for nutrition monitoring and evaluation
10. Discuss the components of nutrition monitoring and evaluation sheets

11.3.5.4 Tools, Equipment and Materials

1. Nutritional assessment data form
2. Weighing scale
3. Colour coded measuring tape
4. Stationery
5. Computers with internet
6. Library and resource Centre
7. WHO guidelines
8. MOH policies and guidelines
9. Skills lab
10. LCDs, video clips, charts and other teaching aids
11. Invitation of competent expertise

11.3.5.5 References

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11.3.6 Learning Outcome 5: Conduct evaluation for the entire nutrition care process

11.3.6.1 Learning Activities

Learning activity	Special instruction
i) Assess outcomes of the entire nutrition care process	➢ Evaluate the entire process of nutrition intervention and nutrition care process ➢ Evaluate the outcomes of the nutrition care and document the outcome ➢ by comparing current findings with previous status/behavior and patient's nutritional intervention goals
ii) Make and document appropriate decisions	➢ Conclude on the effectiveness of nutrition care process ➢ Remember to circulate the document to the relevant offices

11.3.6.2 Information Sheet

Definitions

- **Evaluation:** Evaluation is the systematic process of assessing the relevance, effectiveness, efficiency and impact of a nutrition intervention against set goals. The outcome helps to make the decision to discharge the client or to modify the care plan.
- **Nutrition Evaluation:** the systematic comparison of current findings with the previous status, nutrition intervention goals, effectiveness of overall nutrition care, or a reference standard

Content

The adoption and consistent use of the NCP promotes and strengthens nutrition communications among health professionals, their clients, and other customers.

In order to conduct evaluation of the entire nutrition care process, the nutrition outcomes and associated indicators must be checked;

Outcome	Indicators
Weight change	Weight Weight change Body mass index
Blood glucose control	Post-prandial blood glucose Hemoglobin A1c Mean blood glucose Number of hypoglycemic events
Dietary fat intake	Types of foods/meals Amount of fat in foods consumed Amount of fat in meals consumed Total fat intake
Knowledge regarding modified diet	Pre-test score Post-test score Self-indicated level of knowledge

Types of Evaluation:

- **Context evaluation**: Context evaluation is concerned with the assessment of existing information of the funding agency, the target group and the general programme environment.
- **Formative evaluation**: This is the day to day running of the programme towards acquisition of short term objectives therefore assess programme input, output or services and the general events in the programme environment
- **Impact evaluation**: Determine the ultimate effect on the beneficiaries in the long term. It is concerned with ultimate programme indicators.

Importance of Evaluation:

- Provide useful information for other ongoing or future interventions
- To provide useful information to the interdisciplinary medical care team
- To determine whether the intervention was successful or not

Nutrition care outcome management system

Potential benefits of aggregate nutrition care indicator data include the following:

- Provide for process improvement and foster understanding of what works and what does not

- Can be used for outcomes measurement studies and quality improvement initiatives
- Link care processes and resource utilization
- Give an opportunity to identify and analyze causes of less than optimal performance and outcomes
- Define information for inclusion in centralized data systems relevant to nutrition care
- Can be used to quantify the food and nutrition professional's contribution to health care.

Factors that can impact aggregate nutrition care indicator data interpretation include:

- Method for collecting the outcome (diet record, recall)
- Data source (patient, family/caregiver, chart)
- Intervention components (type, duration, and intensity)
- Education and skill level of nutritionist/dietician
- Nutrition program attributes

Evaluating the nutrition diagnosis statement

- P (Problem): Can the RDN resolve or improve the nutrition diagnosis? Consider the "intake" nutrition diagnosis as the one more specific to the role of the Nutritionist/dietician.
- E (Etiology): Determine if this is the "root cause" for the problem. If addressing the etiology will not resolve the problem, can the Nutritionist/dietician intervention lessen the signs and symptoms?
- S (Signs and Symptoms): Will measuring the signs and symptoms indicate if the problem is resolved or improved? Are the signs and symptoms specific enough that the Nutritionist/dietician can monitor and document resolution or improvement of the nutrition diagnosis?

In summary,

- Nutrition Monitoring and Evaluation describes the patient's progress through consistent terms that are evaluated based on carefully selected indicators and criteria.
- Documentation of patient progress and outcomes with consistent terminology that can be collected using research methodology will result in documenting the value of the work of the nutritionist/dietician

Documentation

This is an ongoing process to support the steps of the nutrition care process. A standardized language now part of NCP improves both written and oral communication among members of the health care team as well as communication with the patient.

Documentation should be Relevant, Accurate, and Timely

Variety of documentation Formats are acceptable:

- SOAP notes
- Focus notes
- PIE
- ADIME – what is laid out by the NCP
- ADA would like to be using this
- Electronic Medical Records

SOAP Note Format

Subjective (S):

- Patient information or data collected from the patient or caregiver
- Have no proof of

Objective (O):

- Empirical information, information drawn from physical tests and medical staff observations that are of consequence to the patient's nutritional status
- Have proof of

Assessment (A):

- Nutrition diagnosis or interpretation of the patient's nutrition problems
- PES Statement

Plan (P)

- An outline of interventions necessary to treat each nutrition problem
- What you plan to do

ADIME Note Format

This format is organized to reflect the Nutrition Care Process

Assessment (A)

- Relevant data about the patient's condition

Diagnosis (D)

- PES Statements listed and prioritized

Intervention (I)

- Documentation of the specific treatment goals and expected outcomes, interventions, and response of the client

Monitoring and Evaluation (M)

- Documentation of progress toward goals
- Factors that are facilitating or hampering progress
- Changes in the client's level of understanding or behavior
- Future plans for care

Other documentation styles

- DAR – diagnosis, assessment, recommendations
- PIE – problem, intervention, evaluation
- PGIE – problem, goal, intervention, evaluation
- content is the same regardless of recording style)

How to correct an error in the medical record

- It should not be erased.
- Draw a line through it and write error over it.
- Put correct information, date of correction, and signature.

11.3.6.3 Self-assessment

1. Define the following terms;
   A. Evaluation
   B. Nutrition outcome
2. ____________________________ is concerned with the assessment of existing information of the funding agency, the target group and the general programme environment.
   A. Formative evaluation
   B. Monitoring
   C. Context evaluation
   D. Impact evaluation
3. Documentation should have the following qualities except?
   A. Relevant
   B. Accurate
   C. Timely
   D. Current

4. The following questions should be asked when evaluating a signs and symptoms in nutrition diagnosis statement (indicate true/false for each)
    A. Will measuring the signs and symptoms indicate if the problem is resolved or improved?
    B. Are the signs and symptoms specific enough that the Nutritionist/dietician can monitor and document resolution or improvement of the nutrition diagnosis?
    C. Can the RDN resolve or improve the nutrition diagnosis?
    D. If addressing the etiology will not resolve the problem, can the Nutritionist/dietician intervention lessen the signs and symptoms?
5. Describe the factors one should look out for in order to evaluate quality documentation for nutrition monitoring and evaluation
6. Discuss the potential benefits of aggregate nutrition care indicator data
7. Explain the factors that impact aggregate nutrition care indicator data interpretation
8. State what the following documentations mean in nutrition care process
    A. DAR
    B. PIE
    C. PGIE
9. How should an error be correct in the medical record?

11.3.6.4 Tools, Materials and resources

1. Computers with internet
2. Library and resource Centre
3. WHO guidelines
4. MOH policies and guidelines
5. Skills lab
6. LCDs, video clips, charts and other teaching aids
7. Stationery
8. Invited expert

11.3.6.5 References

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CHAPTER 12:

PLAN AND MANAGE MEALS

12.1 Introduction of the Unit of Learning / Unit of Competency

This unit addresses the unit of competency: plan and manage meals. This unit specifies the competencies required to plan and manage meals. It includes: determining client nutritional needs, assisting client with meal selection, formulating diet recipes and menu, preparing formulated meals, assessing food safety and hygiene and documenting meal planning and management.

12.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to determine client nutritional needs as per workplace procedures; assist the client with meal selection as per the clients requirements and organisational procedures; formulate and guide on diet recipes and menu based on the care plan developed and organizational procedures; prepare formulated meals as per the menu and client nutritional needs; assess food safety and hygiene as per workplace procedures and food safety plan; and document meal planning and management in line with workplace policy and procedures.

12.3 Learning Outcomes

12.3.1 List of the Learning Outcomes

1. Determine client nutritional needs
2. Assist clients with meal selection
3. Formulate diet recipes and menu
4. Prepare formulated meals
5. Assess food safety and hygiene
6. Document meal planning and management

12.3.2 Learning outcome 1: Determine client nutritional needs

12.3.2.1 Learning activity

Learning activity	Special instruction
i. Obtain client diet history is	➢ Collect clients' data as per work place procedures ➢ Use diet planning tools ➢ Apply diet planning principles
ii. Obtain client medical history	➢ Assemble client medical background ➢ Determine how medical background affects nutrition
iii. Analyze biochemical as per work place procedures	➢ Interpret biochemical results ➢ Use biochemical results to make nutritional diagnosis
iv. Carry out client clinical assessment as per client medical condition	➢ Conduct clinical assessment ➢ Observe clinical signs ➢ Interpret clinical observation ➢ Use clinical observations in making nutritional diagnosis

12.3.2.2 Information Sheet

Definition

1. **Diet history:** It is a structured interview method consisting of questions about habitual intake of food
2. **Medical history:** The part of a patient's life history that is important in determining the risk factors for, diagnosing, and treating a disorder, as in a history of exposure, symptoms, occupational, exposure to causative agents linked to a condition, physical trauma or infection
3. **Client's data:** documentation collected from the patient and further sources on the pathogenesis of the illness**.**

Principles of Diet Planning

- **Adequacy:** Ensuring that the diet contains all nutrients in adequate amounts
- **Balance**: This principle requires that not too much of any type of a nutrient is provided in a diet. Intake of a particular nutrient should be equal to individual needs.
- **Calorie control:** Calorie control calls on one to ensure that amount of energy consumed is equal to energy expenditure. Not too many or too few calories are consumed.

- **Moderation:** Requires that no particular food will be consumed in excess. One food should not crowd the diet.
- **Variety:** Nutrients should be sourced from a variety of foods. There's no superfood as different types of foods contain different amounts of each nutrient.

i. Obtaining clients' diet history

This involves obtaining a diet history involves interviewing the client on the past and/or current food practices It also includes measuring/estimating adequacy of the food consumed (variety, amount, frequency, with whom, sources of food, preparation)

What to assess:

- Total energy and nutrient intake
- Macro- and micronutrient intake
- Water and fluid intake
- Eating habits
- Drug and alcohol intake
- Food preparation methods
- Factors hindering food intake

Tools and methods of dietary assessment are;

- Food record diaries
- 24 hour recall
- Food frequency
- Diet diversity
- Appetite assessment

ii. Analysis of Client's Biochemical Data:

Biochemical data, medical tests and procedures include laboratory data (e.g., electrolytes, glucose, lipid panel, and gastric emptying time). Laboratory values can be useful in assessing nutritional status, which includes; Kidney function test Liver function test (C-RP), Blood glucose, hemoglobin levels, electrolytes, cholesterol levels, Parathyroid function test.

- **Normal Biochemical values**

Cholesterol	Male & female	3.2-8.5mmol/litre or
		120-330mg/100ml
Glucose [fasting]	Male & female	3.3-5.9mmol/litre or
		60-108mg/100ml.

Ketones [total non-fasting.	Male & female	0.02-0.5mmol/litre or 0.1-3.0mg/100ml.
Phosphate	Male & female	0.8-1.4mmol/litre or 2.5-4.3mg/100ml.

- **Urinary values [24 hr urinary excretion]**

Component	Gender	Value
Protein	”	Up to 00 g/24hrs.
Albumin	”	Up to 25mg/24hrs.
Ketones	”	0.1-0.3mmol or 5-15mg/24hrs.
Calcium	”	2.5-7.5mmol/24hrs.

- **Normal values in liver functions tests**

Component	Gender	Value
Total Serum Bilirubin		**5-17 mmol/litre**
Bilirubin esters	”	<6mmol/litre
Urine Bilirubin	”	Negative result
Serum albumin	”	35-50g/litre
Serum alkaline phosphate	”	30-110IU/litre
Serum alanine amino transferase	”	5-40IU/litre
Serum aspartate amino transferase	”	5-40IU/litre

iii.C**linical assessment;** This involves physical observation/ judgement, Signs of nutrient deficiencies like visible wasting, hair changes, oedema, skin changes

Body part or system	Signs/Symptoms	Possible deficiency
Hair	Lackluster, Thinness, sparseness, dryness, dyspigentation, easy pluckability, texture change	Proteins, protein-energy, Zinc, copper biotin.

Face	Paleness, Moon face (swollen), Greasy scaling around nostrils (nasolabial)	Riboflavin, Niacin, Pyridoxine, Iron
Eyes	Pale white eyes and eyelid lining (pale conjunctivae), Redness and fissuring of eyelid corners dullness and dryness (corneal or conjunctival xerosis), redness, lesions of conjunctivae (Bitot's spots)	Iron, folate, vitamin A, C, B2 B_6 and B_{12}
Mouth	Angular redness, lesions or scars at the corners of the mouth (stomatitis), swelling and redness of lips and mouth (cheilosis)	Riboflavin Niacin pyridoxine iron
Tongue	Smoothness, slickness (filiform papillary atrophy), beefiness, redness, pain (glossitis), swollen, magenta color	Niacin, pyridoxine, riboflavin, vitamin B_{12} folate, iron
Body part or system	Signs/Symptoms	Possible deficiency
Gums	Swelling, sponginess, bleeding, receding	Vitamin C
Skin	Dryness, scaling, lightening of skin color often centrally on the face (diffuse pigentation), rough, gooseflesh skin (follicular hyperkeratosis), small skin hemorrhages (petechiae), excessive bruising, hyper pigented patches that may peel off, leaving superficial ulcers or hypo pigented skin (flaky paint dermatosis), oedema, delayed wound healing.	Vitamin A, C and K, Zinc, essential fatty acids, protein, Niacin.
Nails	Spoon-shape (kiolonychia), pale, brittle, ridged.	Iron
Glands	Enlarged thyroid or parotid	Protein, iodine
Musculoskeletal system	Bowlegs knock knees, enlarged joints, hemorrhages, muscle and fat wasting.	Protein-energy, Vitamin D and C, Calcium
Neurological system	Mental confusion, irritability, psychomotor changes, motor weakness, sensory loss	Thiamin, Riboflavin and Vitamin B12

iv. Nutrition-focused physical findings Include oral health, general physical appearance, muscle and subcutaneous fat wasting, and affect.

v. **Client history**: This includes medication and supplement history, social history, medical/ health history, and personal history.

12.3.2.3 Self-assessment

1. List factors that are assessed when obtaining client history
2. List the liver function tests
3. Define clinical assessment
4. _______ is a structured interview method consisting of questions about habitual intake of food
   a. Food security
   b. Diet history
   c. Diet plan
   d. Food habits
5. _____ is the principle of diet planning that requires that no particular food will be consumed in excess. One food should not crowd the diet.
   a. Variety
   b. Adequacy
   c. Moderation
   d. Balance
6. Which one of the following is not part of diet history
   a. Eating habits
   b. Drug and alcohol intake
   c. Food preparation methods
   d. Hemoglobin level
7. Which one of the following is a part of clinical assessment
   a. Blood glucose
   b. Paleness
   c. Serum protein
   d. Fluid intake
8. Which one of the following laboratory values is an indicator of liver function
   a. Protein calcium

b. Urinary bilirubin

c. Dry skin

d. Ketones

12.3.2.4 Tools, equipment, supplies and materials

- Stationery
- Weighing scale
- Stadiometer
- Dietary assessment tools e.g. 24 hour recall, food diary, food frequency
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

12.3.2.5 References

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12.3.3 Learning Outcome 2: Assist client with meal selection

12.3.3.1 *Leaning activities*

Leaning activity	Special instructions.
i. Record and act upon client food preferences	➢ Consider factors influencing food choices
ii. Advise client on meal choices	➢ Plan meals as per clients' condition
iii. Assist client with menus marking, meal orders placement and/or meal selection	➢ Develop menus ➢ Take meal orders

12.3.3.2 Information Sheet

Factors Influencing Food Choices

Food choices are influenced by various factors, some of which are physiological, while others originate from our immediate environment. It is a complex process which changes as individuals go through several stages of the lifespan. These facts should be considered when planning meals from different individuals.

1. Biological determinants of food choice

Hunger and satiety: Hunger and satiety are controlled by the central nervous system. Humans will therefore respond to the feelings of hunger and satiety because the body needs energy and nutrients to carry out various physiological processes.

Palatability: Individuals desire a certain experience when having a meal, and this becomes a major determinant of food choice. A food's texture, aroma and appearance are the main properties of food that determine its palatability. This factor influences food intake in that it can cause an individual to consume larger potions of food and therefore increase their nutrient and energy intake. The aspect of palatability is a main consideration during diet planning.

Sensory aspects: Taste of food has a strong influence on food choice. Sensory characteristics of food are taste, small, texture, all which determine food preference for individuals.

2. Economic and physical determinants of food choice

Cost and accessibility: Cost determines accessibility, which ultimately determines food intake and nutritional status. A person's socio-economic status determines their purchasing power and thus influences the quantity and quality of foods they consume. Individuals of low socio-economic status often choose low quality diets owing to financial constraints. However, there's no guarantee that people who have more money make better food choices. Knowledge of nutrition and health also play a key role in food choice.

Education and Knowledge: A person's education level determines their food behaviour. However, it is important to ensure that individuals get accurate and reliable nutrition information to avoid misleading myths, untrue claims and influence by nutrition quacks.

3. Social determinants of food choice

Influence of social class: Social class has a significant influence on individual food choice. This includes social class differences which determine challenges that people face in society. Social class also determines type of housing, access to clean water, sanitation and healthcare, all which are factors that influence a person's food choices

Cultural influences: Culture is simply defined as a people's way of life which includes their beliefs about food, food acquisition, food distribution and food avoidances. These have a strong impact on individual's food choice because they consider cultural acceptance when making food choice. Although culture resists change, it is a learnt behaviour and so it can be unlearnt.

Social context: Individual food choice is influenced by the eating behaviour of others. Other people may influence an individual either directly, when buying the food, or indirectly where people learn from their peers. Our social environment can have a positive or negative influence on our food choices. People who are clse to us, such as family and friends are a great source of support when we need to change bad food habits, which is helpful in behaviour change for better food choices.

Meal Planning

Meal planning can be defined as taking the time to plan nutritious meals and snacks for a specified time period.

Factors to consider when planning meals

1. **Nutritional Adequacy**: A meal should meet the nutritional needs of individuals, through provision of adequate energy and nutrients. All nutrients should be provided in adequate amounts. No one food should crowd the diet.
2. **Age**: People of different age groups prefer certain types of foods, cooking methods, portions and meal patterns. This is an important consideration when dealing with special groups such as infants and elderly people.
3. **Sex**: Males and females have different nutrient requirements as well as food preferences. This is an important consideration to make when planning a meal.
4. **Physical Activity:** Physical activity level of an individual determines their energy expenditure. This has a bearing on the types of foods and portions they are supposed to consume to meet the varied energy needs. More energy giving foods should be included in the diet of an individual who engages in intense physical activity while the opposite should be done for one who leads a sedentary lifestyle.
5. **Economic Considerations:** The amount of money available determines the types of food an individual can access. Nutritious food does not have to be expensive. Even with

just enough money, one should be able to select high quality foods which will meet the nutritional needs of individuals and households.

Meals for Various Groups

Energy requirements of people vary depending on sex, age and activity level.

a) Sex

The calorific requirement is generally higher in men than in women because men have larger body size, and they are more physically active and have more lean muscle mass.

b) Age groups

(i) Infants

Children under 1 year of age is referred as infants. Growth in the first year of life is more rapid than at any other time in the life cycle and adequate amount of energy and nutrients are required to support rapid growth and development and prevent nutritional inadequacies. A baby doubles its birth weight by 6 months of age and triples it within the first year of life. The energy, vitamin, mineral, protein and water requirements are higher per unit of body weight than any other age. Infants need all the vitamins and minerals that other humans need but in different amounts.

(ii) Children:

They grow at a slower rate than infants, however, their nutrient needs do not diminish. They need energy from food for daily physical activities and nutrients to promote growth and health. Appetite of children at this age is small and varied. Three main meals with nutritious snacks are needed in between to supply enough energy to meet their high activity level but small appetite.

Childhood obesity is common today. Obesity in children increases future risk of chronic disease such as high blood pressure, heart disease and may have social stigma. A balanced diet together with regular physical activity is necessary to prevent excessive weight gain. Regular exercise, healthy snacks and portion control are effective methods to maintain the healthy weight of children. Children should not be put on 'diet' as they are growing and the weight should be maintained during this growth period

(iii) Adolescents:

It is a period of rapid growth with great bodily changes. Bones grow and gain in density; muscle and fat tissues develop; and blood volume increases. Sexual maturity occurs when boys' voices change and girls experience the onset of menstruation. They have enormous appetite compared with children. Calorific requirements increase because of rapid growth

It is a period of growing independence and they become influenced by their peers and media. Eating habits can be affected by schedule of study, extracurricular activities, part-time jobs, social activities, the availability of nutritious food, and the lack of nutritional knowledge. Teachers, care-takers or parents could encourage healthy eating and healthy lifestyle tactfully by informing the adolescents of the nutritional needs, the appropriate choices of food and also by providing them with nutritious food/snacks at school/ home. Sexual maturity and physical changes during puberty could be stressful to some adolescents. The over concern on weight and body image may predispose a teenager to use unhealthy methods to control their weight. They may skip meals, choose very low energy diets, laxatives, diet drugs or purging. This can lead to serious health problems, nutrient deficiencies and eating disorders in later life.

(iv) Adults :

- Growth is usually completed by the age of 25. The aims of nutrition during adult years are to obtain adequate energy and nutrients to maintain a healthy body weight and prevention of chronic diseases through appropriate food choices.
- Adulthood is a period when an individual begins to experience and cope with numerous changes in the realms of work, family and education. Healthy eating and lifestyle are important for them to cope with stress and maintain health.
- The caloric requirement decreases as individual get older as physical activity reduces and physiological demands decrease.

(v) Elderly:

- Elderly people experience various changes that affect their food intake and utilization. These factors include, metabolic, psychological, musculoskeletal, gastrointestinal and dental changes.
- They may also lose their sense of taste and smell, which influences their appetite and food intake.
- The need for energy is decreased for the elderly, owing to the decrease in basal metabolic rate and activity level.

c) Invalids & convalescents:

- These are vulnerable groups of people because disease affects food intake, digestion, absorption and utilization. Also, drugs may affect nutrient utilization through drug and nutrient interaction. Foods must therefore be prepared with such factors in mind.
- Disease may also increase requirement for various nutrients to promote recovery. Such nutrients should be increased in the diet or supplemented when dietary sources are not sufficient.
- Illness may also lead to poor appetite and so , when planning a meal for such individuals, foods should be made appetizing to improve food intake.
- Convalescing individuals are slowly recovering from illness and may eventually be able to consume a normal diet. Portion sizes should be increased as the person improves recovery.

d) Pregnancy

- An expectant mother's nutritional status can affect the outcome of pregnancy. Nutrients are carried from mother's bloodstream through the placenta and umbilical cord into the baby's bloodstream and therefore the diet of a pregnant woman is important for a healthy baby and maintaining own health. The requirements for certain nutrients increase during pregnancy. Energy and protein needs increase in order to sustain the development of fetus, placenta and the maternal tissue. Folate is required for correct development of the brain and nervous systems in the fetus. Vitamin B12 and iron are required for the synthesis of red blood cells and prevention of anemia. Vitamin C can enhance absorption of iron and help to form connective tissues. Zinc is involved in protein synthesis and cell development. An inadequate intake may affect fetal growth and is associated with low-birth weight infants. Besides, calcium, phosphorus and magnesium are essential for skeletal and dental growth.

- Meal planning for pregnant women could be based on the food pyramid for adults. A variety of foods should be chosen to achieve a balanced diet. The extra calories can be obtained from an additional serving from each of the following food groups – grains, vegetables, fruits and low-fat dairy products.
- Pregnant women may experience problems such as morning sickness, heartburn and constipation that affect the nutritional status. Hormonal changes cause nausea and vomiting of pregnancy. This can be relieved by small frequent meals, dry or cold foods (e.g. biscuits, toast, dry cereal, sandwiches, cold vermicelli etc.). Heartburn can be controlled by avoiding spicy or acidic foods. Adequate fluid and a high-fibre diet together with regular exercise can relieve constipation during pregnancy.
- Pregnant women are advised to avoid smoking and alcohol. Smoking increases risk of miscarriage, giving premature birth and low-birth weight baby. Heavy **alcohol** drinking could result in fetal alcohol syndrome (FAS) in infants and result in physical, cognitive and behavioural problems.

Planning Meals for Institutions

a) **Prisoners**

The quality and quantity of food available in a prison has a major influence on the quality of a prisoner's life. The availability of safe and healthy food is essential in maintaining and improving prisoners' health. Supporting and ensuring a safe and healthy food supply in prison will help to prevent diet-related diseases and promote better overall health of prisoners. Considerable benefits can be achieved when prison services work in a complementary manner to promote healthy lifestyles and facilitate healthy eating. These services include those for catering, education, health care, sports activities, treatment for substance users and activities of outside agencies.

Adequate nutrition should be considered one of prisoners' basic human rights, especially as many have poor health. Healthy, nutritious meals will enable them to take their medication properly and prevent the development of life-threatening infections such as HIV/AIDS and tuberculosis. Also, vulnerable population groups in prisons – such as pregnant and breastfeeding women, substance users, teenagers and elderly people – have specific dietary requirements.

b) **Schools**

School-going children have an increased demand for energy and nutrients. They need adequate energy and nutrients to support growth and development at this crucial stage in the lifespan.

Good feeding habits need to be inculcated at this age to help them make good food choices as they advance towards adolescence and adulthood.

A healthy diet during childhood and adolescence reduces the risk of nutritional problems in adulthood.

12.3.3.3 Self-Assessment

1. Outline the factors considered when planning meals
2. Outline considerations to make when planning meals for pregnant women
3. Which one of the following is not a social determinant of food choice?
   a. Social class
   b. Cultural influence
   c. Social context
   d. Cost
4. Indicate whether the following statements are true or false:
   a. The requirements for certain nutrients increase during pregnancy
   b. The need for energy is decreased for the elderly
   c. Calorific requirement is generally higher in men than in women because men
   d. People with little money cannot meet their nutritional needs

12.3.3.4 Tools, Equipment, Supplies and Materials

- Kitchen and service equipment
- Food pyramid
- Food composition table
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

12.3.3.5 References

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12.3.4 Learning Outcome 3: Formulate diet recipes and menu

12.3.4.1 Leaning activities

Leaning activity.	Special instructions.
i. Determine client daily nutrition requirement a. Factors that influence individual dietary requirements	➢ Calculate client daily requirement
ii. Guide client on appropriate menu a. Type of menus b. Categories of food groups	➢ Formulate various types of menu
iii. Select food ingredients	➢ Develop menu costing
iv. Prepare recipe	➢ Formulate recipes

12.3.4.2 Information Sheet

Definitions

Menu: is a list, in specific order, of the dishes to be served at a given meal. Menu is central to the food service concept—it defines the product offering, establishes key elements of financial viability namely price and contribution margin, and provides a powerful marketing tool.

Functions of the Menu:

A menu has the following functions:

1. **Information:** It provides information on foods that are available , cooking methods and prices
2. **Order:** It makes it easy for guests to understand because dishes are presented in an orderly manner.
3. **Choice:** A menu gives the user freedom of choice to pick foods that they prefer and enjoy.
4. **Image:** A menu represents the image of the institution, which is great for aesthetic purposes.
5. **Sales:** Dishes can be made appealing through the menu and this improves sales.

In order for the menu to perform all these functions successfully, it must be informative, accurate, easy to understand, and well designed. Items mentioned on the menu should be available at all times and as per description since it is frustrating for a guest to make a decision only to be told that the dish is not available or to receive a dish that is not as stated.

Types of Menu:

Menus are broadly classified into several types:

They are as follows:

1. A la carte:

It is a list of all dishes on offer, which is within the resources of a particular kitchen. It means 'from the card'. An individual may select items to compose his/her own menu from it. The charge of meal will be the total of the prices of individual dishes served to the guest.

A la Carte

Italian Food Excellently Prepared In Our Scratch Kitchen

ENTRÉES

Prime Rib (Fri., Sat., & Sun.) Regular Cut 38.95	Veal Parmigiana 34.95
Prime Rib (Fri., Sat., & Sun.) Large Cut 48.95	Veal Piccata 32.95
Roast Beef (Top Sirloin) 27.95	Veal Scallopini with Fresh Mushrooms......... 32.95
Sweetbreads Saute with Mushrooms 29.95	Veal Scallopini Sec with Mushrooms 32.95
Eggplant Parmigiana 21.95	Calf's Liver Saute with Mushrooms............ 28.95
Breaded Veal Cutlet 30.95	Calf's Liver with Bacon or Onions 28.95
Veal Cutlet Milanese......................... 32.95	Calf's Liver with Bacon & Onions.............. 29.95

Choice of Steak Fries, Baked Potato, Spaghetti, Vegetables or Ravioli with above orders.

STEAKS & CHOPS

Hamburger Steak (16 oz.) 23.95	Special Top Sirloin (14 oz.) 28.95
Baby Back Ribs 24.95	New York Cut (14 oz.)....................... 38.95
Pork Chops......(One) 24.95 .... (Two) 32.95	New York Cut (18 oz.)....................... 48.95
Lamb Chops .... (Two) 36.95 (Three) 46.95	Filet Mignon...... (8 oz.) 38.95......(12 oz.) 48.95
Rib Steak (26 oz.)........................... 48.95	Porter House Steak (30 oz.) 54.95
Kansas City N.Y. Strip (27 oz.)................ 48.95	

All Steaks with Broiled Prawns 12.95 extra.
All Steaks smothered with Fresh Mushrooms 6.95 extra.
We are proud to serve Certified Angus Steaks, aged and prepared in our own butcher shop.

CHICKEN	SEAFOOD
Half Charcoal Broiled Chicken 23.95	*Calamari Steak 23.95
Charcoal Broiled Chicken Breasts 23.95	*Fillet of Sole.............................. 29.95
Chicken Liver Sautéed with Mushrooms......... 24.95	*Halibut (Broiled or Grilled) 36.95
Chicken Piccata............................. 25.95	*Salmon (Broiled or Grilled) 28.95
Chicken Parmigiana 25.95	*Mahi Mahi (Broiled or Grilled) 28.95
*Chicken Sec with Mushrooms................ 25.95	Golden Fried Scallops 32.95
*Chicken Cacciatora 25.95	Sautéed Scallops (Lemon Caper Sauce)........ 36.95
*Available with Chicken Breasts Only	Golden Fried or Broiled Prawns............... 29.95
	Golden Fried Scallops & Prawns 32.95
	Prawns Scampi 34.95
	*Milanese Sauce with above items 3.95

Choice of Steak Fries, Baked Potato, Spaghetti, Vegetables or Ravioli with above orders.

PASTA

Spaghetti Pomodoro (Tomato Basil) 18.95	Fettuccine Alfredo........................... 18.95
Spaghetti with Meat & Mushroom Sauce....... 18.95	with Smoked Ham & Peas 21.95
Ravioli or Cheese Ravioli..................... 20.95	Pasta Primavera (Red or White Sauce)......... 21.95
Half Spaghetti & Half Ravioli 20.95	Linguine with Clams (Red or White Sauce) 23.95
Pasta al Olio................................ 18.95	Fusilli with Chicken & Broccoli................ 23.95
Pesto with Pinenuts 18.95	Scampi with Linguine........................ 29.95
Mostacioli.................................. 18.95	

One Italian Sausage with Pasta Entrées Only .... 5.95 extra
One Meatball with Pasta Entrées Only .... 5.95 extra
Mushroom Sauce (to take out) ...... Pint 7.95 Quart.................14.95

OUR CHARCOAL BROILER FEATURES MESQUITE CHARCOAL

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SALES TAX WILL BE ADDED TO THE PRICE OF ALL FOOD AND BEVERAGE SERVED AT TABLES.

A la carte Menu

2. Table d' hote:

It literally means 'from the host's table'. A meal is usually divided into various course and one has little or no choice.

Both a la carte and table d’ hote menus are compiled to meet the requirement of the items to be served in the following meals by F&B outlets.

i) **Breakfast /petit dejeuner:** Breakfast is the starting meal of the day and helps boost up the metabolism of the body.

ii) **Brunch:** A meal had between breakfast and lunch.

iii) **Elevenses/gouter:** A light meal usually had at mid-morning hours.

iv) **Luncheon dejeuner:** It is a meal had during the daytime, ideally between 1 p.m. and 2 p.m.

v) **Afternoon tea/high tea/le five o’clock:** It is a light meal, usually had between 4 p.m. and 5 p.m, where tea is served with light snacks.

vi) **Cocktail:** In this meal small bites are served normally with beverages.

vii) **Dinner/diner:** This is the main meal of the day eaten between 7 p.m. and 9 p.m. Many people prefer a light dinner, but for some people it is a lavish fare of wining and dining.

viii) **Supper:** It is a less formal meal eaten before dinner.

Table d’ hote

Recipe Development

Recipe: A standardized and tested procedure for preparing food, in which the ingredients to be used, their proportions, order of mixing and the time and temperature for cooking have all been worked out to produce a uniform and tasty product.

Components of a Recipe:

- The name of the dish.
- How much it will take to prepare the dish.
- Ingredients in required quantities or proportions.
- Equipment and environment needed to prepare the dish.
- Ordered list of preparation steps.
- The number of servings that the recipe will produce

12.3.4.3 Self-Assessment

1. Outline the functions of a menu
2. ______is a list, in specific order, of the dishes to be served at a given meal
   A. Main dish
   B. Menu
   C. Meal planning
   D. Dish
3. Which one of the following is not a component of a recipe:
   A. The name of the dish.
   B. Ingredients in required quantities or proportions.
   C. Price of the end product
   D. Preparation steps.
4. ______is a type of menu with a list of all dishes on offer and an individual may select items to compose his/her own menu from it
   A. A la carte
   B. Cocktail
   C. Table d' hote
   D. Brunch

5. _____ a meal where small bites are served normally with beverages.
   A. Buffet
   B. Cocktail
   C. Luncheon
   D. Dinner
6. Which one of the following is not true about a menu:
   A. It provides information on foods that are available , cooking methods and prices
   B. It makes it easy for guests to understand because dishes are presented in an orderly manner.
   C. A menu shows the sales made over the period of time
   D. A menu represents the image of the institution, which is great for aesthetic purposes.

12.3.4.4 Tools, Equipment, Supplies and Materials

- Recipes
- Stationery
- Food charts
- Calculator
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

12.3.4.5 References

Estes, R. (2018). *The Recipe Development Guide: The Complete Recipe and Cook Book Development Tool*. Independently Published.

12.3.5 Learning Outcome 4: Prepare formulated meals

12.3.5.1 Leaning activity

Leaning activity	Special instructions.
i. Obtain recipe and select ingredients a. Review categories of recipes	➢ Categorize meal courses
ii. Obtain selected ingredients as per client need a. Review guide to selecting quality produce	➢ Prepare for a meal ➢ Purchase ingredients as per budget ➢ Choose quality ingredients
iii. Prepare meal as per menu a. Review food preparation methods	➢ Prepare and serve meals

12.3.5.2 Information Sheet

Definitions

Meal course: A set of food items served at the same time. A meal may contain several meal courses

A full course meal: A meal consisting of three or more courses

Factors to Consider While Planning a Menu

1. **Operations hour:** Consider the operation hours of the establishment/facility so as to ensure efficiency in production and service.
2. **What to serve:** Dishes to be served should be acceptable and in line with the establishment's culture
3. **Production process:** Consider the production process adopted by the establishment. This can be cook-chill, cook-freeze, and sous-vide
4. **Use of convenience products:** A menu will be affected by the use of convenience foods, seeing as some are in ready-to-eat forms.
5. **Style of service**: The style of service is an important consideration to make. This helps to ensure smooth flow of food items during meal service.

Types of Food Service

There are five different types of service

1. **Waiter service**

It is also known as sit-down service. In this type of service, a waiter takes the orders, serves the food and takes care of the payment process too while guests remain seated.

Benefits:

- Since diners are served directly, service provision is more personalized.

Challenges:

- It requires skilled staff because it involves complex processes such as taking and remembering orders and observing principles of meal service
- Miscommunication is a common challenge, which can lead to serving wrong orders to guests.

2. **Chinese banquet service**

   A waiter serves a table or group of tables with about 10-12 guests, where dishes can be communal and shared.

Benefits:

- Sharing dishes gives a homely experience and makes the guests feel more relaxed
- Food is usually pre0rdered, making work easier for the waiters since they don't have to remember orders.

Challenges:

- It is costly in terms of labour because a large number of skilled staff is needed to serve different tables at the same time.
- It is quite tasking to coordinate because all food has to be served fresh at the same time.

3. **Buffet service:**

Guests choose their food from a wide selection on the buffet line. Types of buffet service include:

- **Simple buffet:** Guests pick food from a buffet line while waiters clear tables and serve minor requests.
- **Station-type buffet:** Beverages are served at the table while guests get their food from the buffet line.
- **Modified deluxe buffet**: Waiters serve beverages and dessert while guests get their food from the buffet line. Tables are set with cutlery beforehand.
- **Deluxe buffet:** Waters only serve appetisers, soup and/or salads but guests get the other dishes from the buffet line.

Benefits;

- The tables are easy to prepare
- Makes work easier for waiters because they only serve a few dishes and clear the tables.

Challenges

- Time and resources are limited, so it is difficult to make special requests
- Dinners may feel alienated because there's less interaction with the waiters

4. **Self-service**

Diners place, pay and pick up their orders at a counter similar to fast casual and fast food establishments.

Benefits:

- Waiters have less work because they only need to stay behind the station counter to take orders.

Challenges:

- It requires skilled labour for fast and prompt service.
- Can be tiring during rush hours

5. **Semi-self service**

Similar to self-service, diners order and pay for their orders at the counter but their food is served to them when ready.

Benefits:

- Waiters only need to stay at the counter to take orders and receive payment.
- Services have an easier time delivering orders because diners are identified via a number system.

Challenges:

- Food has to be prepared promptly as quick service is expected.
- Rush hours can be tiring and even more challenging

12.3.5.3 Self-Assessment

1. Explain the advantages and challenges of using the following food service methods:

   A. Chinese banquet service

   B. Buffet service

   C. Self-service

2. Explain factors to consider when planning a menu
3. ______ a set of food items served at the same time. A meal may contain several meal courses
   A. Dish
   B. Meal course
   C. Recipe
   D. Diet
4. Indicate whether the following statements are true or false
   A. In simple buffet, beverages are served at the table while guests get their food from the buffet line.
   B. Meal service where guests pick food from a buffet line while waiters clear tables and serve minor requests is called station-type buffet:
   C. In modified deluxe buffet, waiters serve beverages and dessert while guests get their food from the buffet line. Tables are set with cutlery beforehand.
   D. In deluxe buffet, waiters only serve appetisers, soup and/or salads but guests get the other dishes from the buffet line

12.3.5.4 Tools, Equipment, Supplies and Materials

- Kitchen equipment
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

12.3.5.5 References

Davis, B., Lockwood, A., Alcott, P., & Pantelidis, I. S. (2018). *Food and beverage management*. Routledge.

12.3.6 Learning Outcome 5: Asses food safety and hygiene

12.3.6.1 Leaning activities

Leaning activity	Special instructions.
i. Prepare nutrition support services	➢ Assign responsibilities in hygiene maintenance
ii. Identify processes and practices that are not consistent with the food safety program a. Review HACCP programme	➢ Supervise individuals in food handling ➢ Check condition of food production and service equipment ➢ Assess knowledge and skills for staff in food production areas ➢ Observe food safety measures ➢ Read and interpret time-temperature logs in food production areas
iii. Take corrective action a. Review HACCP programme	➢ Monitor food handling chain ➢ Document discrepancies for corrective action ➢ Implement appropriate corrective measures
iv. Supply nutrition support information or items	➢ Prepare foods in hygienic conditions ➢ Educate relevant persons on food hygiene practices
v. Identify personal hygiene requirements of the food safety program	➢ Keep short nails ➢ Cover hair while in food production areas ➢ Observe proper handwashing procedures ➢ Wear appropriate gear
vi. Report health conditions and/or illness a. Identify types of food borne illnesses	➢ Assess health of people in food handling areas ➢ Observe signs of food borne illnesses ➢ Apply relevant measures to prevent food borne illnesses
vii. Wear PPEs for food handling tasks a. Identify types of PPEs	➢ Choose appropriate PPEs for tasks assigned ➢ Clean and store PPEs appropriately

12.3.6.2 Information Sheet

Food hygiene: Food hygiene refers to all measures taken to ensure food is safe from contamination

It is the responsibility of all people in the food industry from cleaners to managers. As a result, all individuals concerned with food hygiene must practice great care when preparing or handling food to avoid irrelevant wastage of food due to contamination or spoilage by mould, vermin, bacteria or physical damage. Furthermore, many people perceive food hygiene as mere common sense where they aim to do the correct thing and they do not intend to poison anyone. However, while working in the food industry, one must consider various important issues pertaining their kitchen and personal hygiene.

Good hygiene involves – preventing the escalation of infection by individuals who handle food by ensuring that food preparation surfaces, equipment and areas are clean.

Aims of food hygiene

- To protect food from being contaminated
- To prevent bacteria from accumulating to levels that can cause ill-health
- To destroy bacteria in food through sufficient processing or cooking

The benefit of food hygiene

- Compliance with set regulations
- Good reputation
- Enhanced business through customer satisfaction
- Good working environment for employee improved job satisfaction and staff morale
- Improved food quality and increased lifespan for food

The cost of poor hygiene

- Pest contamination
- Poor reputation through media exposure and word of mouth
- Costly fines and legal actions by people suffering from food poisoning
- Outbreaks resulting from food poisoning and sometimes death
- Loss of goods due to spoilage
- Business termination by local health bodies

Sources of contamination

- Clothes
- Pests and flies
- People – (skin, anus, nose, mouth, hands)
- Uncooked food – (specially water, vegetables, seafood, chicken, red meat)

- Utensils – (contaminated utensils specially ones used for raw then cooked food without enough sanitizing and cleaning in between, tea towels)
- Trash

Personal Hygiene Rules

- Fingernails

  Individual preparing or serving food should ensure that they have clean and short nails, and should not have no false nails or nails with vanish

- Gloves

  Before wearing gloves, one should ensure that his/her hands are washed and dried. Once put on, a pair of gloves should not be used for more than one task.

- Hair

  Long hair should be tied back with a ribbon or kept back with a hat or a hair net

- Protective clothing

  Attendants handling cooked food, prepared salads and soft cheese should not travel to and from their place of work wearing their protective clothing. Instead, they should put on their work clothes on site.

Staff should not;

- Cough or sneeze near food
- Scratch
- Use or smoke tobacco within the kitchen area
- Taste any food by using dirty spoon or dipping their finger in it
- Have their breaks in food handling and processing areas
- Put on plain band type rings, wear limited jewellery and plain sleeper style earrings

Kitchen Hygiene Layout

Food Premises

The design, layout and structure of food premises and the provision of essential services, facilities and equipment must meet the required legal requirements of recent laws as well as the industry guidance. In addition, laws are not limited to building but also delivery vehicles, market stalls and other moveable structures. Overall, food premises can be taken to mean;

- Cafes
- Buffet Car On Trains
- Delivery Vehicle
- Warehouses

- Supermarkets
- Staff Canteens
- Shops
- Restaurants
- Market And Other Stalls
- Kitchen Offices
- Hotels
- Hotdog And Ice Cream Vans
- Guest Houses

Physical standard of the premise

Legislations desire that the design, layout, size and construction of food premises should allow for efficient cleaning. Below are points to take into consideration;

a) **Construction**

This is exclusive of any substance that may add harmful material to food either through vapor or through direct contact

b) Ceilings

High level surfaces and ceilings should not have any finishes that may result in particles being shed such as plaster, fibers or flaking paint. In addition, they should be fire, steam and heat resistant.

c) Condensation

Business owners should take into consideration to places in food preparation sections where humidity and steam are produced in order to limit condensation from building up

d) Changing facilities/rooms for staff responsible for handling food should be provided with secure place where they can change from and store their personal possessions and clothes. As a result, employees will not expected to change in toilet area or other sanitary conveniences

Delivery of supplies

Measures should be in place to audit the quality and quantity all supplies received. It is essential to look for signs of poor quality such as rotten or mouldy products. Furthermore, perishable goods should be marked and stored directly to keep the kitchen organized and to ensure that it remains at safe temperatures. Labelling incoming food supplies and creating specific shelf life charts that can be hung in food preparation areas is important because it enables employees to have easy and quick reference when sorting food items.

Drainage system

Drainage should be designed to enable solid and liquid waste to flow away from food preparation area.

Electrical socket and switches

The premise should have enough number of electrical sockets outlet that help to eliminate the necessity for extension leads and long cable runs. Additionally, switches and fittings should not be set within two meters or exposed to water unless they are water resistant.

Floor and walls

Floors should be durable, slip resistant and have the ability to tolerate the spillage of hot liquids and impact damage. This applies to walls, which should also be steam and heat resistant.

Food waste and disposal

Food waste should not be unavoidably be allowed to pile up in sections where food is prepared. Rather, it should be removed at the end of each working day. Bins with lids and lined with plastic refuse are ideal for internal use. On the other hand, bulk storage for external use should be in the form of wheeled covered skips.

Food storage areas

- Food should be stored above floor levels to ensure easy cleaning and pest control. On the other hand, dry food substances and vegetables area should be maintained in good state and with adequate ventilation to provide dry and cool conditions with an air temperature ranging between 10^0C to 25^0C. All food items should be adequately rotated by ensuring that all incoming stocks are stored behind those already in refrigeration or storage units.
- Raw and cooked food should be kept separate
- All storages areas should be kept clean, sanitary and free from debris or trash

Interior surfaces

Interior surfaces should be resistant to formation of mould and be finished in a way that will ensure that they do not shred debris or flake

Lighting

Premises should have suitable and adequate natural or artificial glare lighting to ensure proper cleaning, safe food handling and the right monitoring of standards

Mobile equipment

Catering equipment should be made movable to ensure they are correctly disinfected and protected against accumulation of dirt, formation of moulds or condensation on surfaces or getting into contact with toxic material.

Refrigerators

Refrigerators should have temperature display on the outside casing and an internal thermometer. To ensure that the unit is functioning effectively, readings on both the fridge and freezer should be periodically monitored. Furthermore, fridge doors should only be opened when necessary and it must not be overloaded.

Space

In any premises where food prepared, cooked and served, there is need to include enough space for all related practices expected to take place.

Toilets

Staff should be provided with enough flush lavatories. The recommended number is one toilet for every five employees. Offensive and aerosol odors may be prevented from getting into food preparation areas by ensuring the premise is well ventilated through mechanical or natural ventilations. Additionally, toilets should not lead directly to areas where food is handled, prepared or served. Hence;

- All toilet facilities should be cleaned daily and in good state of repair
- Signs should be p[laced in toilet to advice staff to wash their hands

Wash Basins

Staff members should be provided with enough number of washbasins with cold and running water. These should be placed in the appropriate locations such as food preparation areas or close to toilets. The staff should also be provided with paper towels or warm hand driers and soap (or similar). Temperature for hot tap water should be between 50 and 60 degree C.

Worktop

Worktop should be made of material that is non-toxic, smooth, non-reactive to food ingredients.

Wood

If possible, wood should be avoided in food hygiene premises. However, it may be used for shelves if its surface is free of imperfections and it is sealed with paint or vanish to make it fully washable.

HACCP

Hazards Analysis and Critical Control Points (HACCP) is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product". HACCP is designed for use in all segments of the food industry from growing, harvesting, processing, manufacturing, distributing, and merchandising to preparing food for consumption. It is the means of securing food safety from harvesting to consumption. Tool to identify the hazards and applying the major for the food safety. HACCP can be applied in every step of food processing.

Principles of HACCP

Principles of HACCP

1. Assessing the Hazards: Hazards are assessed at each step in the flow of food throughout an operation.
2. Identifying Critical Control Points(CCPs): A CCP is a point, step or procedure at which *control can be applied* and a food safety hazard can be *prevented, eliminated, or reduced* to acceptable levels. This step involves identification of CCPs regarding hygiene, avoiding cross contamination, temperatures and procedures for cooking and cooling.
3. **Establish critical limits**; Setting up control procedures and standards for critical control points. Establish *standards (criteria) for each CCP* and measurable procedures such as:
    - specific times and temperatures
    - Moisture level
    - PH level
    - Observable procedures such as hand washing
4. **Monitoring critical control points:** Checking to see if criteria are met is one of the most crucial steps in the process. E.g Assigning an employee to monitor temperatures of storage, cooking, holding and cooling are necessary to see if standards are met.
5. **Taking corrective action:** Observe if there's a deviation between actual and expected results. Correct the procedures by using an alternate plan if a deficiency or a high-risk situation is identified in using the original procedure. This may be accomplished by a trained employee empowered to initiate corrective action without a supervisor being present.

6. **Establish record-keeping and documentation procedures**

   Records maintained should have the records or information regarding HACCP plan, CCP, critical limits, monitoring, corrective action, all the procedures including the verification procedures. Recording keeping is necessary of validation and proper application of HACCP.

7. **Establish verification procedures:** HACCP plan must be validated. For testing the validity of the plan several steps can be taken such as checking out the random samples, reviewing the process, confirming that the CCP are under control. Verification activities can be carried out by the external hired officers or the internal members.

Benefits of HACCP:

- Ensures the consumer regarding the safety of the product
- Prioritizes food safety and works to eliminate any kind of hazard
- Necessary for the consistent quality products
- Provides the framework to produce foods safely and to prove they were produced safely.
- Prevents from the possible health outcomes that could have occurred due to mishandling during food production steps
- HACCP is also necessary for obtaining validation.

12.3.6.3 Self-Assessment

1. Discuss the costs of poor food hygiene
2. Discuss the Hazards Analysis and Critical Control Points(HACCP)
3. Discuss the personal hygiene rules and regulations
4. List the sources of food contaminants
5. ____is a point, step or procedure at which control can be applied and a food safety hazard can be prevented, eliminated, or reduced to acceptable levels
   a. Food hygiene
   b. Critical control point
   c. Food contamination
   d. Deviation
6. ____refers to all measures taken to ensure food is safe from contamination
   a. Cross-contamination
   b. Hand washing
   c. Food hygiene
   d. Corrective measure

7. Indicate whether the following statements are true or false
    a. Raw and cooked food should be stored together in a clean dry place
    b. Catering equipment should not be movable
    c. Worktop should be made of material that is non-toxic, smooth, non-reactive to food ingredients
    d. Drainage should be designed to enable solid and liquid waste to flow away from food preparation area

12.3.6.4 Tools, Equipment, Supplies and Materials

- PPEs
- Disinfectants
- Stationery
- Fumigants
- Kitchen plan/lay out
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

12.3.6.5 References

Vaclavik, V., & Christian, E. W. (2003). *Essentials of Food Science*. New York, NY: Henry Holt and Company.

Karel, M., & Lund, D. B. (1975). *Principles of food science*. O. R. Fennema (Ed.). New York: Dekker.

Pierson, M. D. (2012). *HACCP: principles and applications*. Springer Science & Business Media.

https://www.foodsafety.com.au/resources/articles/everything-you-need-to-know-about-haccp

12.3.7 Learning Outcome 6: Document meal planning and management

12.3.7.1 Leaning activities

Leaning activity	Special instructions.
1. Avail registers	• Record meal plans • Maintain meal plan records
2. Avail dietary regime	• Document dietary regime
3. Maintain patient file	• Record dietary modifications on patient file • Collaborate with other disciplines

12.3.7.2 Information Sheet

Record keeping: a permanent written communication that documents information relevant to meal planning and service

Food production records: written records of types and amounts of all food prepared and used on a given day for a certain number of children and adults and required worksheets that demonstrate that meals planned have been prepared and served.

Keeping good records of the meals prepared and served each day is part of any successful food service operation. Records are a valuable written history of site operation and can be used for future reference when menu planning.

Importance of keeping meal records

- Planning Tool
- Communication Tool with staff
- Written History of actual quantities prepared
- Required by regulation
- Demonstrates compliance

Daily Food Production Records

Production records are documentation of the type and amount of food produced for meals. They are also a planning tool.

Daily food production records should include the following:

- Menu item
- Recipe number/code
- Portion size

- Number of portions planned.
- Quantity of food used
- Cooking time/temp
- Serving time/temp
- Actual number of portions prepared.
- Actual number of portions served.
- Leftovers

12.3.7.3 Self-Assessment

1. List the components of a daily food production record
2. _____ are written records of types and amounts of all food prepared and used on a given day for a certain number of children and adults and required worksheets that demonstrate that meals planned have been prepared and served

   A. Menu

   B. Recipe

   C. Food production records

   D. Meal plan
3. Indicate whether the following statements are true or false about keeping meal records

   A. Records are a planning tool

   B. Meal records are a communication tool with staff

   C. They show a written history of actual quantities prepared

   D. Required by regulation and demonstrate compliance

12.3.7.4 Tools, Equipment, Supplies and Materials

- Food record samples
- Stationery
- Inventory registers
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids

- Invitation of competent expertise
- Computers with internet
- Library and resource centre

12.3.7.1 References

Bantin, P. C. (2008). *Understanding data and information systems for recordkeeping*. Neal-Schuman Publishers.

www.eamnutrition.usda.gov

CHAPTER 13:

MATERNAL, INFANT AND CHILD NUTRITION

12.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to manage maternal and child nutrition. It involves advising on nutrition requirement during pregnancy, managing preterm and low birth weight baby manage challenges in maternal child nutrition, providing nutrient supplementation in pregnancy and childhood and documenting maternal and child nutrition care

13.2 Performance Standard

By the end of this unit of learning, the trainee should demonstrate ability to analyse the scope of maternal, infant and young child nutrition based on WHO maternal and child guidelines, advice mothers on nutrition requirement during pregnancy based on the pregnancy stage and workplace procedures, manage preterm and low birth weight baby in accordance with national guidelines for nutrition care of premature and low birth weight infants, inform on complementary feeding and weaning commensurable with WHO guidelines and workplace procedures; manage challenges in maternal and child nutrition per nutritional needs, workplace procedures and standard operating procedures; provide nutrient supplementation in pregnancy and childhood in line with WHO and IMAM guidelines; and document maternal and child nutrition care in keeping with MOH guidelines.

13.3 Learning Outcomes

13.3.1 List of the Learning Outcomes

1. Advise on nutrition requirement during pregnancy
2. Manage preterm and low birth weight baby
3. Inform on complementary feeding and weaning
4. Manage challenges in maternal and child nutrition
5. Provide nutrient supplementation in pregnancy and childhood
6. Document maternal and child nutrition care.

13.3.2 Learning Outcome 1: Advise on nutrition requirement during pregnancy

13.3.2.1 Learning activity

Learning activity	Special instruction
i) Promote adequate weight gain through sufficient and balanced protein and energy intake	➢ Consider the pre-pregnancy weight and nutrition status ➢ Ensure you also confirm the pregnant woman's age so as to put the adolescent primigravidas on the appropriate diet ➢ Monitor weight gain of mothers throughout the pregnancy to ensure weight gain is adequate. ➢ Counsel mothers on adequate weight gain during pregnancy ➢ Counsel and support pregnant mothers with inadequate or excess weight gain. ➢ Carry out comprehensive assessment if weight gain is below the recommended range
ii) Encourage consistent and continued use of micronutrient supplements, food supplements or fortified foods.	➢ Emphasize on the need of micronutrients especially IFAS to the pregnant women ➢ Advise mothers to start IFAS supplementation one month before conception to support health pregnancy and prevent neural tube defects ➢ Give micronutrient supplements depending on nutrient needs and pregnancy stage. ➢ Administer folate and iron supplementation for the first 180 days during pregnancy ➢ Avoid giving vitamin A supplements to the pregnant women ➢ Consider discussing on the appropriate time to take IFAS with women who experience a lot of nausea
iii) Encourage intake of variety of foods during pregnancy which contains adequate energy, protein, vitamins and minerals.	➢ Carry out dietary assessment for pregnant women ➢ Be sure to encourage the pregnant women to take foods from each food group ➢ Discourage pregnant women from taking junk foods like cookies, biscuits, candies, chips etc ➢ Advise pregnant women who have diabetes on the appropriate diet which meets all their nutritional requirements ➢ Prepare a meal plan that contain variety of foods that are nutrient dense.

13.3.2.2 Information sheet

Definitions

- o *Pre-natal care-* care given to a family of child bearing age prior to conception, after conception and the period before onset of labor.
- o *Conception-* Refers to fertilization of a female ovum with a male sperm.
- o *Pre-conceptual care-* It's the care of a woman prior to conception.
- o *Peri-conceptual care-* It's the care given to a woman prior to conception up to 12-14 weeks of pregnancy (gestation).
- o *Pregnancy:* the state of carrying a developing embryo or foetus within the female body.
- o *Morning sickness:* early morning nausea common to some pregnancies
- o *Hyperemesis gravidarum:* nausea so severe as to be life-threatening
- o *Pica:* abnormal craving for nonfood substances such as starch, clay (soil), or ice.
- o *Anaemia:* condition caused by insufficient number of red blood cells, hemoglobin, or blood volume
- o *Fetal alcohol syndrome (FAS):* subnormal physical and mental development caused by mother's excessive use of alcohol during pregnancy
- o *Gestational diabetes:* diabetes occurring during pregnancy; usually disappears after delivery of the infant
- o *Macrosomia:* birth weight of 4.5kg and above
- o *Neural tube defect:* malformations of the brain, spinal cord or both during embryonic development that often results in lifelong disabilities or death

PREGNANCY

During pregnancy many body changes occur in the mother and the fetus. Good maternal nutrition is important for woman's ability to conceive, optimal fetal growth & development, successful child delivery and the overall health of the baby and mother. Good dietary advice during pregnancy determining the future well-being of a child conceived. Good nutrition during pregnancy reduces childhood morbidity and mortality, and minimizes the risks of maternal death associated with pregnancy. Poor nutrition during pregnancy lead to physical, emotional and neurological disorders in the infant.

Weight gain during pregnancy

Adequate weight gain during pregnancy is essential for fetal growth and desired weight gain is desired upon pre-pregnancy weight using BMI criteria and pre-conception nutrition status of the woman. On average a healthy well-nourished woman should gain approximately 12-15 kg. This will translate to an average weight gain of 1.0kg per month, a minimum of 0.5kg per month for the first trimester and thereafter a minimum of 1-1.5kg per month for the last six months. Underweight are advised to gain more to avoid preterm, low birth weight and small for gestational age babies. Obese women should gain relatively low amount of weight. A pregnant adolescent who is still growing should gain more weight than a mature woman of the same size.

The recommended index for assessing nutritional status for pregnant women is Mid-Upper Arm Circumference (MUAC).

Optimal weight gain during pregnancy

BMI before pregnancy	Ideal weight gain	Rate of weight gain after 1^{st} trimester
Underweight (BMI<18.5)	12.5-18kg	Appro. 0.5kg/week
Normal (BMI 18.5-24.9)	12-15kg	Appro. 0.4kg/week
Overweight (BMI >25)	7-11.5kg	Appro. 0.3kg/week
Obese (BMI>30)	<7.0kg or 6kg	Appro. 0.3kg/week
Twin pregnancy	16.0-20.5kg	
Adolescent pregnancy	Upper end of recommended values	

Source: Maternal, Infant and young child nutrition, MOH, 2013.

Recommended weight gain during pregnancy

Pregnancy state (if pregnancy weight was)	Recommended weight gain in Kg
Normal	11.5 -16.0
Overweight	7-11
Obese	5-9

Average distribution of weight during pregnancy

Composition of weight gain	Weight (kg)
Infant birth weight	3.5
Placenta	0.7
Increased maternal blood volume	18
Increased maternal fluid volume	1.8
Increased breast size	1
Increased uterine size	1-1.5
Amniotic fluid	1
Maternal fat stores	3-4.5

Weight gain in the first trimester should be 1-3kg. Second trimester and third trimester should be ½ to 1 kg per week. A higher weight gain is not desirable and is associated with pregnancy complications. Early postnatal nutrition interventions during the first two years of life is critical for brain development and has been shown to have a substantial impact on clinically important outcomes, including long term neuro development.

Nutrient requirements during pregnancy

a) First trimester

This is a time of rapid cell division, organ development and preparation for the demands of rapid fetal growth that occur during 2nd and 3rd trimesters

Critical nutrients during this phase include;

- Protein: Provide 55g+7.5g=62.5g for growth and maintenance of tissue and overall metabolism.
- Folic acid: provide 600mcg for synthesizing nucleotide and cell division to prevent serious birth defects
- Vitamin B12
- Iron: provide 27mg/day to help carry oxygen to cells, development and for infants iron storage
- Zinc: provide 5.5mg 1st trimester; 7mg 2nd trimester and 10mg 3rd trimester for synthesis of nucleic acids DNA and RNA and important in reproduction

b) Second and Third trimesters

Energy intake is especially important since 90% of fetal growth occurs during the last half of gestation. Critical nutrients during this phase include;

- Protein: Provide 55g+7.5g=62.5g for growth and maintenance of tissue and overall metabolism.
- Iron
- Calcium: provide 1000mg/day for fetal bone and teeth calcification during 3rd trimester
- Magnesium
- B vitamins
- Omega-3 fatty acid, dosahexanoic acid (DHA).

Energy requirements during pregnancy

Additional energy needs for normal weight women:

- 2nd trimester+360kilocalories
- 3rd trimester+470kcal
- Lactation+500kcal

The nutritionist/dietician should factor in the different energy requirements in age, body size, pre-pregnancy weight and lifestyles.

More healthy food choices include;

- Steamed fish (240kcal)+1 slice fruit (60kcal)
- Egg sandwich (185kcal)+Milk (125kcal)

Effects of nutritional deficiency during pregnancy

Nutrient	Deficiency
Protein	Reduce head circumference
Folate	Miscarriage and neural tube defects
Vitamin D	Low infant birth weight
Calcium	Decreased infant bone density
Iron	Low infant birth weight and premature birth
Iodine	Cretinism(varying degree of Mental and physical retardation)
Zinc	Congenital malformation

Weight loss after pregnancy

At delivery, the pregnant woman losses some weight. She then continues to lose more in the following weeks as her blood volume returns to normal and she sheds accumulated fluids. It is extremely difficult for a typical woman to return to her pre-pregnancy weight. The more the extra weight the woman gains during pregnancy, the more the likelihood of retaining and continue adding the weight. This extra weight may predispose the woman to diabetes and hypertension in the future pregnancies and chronic diseases later in life.

Eating breakfast regularly supports postpartum weight loss.

Exercise during pregnancy

An active, physically fit woman experiencing a normal pregnancy can continue to exercise throughout pregnancy. However, a pregnant woman should;

- Have simple exercises like walking, swimming
- Avoid lifting heavy weights e.g. mattresses, furniture: abortion
- Avoid long periods of standing: exposes her to varicose vein
- Avoid sitting with legs crossed: impede circulation

Purpose of exercises

- To develop a good posture
- To reduce constipation & insomnia
- To reduce backache and fatigue

- To ensure good muscle tone & strengthen pelvic support
- To develop good breathing habits, ensure good oxygen supply to the fetus
- To prevent circulatory stasis in lower extremities, promote circulation, lessen the possibility of venous thrombosis

Exercise guidelines during pregnancy

Do	Don't
Begin to exercise gradually	Don't exercise viogoyrsly after long periods of inactivity
Exercise regularly	Don't exercise in hot humid weather
Do warm up with 5 to 10 minutes of light activity	Don't exercise when sick with fever
Do at least 30 minutes of moderate physical activity	Don't exercise while on the cback after 1st triemester
Drink water before, during and after exercise	Don't exercise amidst pain, discomfort or fatigue
Eat enough to support the needs of pregnancy plus exercise	Don't participate in activities that may harm the abdomen
Enjoy adequate rest	

However, pregnant women should also stay out of saunas, steam rooms, and hot tubs.

High risk factors during pregnancy

1. **Maternal weight*:*** Both total weight gain and patterns of weight are important indicators of pregnancy outcomes. Weight should be gained gradually. Excessive weight gain is gaining more than one kilogram of body weight in a week (>1kg/week) while inadequate weight gain is gaining less than one kilogram of body weight in one month (<1kg/month).

2. **Pre-pregnancy BMI either < 19.8 or > 26.0*:*** This may lead to nutrient deficiencies or toxicities and eating disorders.

3. **Socio-economic status*:*** Poverty, lack of family support, low level of education, limited food availability.

4. **Lifestyle habits*:*** Smoking, alcohol intake or other drug use. These are associated with low birth weights, stillbirths and birth defects.

5. **Age*:*** Teens 15 years or younger, women 35 years or older.

***6.* Previous pregnancies may put the mother at a nutritional risk**

- Many previous pregnancies (3 or more to mothers under age 20, 4 or more to mothers age 20 and older)
- Short intervals between pregnancies (< 1 year)

- Previous history of pregnancy-related problems
- Multiple pregnancies e.g. twins or triplets etc
- Low or high birth weight of infants

7. **Maternal health:**

- Development of pregnancy related hypertension
- Development of gestational diabetes
- Diabetes, heart, respiratory and kidney diseases, certain genetic disorders, special diets and drugs

Complications during pregnancy

Toxemia (pre-eclampsia*)*-This is acute hypertension with proteinuria, oedema or both after the 20th week of pregnancy. For expectant women suffering from this condition;

- Restrict fat and sodium intake
- Ensure optimal protein intake in the absence of renal disease

Oedema (that does not seem to develop to pre-eclampsia*)*-this is accumulation of fluids in the body. For expectant women having edema:

- Sodium restriction or diuretics are not necessary
- Where oedema occurs on the legs, ensure that the mother sits with her legs placed on a raised surface

***Leg cramps*-**This is neuro-muscular irritability caused by low serum calcium and high serum phosphate). For expectant women experiencing this condition:

- Encourage the client to reduce milk intake to reduce phosphorus intake
- Supplement with calcium
- Regular ingestion of aluminum hydroxide to prevent phosphate absorption is recommended

Potential hazards of pregnancy

1. Vitamin mineral mega dose

Excessive vitamin A (more than 3,000 RE) has been known to cause malformations of the cranial nervous system and birth defects such as hydrocephaly (enlargement of the fluid-filled spaces of the brain), microcephaly (small head), mental retardation, ear and eye abnormalities, cleft lip and palate, and heart defects. Intake before the seventh week appears to be most damaging. Vitamin A is not given as a supplement in the first trimester of pregnancy. Pregnant women should take supplements only on the advice of a registered dieticians or physician.

2. Caffeine

Caffeine crosses the placenta and the developing fetus has limited ability to metabolize it.

Heavy caffeine use is defined as the use of 3-6 cups a day1

3. Weight-loss dieting

Low carbohydrate diets that cause ketosis deprive the fetal brain of the needed glucose and may impair cognitive development. Such diets lack nutrients vital for fetal growth. Regardless of pre-pregnant weight; pregnant women should never intentionally lose weight.

Pregnant mothers should be counseled on the following;

- Alcohol abuse
- Chronic disease requiring special diet
- Drug addiction
- Weight gain
- Food faddism
- Cigarette smoking
- Unwanted pregnancies
- Birth spacing

Pregnancy during adolescence

With the increasing concern for teenage pregnancies, nutritional, physical, psychological, social, and economic demands continue to rise. The situation does not get any better after birth since the teenagers still need nurturing and financial support are held responsible for their helpless newborns.

The young woman may need prenatal health care, infant care, and psychological, nutritional, and economic counselling, as well as help in locating appropriate housing. And at this time, the young woman's family may or may not be supportive. At such a time, nutritional habits can seem to some as being of slight importance. They are, however, of primary importance. An adolescent's eating habits may not be adequate to fulfil the nutritional needs of her own growing body. When she adds the nutritional burden of a developing fetus, both are put at risk. Adolescents are particularly vulnerable to pregnancy-induced hypertension and premature delivery. PIH can cause cardiovascular and kidney problems later. Premature delivery is a leading cause of death among newborns. Inadequate nutrition of the mother is related to both mental and physical birth defects. These young women will need to know their own nutritional needs and the additional nutritional requirements of pregnancy. The government-funded WIC (Women, Infants, and Children) program can help with prenatal care, nutrition education, and adequate food for the best outcome possible. Pregnant teenagers will need much counselling and emotional support from caring, experienced people before nutritional improvements can be suggested.

Case study

Ann is a 25 year old pregnant lady. She is 3 months pregnant and she weighs 45kgs. She is 150 cm tall. She complains of morning sickness which includes nausea and vomiting, headaches and weakness. She weighed 45kgs before conception. She has not started her antenatal clinics. She has had two previous pregnancies 4 years ago. She works as a vegetable vender.

1. Determine her nutritional status.
2. Make a meal plan for her depending on her nutritional needs

13.3.2.3 Self-Assessment

1. The name given to an infant developing in the mother's womb is____
   A. Sperm
   B. Fetus
   C. Ovary
   D. Placenta
2. High blood pressure, edema, and albumin in the urine are symptoms of ____
   A. Pregnancy-induced hypertension
   B. Anaemia
   C. Pica
   D. Morning sickness
3. Appropriate snacks for pregnant and breastfeeding mothers include____
   A. Fruits and raw vegetables
   B. Potato chips and cookies
   C. Candies
   D. Sweetened beverages
4. . Heartburn may be prevented by______
   A. Eating small, frequent meals
   B. Lying down immediately after eating
   C. Taking an aspirin
   D. Increasing liquid at meals
5. Pregnant women should not take supplements of;
   A. Iron
   B. Vitamin a
   C. Folate
   D. Vitamin C

6. Define the following terms
    A. Toxemia
    B. Oedema
    C. Periconceptual care
7. State the required nutrient intake and possible deficiencies associated with the following nutrients during pregnancy;
    A. Zinc
    B. Calcium
    C. Protein
    D. Folic Acid
    E. Iron
8. State the potential hazards of pregnancy
9. How do you control obesity, toxemia and oedema in pregnancy
10. Discuss weight gain during pregnancy from the first month through the ninth. Why is an excessive weight gain during pregnancy undesirable? Is pregnancy a good time to reduce? Explain.
11. Describe the additional energy needs for normal weight women during pregnancy

13.3.2.4 Equipment, materials and resources

Weighing scales/Beam balance	Adult MUAC tape
	

1. WHO guidelines
2. MOH guidelines
3. Stationery
4. Skills lab
5. Use of LCDs, video clips, charts and other teaching aids

6. Invitation of competent expertise
7. Workplace procedure manuals
8. Computers with internet
9. Library and resource centre

13.3.2.5 References

Maternal, infant and Young child Nutrition. National operational guidelines for health workers, MOH 2013

Kenya National Clinical Nutrition and Dietetics Manual, MOH 2010

Ruth O., (2011) Nutrition and Diet Therapy. 10th edition

Ellie & Rolfes (2013). Understanding Nutrition. New York: Yolanda Cossio.

13.3.3 Learning Outcome 2: Manage preterm and low birth weight baby

13.3.3.1 Learning Activities

Learning activity	Specific instruction
i) Monitor Babies growth through regular weight taking	➢ Assess and plot the weight of the baby daily.
ii) Feed the babies	➢ Assess and determine the appropriate feeding option for the individual infant ➢ Ensure proper measurement of the fortified breast milk or formula milk according to energy and nutrient requirements and also observe feeding time. ➢ Practice appropriate sanitation techniques
iii) Monitor regularly the health status of the babies	➢ Screen the babies regularly for possible illnesses or infections
iv) Encourage Exclusive breastfeeding for the first six months	➢ Ensure proper positioning and attachment of the baby to the breast. ➢ Advise mother to ensure the baby breastfeeds for about 15minutes or more in one breast.
v) Fortify Breast milk	➢ Select most important and appropriate nutrients required for breast milk fortification. ➢ Ensure proper measurements of the nutrients are taken during fortification.

13.3.3.2 Information Sheet

Definitions

- **Preterm infant** – A baby born before 37 weeks of gestation have passed. The infant weighs 2500g or less during birth
- **Term infant:** baby born between the beginning of week 38 and end of week 41
- **Gestational age:** estimated time since conception
- **Exclusive breastfeed** – it means the infant receives only breast milk, no other solid or liquids are given.
- **Low birth weight (LBW) infant:** any infant born with a birth weight less than 2.5kg.
- **Breast milk Fortification** – it is the addition of nutrients in short supply e.g protein calcium and posphates in breast milk to meet high requirements especially on preterm infants.
- **Necrotizing enterocolitis:** an inflammatory disease of the small and large intestines combined with death of the intestinal wall.

- o **Lactation:** the period during which the mother is nursing the baby.

Breastfeeding

Importance of breastfeeding for the infant/young child

Breast milk:

- Saves infants' lives
- Human breast milk perfectly meets the needs of human infants
- Is a whole food for the infant, and covers all babies' needs for the first 6 months
- Promotes adequate growth and development, thus helping to prevent stunting
- Is always clean
- Contains antibodies that protects against diseases, especially against diarrhoea and respiratory infections
- Is always ready and at the right temperature
- Is easy to digest. Nutrients are well absorbed.
- Contains enough water for the baby's needs.
- Helps jaw and teeth development: suckling develops facial and jaw structure.

Frequent skin to skin contact between mother and child leads to bonding, better psychomotor, affective and social development of the infant.

The infants benefits from the colostrums, which protects him/her from diseases (colosrum is the yellow or golden (first) milk the baby receives in his or her first few days of life. It has high concentrations of nutrients and protects against illnes.Colostrum acts as laxative, cleaning the infant's stomach).

Long- term benefits of breastfeeding include risk of obesity and diabetes.

<u>Importance of breastfeeding for the mother</u>

- Breastfeeding is more than 98% effective as a contraceptive method during the first 6 months if her menses/period has not returned.
- Putting the baby to the breast immediately after the birth facilitates the expulsion of placenta because the baby's suckling stimulates uterine contractions.
- Breastfeeding reduces the risks of bleeding after delivery.
- When the baby is immediately breastfed after birth, breast production is stimulated.
- Immediate and frequent suckling prevents engorgement.
- Breastfeeding reduces the mother's workload (no time is involved in going to buy the formula, boiling water, gathering fuel, or preparing formula).

- Breast milk is available at anytime and anywhere, is always clean, nutritious and at the right temperature.
- Breastfeeding is economical: formula costs alot of money, and the non-breastfed baby or mixed-fed baby is sick more often, which brings costs for health care.
- Breastfeeding stimulates a close bond between mother and baby.
- Breastfeeding reduces risks of breast and ovarian cancer.

Importance of breastfeeding for the family

- Mothers and their children are healthier
- No medical expenses due to sickness that other milks could cause
- There are no expenses involved in buying other milks, firewood or other fuel to boil water, milk or utensils.
- Births are spaced if a mother is exclusively breastfeeding in the first six months, day and night, and if her menses/period has not returned.
- Time is saved because there is less time involved in purchasing and preparing other milks, collecting water and firewood, and there is less illness-required trips for medical treatment.

Note: families need to help mother by helping with non-infant household chores.

Importance of breastfeeding for the community/nation

- Healthy babies make a healthy nation.
- Savings are made in health care delivery because the number of childhood illness are reduced, leading to decreased expenses.
- Improves child survival because breastfeeding reduces child morbidity and mortality.
- Protects the environment (trees are not used for firewood to boil water, milk and utensils, and there is no waste from tins and cartons of breast milk substitutes). Breast milk is natural renewable resource. Not importing milks and utensils necessary for the preparation of these milks saves money that could be used for something else.

Barriers to effective breastfeeding

- Lack of confidence in mother
- Belief that breast milk is not sufficient
- Lack of adequate support system
- History of previous breast surgery
- Breast engorgement, cracked and sore nipples
- Retractile nipples

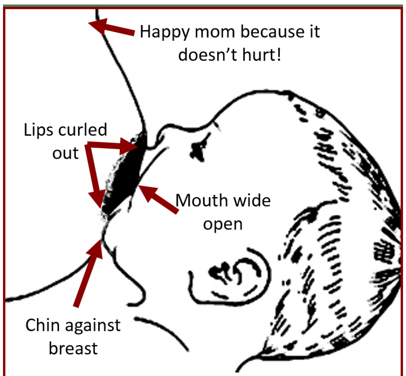
- Embarrassment by mother
- Jealousy by siblings
- Chronic illness in mother; psychosis, Cancer

The proper way to breastfeed

- Stimulate the baby mouth to open by touching the nipple.
- Let the baby open the mouth wider.
- Bring the baby near to the breast
- Latch the baby to the breast

Proper way to latch on

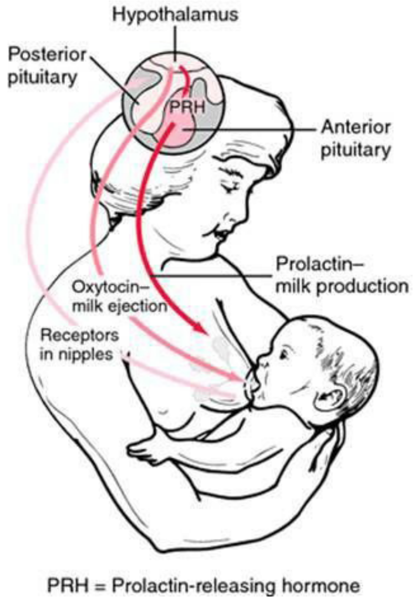
1. Baby open the mouth wider.
2. The chin touching the breast
3. The chick looked flatulent.
4. The lip are flanged out.
5. The breast looked full and round
6. Can hear the sound suck and swallow
7. The nipple looked long and round after breastfeed.



Picture by the World Health Organization

Milk production during lactation

Oxytocin and prolactin instigate the lactation process. Prolactin is responsible for milk production, and oxytocin is involved in milk ejection from the breast. The infant's sucking initiates the release of oxytocin, which causes the ejection of milk into the infant's mouth. This is called the let-down reflex. It is a supply-and-demand mechanism.



Prolactin and oxytocin in milk production

How long to breast feed

- Newborns can nurse for 5 to 10 minute per breast; every 2 to 3 hours. This comes to about 10 to 12 feedings per day. In the beginning, there is only colostrum, and there's not very much of it, so be ready to feed often but for short durations.
- One month or more: as baby gets older, his stomach will get larger. He will nurse less frequently but for a longer duration at each feeding session. For example, he may nurse 20 to 40 minute per breast every 3 to 4 hours.
- By 6 months, Baby may breastfeed for 20 to 40 minutes per breast; 3 to 5 times per day.

Burping baby after breastfeeding

- During and after the feeding, the infant should be burped to release gas in the stomach, just as the breast-fed infant should be burped.
- Burping helps prevent **regurgitation.**
- To burp a baby, hold him or her in one of the two positions shown and gently stroke his or her back**.**

Breast feeding positions

Cross-cradle hold 	Under arm (football hold) position 	Cradle (Normal) position 
Side-Lying position 	Sandle hold position 	

Counsel mothers on and practice optimal breastfeeding practices

1. **Place infant skin-to-skin with mother immediately after birth**
    - Skin to skin with mother keep the newborn warm and helps stimulate bonding or closeness, and brain development this is done by assisting the mother to place the baby on her tummy immediately after delivery.
    - Skin-to-skin helps the “let down” of the milk/colostrum (Colostrum is the first thick, yelowish milk that contains antibodies which protects baby from illness).
    - There may be no visible milk in the first hours. For some women it even takes a day or two to experience the “let down”. It is important to continue putting the baby to the breast to stimulate milk production and let down.

2. **Initiate breastfeeding within the first hour of birth**
    - *Ensure there is rooming in:* keep the baby with the mother in the same bed for unlimited breastfeeding.
    - Give newborn infants no food or drinks -- no water, no infant formula (pre-lacteal feeds) other than breast milk unless medically indicated. Support the mother to attach and position the baby to initiate breastfeeding immediately within 1 hour after delivery.
    - Assist the mother to breastfeed frequently from birth as it helps the baby to learn to attach and also helps to prevent the engorgement and other complications.

- In the first few days, the baby may feed only 2 to 3 times/day. If the baby is still sleepy on day 2, the mother may express some colostrum and give it from a cup.

Benefits of early initiation

Note: Breastfeeding in the first few days:

- It facilitates milk production
- It helps in the release of oxytocin hormone which helps the uterus to contract and control post-partum bleeding.
- The baby gets colostrum which has the following benefits:
  1. Rich in antibodies – protects against allergy & infection
  2. Many white cells – protects against infection
  3. Purgative – clears meconium helping to prevent jaundice
  4. Growth factors – helps intestine to mature, prevents allergy and intolerances
  5. Rich in vitamin A – prevents and reduces severity in case of infection.

3. Encourage and promote exclusive breastfeeding for infants from birth up to six months (no food or drink, not even water should be given to the baby during this period)

- Breast milk is all the infant needs for the first 6 months.
- Do not give anything else to the infant before 6 months, not even water.
- Breast milk contains all the water a baby needs, even in a hot climate
- Giving water will fill the infant and cause less suckling; less breast milk will be produced
- Water and other liquids and foods for an infant less than six months can cause diarhoea.

4. Breastfeed frequently day and night

- After the first few days, most new-borns want to breastfeed frequently, 8 to 12 times/day. Encourage the mother to frequently breastfeed as this helps to produce lots of breast milk.
- Once breastfeeding is well established, breastfeed 8 or more times day and night to continue to produce plenty of (or lots of) breast milk. If the baby is well attached, contented and gaining weight, the number of feeds is not important.
- More suckling (with good attachment) makes more breast milk.

5. Encourage breastfeeding on demand

- Breastfeed on demand every time the baby wants to breastfeed

- Crying is a late sign of hunger. Encourage the mother to breastfeed every time the baby demands.
- Advice the mother to observe the early signs that baby wants to breastfeed e.g
    - Restlessness
    - Opening mouth and turning head from side to side
    - Putting tongue in and out
    - Suckling on fingers or fists.

6. Let the infant finish one breast and come off by him /herself before switching to the other breast.

- Ensure that the baby empties one breast before switching from one breast to the other as this prevents from getting the nutritious "hind milk".
- The "fore milk" has more water content and quenches infant's thirst; the "hind milk" has more fat content and satisfies the infant's hunger.

PRETERM AND LOW BIRTH WEIGHT (LBW) Infants

Classification of preterm and low birth weight babies

i. Late preterm: born between 34 and 36 completed weeks of pregnancy (borderline)

ii. Moderately preterm: born between 32 and 34 weeks of pregnancy

iii. Very preterm: born at less than 32 weeks of pregnancy

iv. Extremely preterm: born at or before 25 weeks of pregnancy

Classification for gestational age

i. Small for date (SFD) babies: babies with birth weight of less than 10^{th} percentile for their gestational age.

ii. Appropriate for dates (AD) babies: with birth weight between 10^{th} to 90^{th} percentile for the period of their gestation

iii. Large for dates (LFD) babies: with a birth weight more than 90^{th} percentile for the period of their gestational age.

Classification of low birth weight babies

i. Low birth weight (LBW) baby: neonate with birth weight of <2500g

ii. Very low birth weight (VLBW) babies: babies with a birth weight of less than 1500g

iii. Extremely low birth weight: neonate with a birth weight of less than 1000g and greater than 750g

iv. Micronates: neonates weighing below 750g

v. Intrauterine growth retardation (IUGR): Failure to sustain intrauterine growth at expected rates; can be caused by placental insufficiency, infection, malnutrition, etc-has high chances of being born prematurely

Nutrition assessment for Preterm and LBW infants

Nutrition assessment is the process of gathering or collecting nutrition and health related information to enable making sound judgement of a person's nutrition status. Assessment of preterm and LBW infants is important because it helps to:

- Measure changes in nutritional status in order develop optimal nutritional care approaches
- Identify nutritional problems early for prompt action to prevent them from worsening
- To inform drug and fluid (feeds) administration to suit the infant

Monitoring growth rate of preterm and LBW infants

The following anthropometric assessment should be assessed;

- Weight- on a daily basis
- Length- on a weekly basis
- Head circumference- on a weekly basis

Ideal weight gain: ≥15g/kg/day (at 2-3 weeks after birth)

- Expect an initial weight loss of 5-15% of birth weight during the first week of life, due to loss of lung fluid, passage of urine and meconium and energy produced for maintenance of body temperature
- Birth weight should be regained at 10-14 days after birth in both preterm and term infants

Ideal length accretion rate: 0.8-1.0 cm/week

- Accurate length measurement is difficult to obtain

Ideal head circumference: 0.5-0.8 cm/week

- Changes will keep occurring from birth to week one of life due to head molding and edema. The measurements should be done weekly while the infant remain in hospital

1. **Anthropometric assessment**

The following anthropometric measures should be assessed:

- Weight- taken on a daily basis
- Length- on a weekly basis
- Head circumference- on a weekly basis

Weight, length and head circumference by gestational age for boys

Gestational age	Weight (kg)	Length (cm)	Head circumference (cm)
40 weeks	3.4	51	35
35 weeks	2.5	46	32
32 weeks	1.8	42	29.5
28 weeks	1.1	36.5	26
24 weeks	0.65	31	22

Weight, length and head circumference by gestation age for girls

Gestational age	Weight (kg)	Length (cm)	Head circumference (cm)
40 weeks	3.4	51	35
35 weeks	2.4	45	31.5
32 weeks	1.7	42	29
28 weeks	1.0	36	25
24 weeks	0.60	32	21

The growth chart which is recommended by most for use in assessing preterm infants is as shown in the figure on the next page.

2. Biochemical assessment

Serum electrolytes, glucose, urea nitrotogen and creatinine are frequently monitored during the first week because the values are usually abnormal. If the infant is on parenteral nutrition administration for more than 5 days, the following tests must be done on a routine basis;

i) Serum albumin, urea and creatinine: 2-3times a week

ii) Calcium, magnesium and alkaline phosphate; once a week

iii) Full blood count: once a week

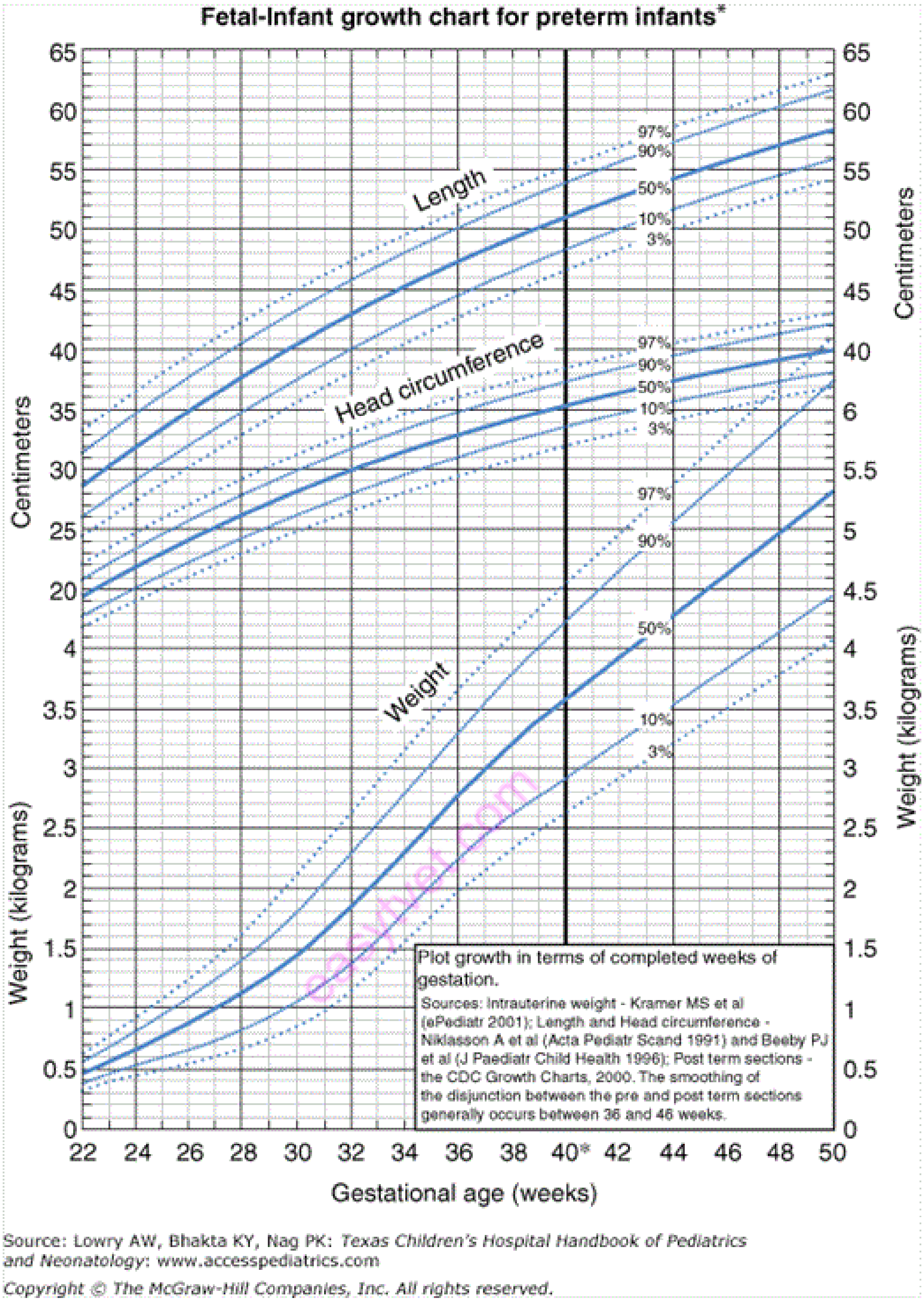
iv) Blood glucose: once a week

v) Cholesterol and triglycerides: once a week

vi) Direct bilirubin: once a week

vii) Serum Alanine Aminotransferase: once a week

viii) Electrolytes (Sodium, Chloride and Bicarbonate): 2-3 times a week



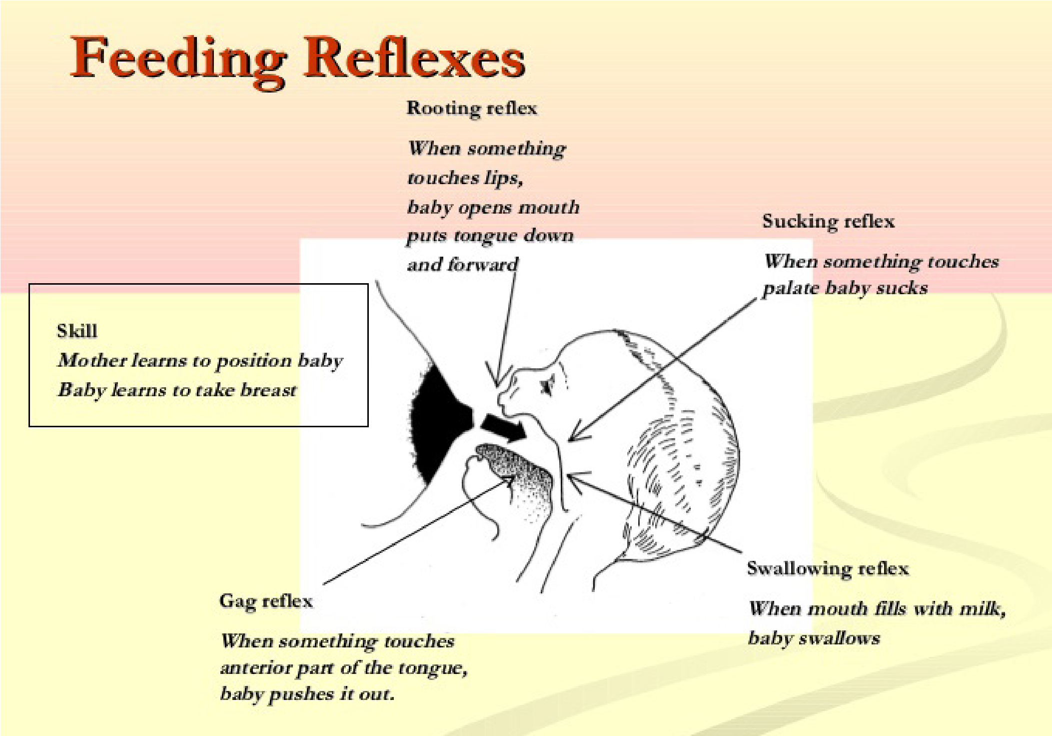
Growth chart for preterm infants

Biochemical indicators for evaluation of the adequacy of nutrient intake

Biochemical indices	Values indicating deficiency	Interpretation
Serum Urea	<1.8 mg/dl	Insufficient nutrient intake (esp. protein)
Serum total protein	<44g/L	Insufficient nutrient intake (esp. protein)
Serum pre-albumin	<10mg/L	Insufficient nutrient intake (esp. protein)
Serum retinol binding protein	<1.05mg/dl (children's values=$^{1/2}$ adult values until puberty Adult values =2.1-6.4mg/dl	Insufficient nutrient intake (esp. protein)
Serum alkaline phosphatase	<450IU/L	Insufficient nutritional intake of calcium, phosphorus and subsequent decreased bone mineral deposition
Serum Phosphatase	<4.5mg/dl	Insufficient phosphatase intake

Clinical features

- General appearance: preterm infants look small and lean due to the presence of very little subcutaneous fat.
- Their skin is thin and may have a yellow pigmentation if neonatal jaundice is present. Depending on the gestational age, lanugo (fine black hair which is present on the skin of a neonate) might be present.
- Small size, with a disproportionately large head
- Sharper looking, less rounded features than a full-term baby's features, due to a lack of fat stores
- Fine hair (lanugo) covering much of the body
- Low body temperature, especially immediately after birth in the delivery room, due to a lack of stored body fat
- Labored breathing or respiratory distress
- Lack of reflexes for sucking and swallowing, leading to feeding difficulties



4. Dietary assessment

The preterm and LBW infants'' fluids, nutrients and energy intake must be assessed on a daily basis. The health worker should take note of any food intolerance which can be signaled by emesis; physical findings such as abdominal distention, tenderness and absent bowel sounds and gastric residue fluid such as stool output, change in frequency and blood stains.

The following red flags are contraindications that if practiced will lead to complications or failure to thrive;

- Infant taking preterm formula or human milk fortifier if infant is currently >1.5kgs
- Mixing formula stronger than standard dilution; mixing formula with expressed maternal milk
- Infant taking low-iron infant formula, soy formula or goat milk
- Improper formula dilution
- Mixing supplements to breast milk or formula
- Lethargy, decreased arousal during feedings
- Infant is fussy or distressed during feedings; has trouble breathing during feeding; difficult to wake for feedings or tires easily; or has difficulty finishing feeding.
- Infant refuses to eat; is difficult to feed or arches backwards when feeding, frequently gags, coughs or chokes during feeding.
- Feedings are frustrating and stressful to parent or infant
- Parents or caregivers have difficulty interpreting or responding appropriately to feeding cues
- Infant taking cow's milk before 6 months

The amount of milk taken can be evaluated more accurately by test-weighing, a procedure in which a clothed infant is weighed on an electronic scale immediately before and after breastfeeding.

Good attachment is important for effective removal of milk from the breast into the baby's mouth and for simulation of continued breast milk production.

Premature babies, especially those born very early, often have complicated medical problems. Typically, complications of prematurity vary. But the earlier the baby is born, the higher the risk of complications.

Risk factors associated with premature babies

Factor	Description
1) Behavioral	– Low pre-pregnancy weight for height – Smoking especially >11 cigarettes per day – Drug and substance abuse
2) Demographic	– Age below 18 years – Age of first pregnancy greater than 35years – Less than high school education – Poverty – Non-Caucasian race – Unmarried – Underweight or overweight before pregnancy
3) Reproductive system	– Hypertension during pregnancy – History of infertility – Multi-parity >5 – No prenatal care – Multiple gestation – Placental abnormalities – Previous preterm birth – Previous still birth or neonatal loss – Previous first or second trimester abortions – Uterus abnormalities – Short inter-pregnancy interval
4) Psychosocial	– Domestic abuse – Exposure to job related teratogens – High stress – Inadequate housing – Strenuous job activity

Nutritional challenges of premature and LBW infants

a) High metabolic rates as a result of high rate of growth and higher proportion organs like heart, liver and brain which are more metabolically active

b) Difficulty in maintaining normal body temperature due to lack of adipose tissue

c) Excessive water loss owing to the very thin and highly permeable skin

d) Immaturity of renal function leading to limited capacity for concentration of urine and excretion of waste products, vulnerability to very high solute overload and dehydration and inability to maintain acid-base balance

e) Immature digestive system:

- Very low stomach capacity
- Slow gastric emptying and stool passage
- Slower upper and lower intestinal motility
- Fragile intestines leading to high risk of necrotizing enterocolitis (NEC)
- Immature liver hence reduced bile production
- Deficiency of digestive enzymes
- Immature digestion and absorption of macronutrients
- Inability to coordinate sucking and swallowing
- GI tract sterility hence immunologically immature

f) Conditions affecting feeding and nutritional demand

- Poor sucking and swallowing reflexes as they only develop at 32-34 weeks
- Poor feed tolerance due to increased chances of aspiration
- Fluid restrictions imposed
- Low levels of micronutrients such as calcium, zinc, iron etc
- Few nutrient reserves
- Accelerated growth

Nutritional requirements for preterm and low birth weight infants

The nutritional requirements of preterm and LBW babies is high compared to a term neonate

Goals of nutritional management of **preterm and low birth weight infants**

i. Ensure growth and nutritional patterns similar to intrauterine growth

ii. To provide sufficient nutrients and calories to support accelerated rates of growth and nutrient accretion equal to intrauterine rates

iii. Improve long-term nutritional results

iv. Prevent morbidity related to feeding options

Guidelines on nutritional requirements

Energy and nutrient requirements are usually much higher compared to term neonates because;

a) Preterm babies have not achieved the optimal deposition of nutrients in the body. The babies have not stayed in the womb long enough to build storage of nutrients (which happens in 3rd trimester) hence they must take supplements.

b) Infants born at the beginning of third trimester of pregnancy often are growth restricted because of decreased intrauterine nutrient deposition

c) Compositional differences exist between term and preterm human milk due to early interruption of pregnancy, variable hormonal profile, and delay in initiation of pumping, maternal anxiety and decreased milk flow.

d) The nutritional needs of preterm infant exceed the content of human milk for protein, calcium, phosphorus, magnesium, sodium, copper, zinc and vitamins B12, B6, C, D, E and K and folic acid (See Table below).

Macro and Micronutrients recommend intakes for infants 1000g to 1500g

Nutrient	Preterm Infant	Term infant
Energy kcal/kg/bwt	110-135	108
Protein (g)<kg bwt	4.0-4.5g/kg/day	2.2g/k/day
Protein (g)1-1.8kg bwt	3.5-4.0g/kg/day	
Fat g/kg/day	4.8-6.6g/kg/d	5.5g/100kcal
DHA (mg)/kg	≥18 (0.2 to 0.5% fat)	0.1 to 0.4%
ARA (mg)/kg	≥24 (0.3 to 0.7% fat)	0.2 to 0.7%
ARA:DHA ratio	1.2:2.1	1 to 2
CHO g/kg/day	3.4 to 4.2	11g/100kcal
Iron (mg)/kg	2 to 4	10mg/day
Calcium (mg)/kg	100 to 220	360mg/day
Phosphorus (mg)/kg	60 to 140	240mg/day
Sodium (mg)/kg	69 to 115	350mg/day
Potassium (mg)/kg	78 to 117	925mg/day
vitamin A (mcg)/kg	210 to 450	420mcg/day
Vitamin D (mcg)/kg	3 75 to 10	10mcg
Folic acid (mcg)/kg	25 to 50	30mcg/day
Vitamin C (mcg)/kg	18 to 24	35mcg/day

Feeding options for preterm and LBW infants

The recommended types of feeds for preterm and LBW infants are;

a. Expressed breast milk + fortifier
b. Expressed breast milk +preterm formula milk substitute
c. Preterm formula
d. Breastfeeding +alternate fortified expressed breast milk

a) Breastfeeding

It's the best method because it has many health benefits for premature babies. However, it is not always adequate for premature infant. This being the case, the following categories of infants will need breast milk fortification or supplementation to meet their nutrient requirement for a limited period before breast milk can be optimal for optimal growth and development;

- Very low birth weight
- Born between 1500 to <2000g – those unable to consume or tolerate large quantities of breast milk and those displaying inadequate growth require a breast milk fortifier- fortification for a minimum of three months post discharge is recommended and then reassess needs after that.
- Newborn infants who are at risk of hypoglycemia
- Where mother is unable to breastfeed or breastfeeding is contraindicated

Low birth weight babies as well as for babies weighing 2500g or more who have no problem breastfeeding should be initiated on the breast within the first hour of birth.

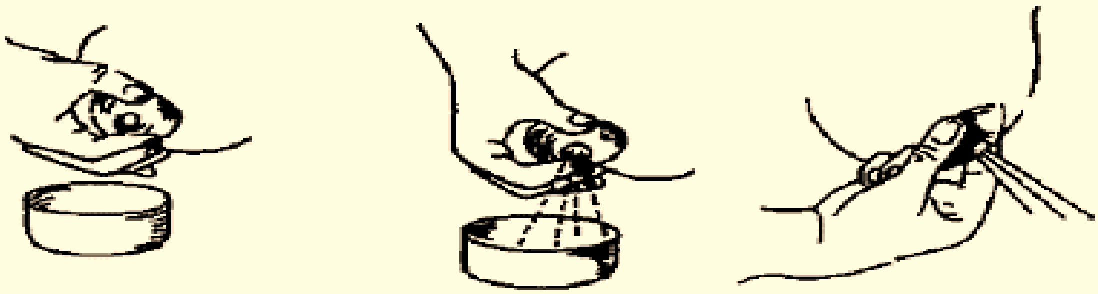
b) Expressing milk for the premature baby

Start expressing colostrum as soon as possible after birth. This should be within 6 hour of delivery. She can then feed the baby with the colostrum drop by drop at first but can later use cup and a spoon/syringe to feed the infant instead of a bottle. The mother should express as much breast milk as she can and as often as her baby could express. This should be at least every three hours, including during the night.

During hand expression of breast milk, a mother should;

- Wash hands
- Prepare a sterile/clean container
- Gently massage breasts in a circular motion with her fingers position the thumb on the upper edge of the areola and the first two fingers on the underside of the breast behind the areola
- Press behind the nipple and areola between the finger and thumb
- Compress and release the breast with the fingers and the thumb a few times
- Press form all the sides to empty all the segments

- If no milk is expressed, move thumb and fingers towards or further away from the nipple and try again
- Repeat compressing and releasing rhythmically
- Rotate the thumb and finger positions to remove milk from other parts of the breast
- Avoid squeezing the breast, pulling out the nipple and the breast, and sliding the finger along the skin



Expressing breast milk
Fig. 6

Milk supply and demand

Removal of milk helps to stimulate milk production. The amount of milk removed at each feed determines the rate of milk production in the next few hours. This then means that it is critical to remove continue removing milk even when mother and baby are separated in order to maintain supply.

To keep up with her milk supply, the mother should express at least every three hours. To build up her milk supply if it seems to be decreasing, the mother should express ever 1-2 hours during the day and at least three hours during the night.

Stimulating oxytocin reflex

Oxytocin works better when the baby is suckling than when expressing. A mother needs to know how to help her oxytocin reflex when expressing the milk.

- Help the mother psychologically:
    - Build her confidence
    - Try to reduce any sources of pain or anxiety
    - Have good thoughts and feelings about the baby
    - Advise her to sit quietly and privately or with a supportive friend
    - Hold her baby with skin-skin contact if possible (she can hold her baby on the lap as she expresses or even look at its photograph)
- Advise her to warm her breasts: she can take a warm shower or massage the breasts with warm water

- Encourage her to stimulate her nipple either by gently pulling or rolling her niples with her fingers
- Encourage her to massage or stroke her breasts lightly using fingers, closed fist or a comb
- Advise her to have a helper to rub her back

Using back massage to stimulate the oxytocin secretion and improve the let-down reflex

Picture: World Health Organization

Breast milk fortification

All infants below 1500g require breast milk fortifier in addition to breast milk.

Benefits of breast milk for the preterm

- Whey predominant protein
- Improved nutrient absorption
- Low renal solute load
- Increased Omega-3 fatty acids
- Presence of anti-infective factors
- Possible protection against NEC and late onset sepsis
- Promotion of maternal infant attachment

Limitations of human breast milk for preterm infants

- Inadequate supply
- Volume restrictions
- Inadequate nutrients
- These limitations result in:
  - o Slower growth rates
  - o Decreased bone mineralization and risk of osteopia
  - o Nutrient deficits
  - o Long-term poor neurodevelopment outcomes

The limitations necessitate the use of FHM (Fortified Human Milk) which helps achieve optimal growth and nutrition for the infant. Examples of breast milk fortifiers include; Nutripre Breast milk fortifier (Cow & Gate) .1g sachet and FM 85 (Nestle) 5g scoop/100ml

The addition of multi-nutrient fortifiers to human milk results in:

- Improvement in weight gain
- Increments in both length and head circumference in the premature infant
- Normalization of serum calcium, phosphorus and alkaline phosphatase
- Improved protein status
- Increased bone mineralization
- Improved long-term development

c) Preterm formula

Since breast milk may not always be available, preterm infant formula may be used. This is a formula designed for premature infants, and is calorie-enriched (80kcal/100ml), protein and mineral enriched to support intra-uterine accretion rates. The formal helps to increase the rate of weight gain and head growth and improves the neurodevelopmental outcomes.

It is suggested that a preterm infant milk formula should contain calcium and phosphorus at a minimum level of 75mg/100ml and 42mg/100ml respectively (if fed at 180ml/kg/day).

Standard procedures for personnel deployed in neonatal intensive care feed room personnel

1. Trained, skilled health workers are essential in the care setting to be in compliance with all applicable health regulations and sanitation codes
2. Do precise measurements and ensure maximum concentration when preparing formula
3. The health worker should be in good health and must practice appropriate sanitation techniques
4. Health worker should always remove all jewerly while on duty in order to prevent any possible contamination of the formula
5. All staff must follow hand hygiene per hospital
6. A short-sleeved scrub uniform should be worn under a clean gown during periods of preparation
7. Hair must be completely covered with a hair restraint
8. Artificial nails are prohibited, and nails must be short and well-manicured.

Mode of feeding

i) **Through an IV line**

It is a thin line that goes straight to the veins. Carries all the nutrient directly to blood supply. Sugar and salt solution can be given or a nutrient rich solution called total parenteral nutrition (TPN).the method depends on baby weight and how long they think it will take to establish the mother's breast milk.

ii) **Tube feeding (infants <1500g)**

This feeding method is recommend for preterms with impaired suck swallow breat pattern until they can obtain adequate quantities of milk from the breast. The tube, which is very fine and soft, goes into their stomach - either through the nose and down to the back of the throat (a nasogastric tube) or through the mouth (an orogastric tube). Nasogastric tube is recommended for all neonates with breathing problems, very low oxygen levels, gagging, circulatory problems, blood infection, or other illnesses since they may not suckle.

iii) **Breastfeeding** is appropriate for stable growing infants above 2000g

iv) **Cup feeding** (infants 1500-2000g): used for those whose swallowing reflex has developed

v) Premature infants should be fed very slowly to reduce the risk of getting an intestinal infection (necrotizing enterocolitis).

Quantity of feeds

Weight	Volume
≤1500g	80-100 ml/kg/day
1501-2000	80 ml/kg/day
Above 2000	60ml/kg/day

Feeding frequency; 2 hourly

Approaches to feeding

- For preterm well babies, immediate milk feeding should be initiated at 6oml/kg/day
- For sick babies or weight <1.5kg start with 24hr IV 10% Dextrose on day 1
- Day 2, minimal enteral tube feeds may be started depending on whether the neonate is ready as per the guidelines
- Starting from day two depending on whether the infant is ready for initiation of enteral feeds, the volume is increased by 10-20ml/kg per body weight and IV fluids reduced with the same amount to keep within the total daily volume
- For bare maintenance, 150ml/kg/day is required
- Fortification is started when a volume of 150ml/kg/day is reached
- The increament should continue until a maximum volume of 240ml/kg/day fortified breast milk reached or 200ml/kg/day when using preterm formula
- Follow the paediatric protocol in administration of the bolus feeding or IV fluids

Case study

Joseph is a two days old baby. He was born after 32 weeks with a birth weight of 1000g. The mother is HIV positive and she ddelivered through caesarean section. Since birth he has been in the incubator. He is reportedd to have difficulties in breathing and high fevers.

1. Give advice on the best feeding method to be used
2. Give formulation to be given and the nutrients to be supplemented

13.3.3.3 Self-Assessment

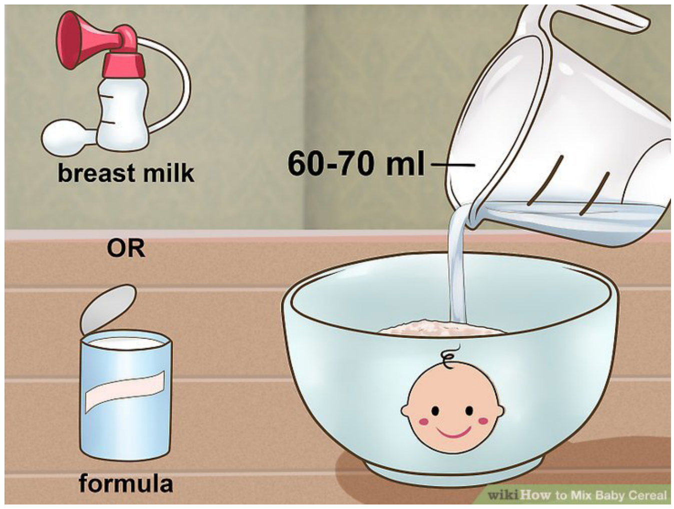
1. **D**efine;
    A. Preterm infant
    B. Exclusive breastfeeding
    C. Breast milk fortification
2. A small for date baby is a ________________
    A. Born between 34 and 36 completed weeks of pregnancy
    B. A baby with birth weight between 10th to 90th percentile for the period of their gestation
    C. Name given to a baby from birth up to 28 days
    D. Babies with birth weight of less than 10th percentile for their gestational age.
3. When a ____________________ helps the baby to open the mouth, put the tongue down and forward when something touches the lips
    A. Gag reflex
    B. Rooting reflex
    C. Swallowing reflex
    D. Sucking reflex
4. The following methods are used to feed preterm and low birth except?
    A. Bottle feeding
    B. Breast feeding
    C. Cup feeding
    D. Parenteral feeding
5. The volume of milk recommended for low birth weight baby weighing 1800g is___
    A. 90 Ml/kg/day
    B. 80-100 Ml/kg/day
    C. 50-60 Ml/kg/day
    D. 80 ml/kg/day

6. To facilitate lactation, a mother needs ;
    A. About 5000kcal a day
    B. Adequate nutrition and rest
    C. Vitamin and mineral supplements
    D. A glass of wine or beer before each feeding
7. State the signs and symptoms of a premature infant
8. Describe the various methods of feeding a preterm baby
9. Explain the benefits and limitations of breast milk for preterm and LBW infants
10. Discuss the expression of breast milk for preterm and LBW infants

13.3.3.4 Tools, Equipment, Supplies and Materials

1. WHO guidelines
2. MOH guidelines
3. Stationery
4. Skills lab
5. Use of LCDs, video clips, charts and other teaching aids
6. Invitation of competent expertise
7. Workplace procedure manuals
8. Computers with internet
9. Library and resource centre

Weighing scale 	MUAC tape
Head circumference tape 	Length board 

Cup & spoon	Mixing equipment and graduated cylinders
	
Tray	Feeding Syringe
	

13.3.3.5 References

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Maternal, infant and Young child Nutrition. National operational guidelines for health workers, MOH 2013

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13.3.4 Learning outcome 3: Inform on complementary feeding and weaning

12.3.4.1 Learning Activities

Learning activity	Specific instructions
i) Obtain Dietary requirements of the babies. • Review WHO guidelines on complementary feeding	➢ Assess the infant's readiness for solid foods ➢ Give diet guides depending on baby nutrition needs and the age. ➢ Support mothers in appropriate and optimal complementary feeding for 6 to 24 months through the use of locally available home based foods
ii) Observe Breastfeeding for two years as per WHO guidelines	➢ Counsel mothers on optimal breastfeeding practices ➢ Encourage the mother to exclusively breastfeed up to 6 and continue breastfeeding up to 2 years of age after starting complementary feeding. ➢ Observe the signs of good positioning during breastfeeding
iii) Monitor Babies growth	➢ Take and plot babies weight every month to determine growth pattern
iv) Supplement the babies with micronutrients as per their nutrition requirements	➢ Give vitamin A supplement at 6 months upto to 59 months. ➢ Give other supplements depending on nutritional needs of the baby.

13.3.4.2 Information Sheet

Definitions

- Complementary feeding - Complementary feeding means giving other foods in addition to breast milk. These other foods are called complementary foods.
- Weaning - It is the process of introducing an infant to what will be adult diet while withdrawing the supply of its mother's milk.
- Breastfeeding is the feeding of an infant or young child with breast milk directly from female human breasts (i.e., via lactation) not from a baby bottle or other container
- Lactation, the production and secretion of breast milk for the purpose of nourishing an infant, is facilitated by an interplay of various hormones after delivery of the infant.

Nutritional requirements

During the first year of life, infants experience the most rapid growth in one's life. An infant is expected to double its birth weight by 6 months of age and triple it within the first year. This explains why the infant's energy, vitamin, mineral, and protein requirements are higher per unit of body weight than those of older children or adults. Nutritional needs will depend largely on a child's growth rate. As nutrient requirements vary with growth rate. The infant is expected to obtain its nutritional requirements from the breast milk for the first six months.

WHO recommends that when breast milk is no longer enough to meet the nutritional needs complementary feeds should be introduced after 6 months. It is during complementary feeding when the transition from breast milk to family foods happens, a period that takes 6 to 18-24 months of age. According to WHO, infants should start receiving complementary foods at 6 months of age in addition to breast milk, initially 2-3 times a day between 6-8 months, increasing to 3-4 times daily between 9-11 months and 12-24 months with additional nutritious snacks offered 1-2 times per day, as desired.

Continuing breast milk or formula milk and introducing complementary food and drink needs to be started at six months to:

- o Provide extra energy (calories) and nutrients to sustain normal growth and optimal health and development
- o Give infants the opportunity to learn to like new tastes and textures, based on family foods, at a time when they are receptive to them, thus potentially preventing food refusal later

Complementary foods can be subdivided into:

- o Transitional foods: complementary foods specifically designed to meet the particular nutritional or physiological needs of the infant;
- o Family foods: complementary foods given to the young child that are broadly the same as those consumed by the rest of the family.

Guidelines for feeding a baby from birth to 6 months

- Exclusive breastfeeding is recommended for the first 6 months
- Encourage parents to feed children on demand
- Encourage parents to hold and position their babies correctly during feeding and make eye contact
- If an infant is not breastfeeding infant formula is the most acceptable alternative
- Avoid fruit juice water or any beverage other than breast milk

Introduction of complementary foods

- o One food is introduced and then no other new food for 4 or 5 days.
- o If there is no allergic reaction, another food can be introduced, a waiting period allowed, then another, and so on.

- o The typical order of introduction begins with cereal, usually iron-fortified rice, then oat, wheat, and mixed cereals.
- o Cooked and pureed vegetables follow, then cooked and pureed fruits, egg yolk, and, finally, finely ground meats.
- o Between 6 and 12 months, toast and teething biscuits can be added in small amounts. Food should also be given so as to allow the infant to learn to chew and accept a wide variety of food textures
- o Honey should never be given to an infant because it could be contaminated with *Clostridium botulinum* bacteria. Naturally sweet fruits (such as bananas) should be used to sweeten foods rather than adding sugar
- o When the infant learns to drink from a cup, juice can be introduced. Juice should never be given from a bottle because babies will fill up on it and not get enough calories from other sources.

Effects of early complementary feeding

The introduction of solid foods before the age of 4 to 6 months is not recommended because;

- o The child's gastrointestinal tract and kidneys are not sufficiently developed to handle solid food before that age.
- o It is thought that the early introduction of solid foods may increase the likelihood of overfeeding and the possibility of the development of food allergies, particularly in children whose parents suffer from allergies.

Signs of an infant's readiness for solid foods

1. The physical ability to pull food into the mouth rather than always pushing the tongue and food out of the mouth (extrusion reflex disappears by 4–6 months)
2. A willingness to participate in the process
3. The ability to sit up with support
4. Having head and neck control
5. The need for additional nutrients.
    - o If the infant is drinking more than 32 ounces of formula or nursing 8 to 10 times in 24 hours and is at least 4 months old, then solid food should be started.

Food selection for complementary feeding

Nutritional requirements may vary from one individual to others and depends upon metabolic and genetic difference. No single food meets the essential requirements for children except mothers' milk which provides all nutritional substances to the infants till six months of age. Social and cultural influences determine dietary habits upon complementary feeding.

The child's diet should contain sufficient amount of fluids, calories, proteins, fats, carbohydrates, vitamins, minerals, and salts. Food items should be digestible palatable, attractive, choiceable and easily available

To help prevent iron deficiency, the diet should include the following:

- o iron-rich foods (meat, fish, well-cooked eggs, pulses [beans, peas, lentils], nut butters or pastes of finely ground nuts, fortified [non-organic] breakfast cereals, softened dried fruits and green vegetables).

Foods containing vitamin C will aid the absorption of iron. To help prevent iron deficiency, unmodified cow's milk should not be introduced as a main drink before 12 months of age.

There is no advantage in using follow-on formula (with a higher iron content) compared to an infant formula. However, if an infant's diet is low in iron a follow-on formula may be helpful.

Organic baby cereals are not a good source of iron since organic restrictions prevent iron fortification.

Introducing gluten between 4–7 months of age while breast-feeding may reduce the risk of coeliac disease, type 1 diabetes and wheat allergy. (Foods containing gluten are wheat, rye, barley and oats. These cereals are present in bread, wheat, some breakfast cereals and rusks)

High-allergen foods such as egg and fish do not need to be delayed until after six months as there is no evidence that this will reduce the likelihood of allergies. The risk of vitamin D deficiency between 0 and 12 months may be due to the rapid rate of bone growth. In addition, infants with dark skin who do not make enough vitamin D in their skin, or whose mothers have low vitamin D status, may also be at risk of deficiency. Vitamin A requirements are also high and about 50% of infants do not eat enough vitamin A in their food

Complimentary Feeding at different stages

Guide on quantity, variety and frequency of complementary foods

Age	Texture	Frequency	Amount of food an average child will eat in each meal
6-8 months	Start with thick porridge, well mashed food and continue with mashed family foods	2-3 meals per day plus frequent breast feeds, Depending on the child's appetite, 1-2 snacks may be offered	Start with 2-3 tablespoons per feed increasing gradually to ½ of a 250 ml cup
9-11 months	Finely chopped or mashed foods and foods that baby can pick up	3-4 meals plus breastfeeds. Depending on the child's appetite, 1-2 snacks may be offered	½ of a 250 ml cup or bowl
12-23 months	Family foods, chopped or mashed if necessary	Depending on the child's appetite, 1-2 snacks may be offered	¾ to one 250ml cup/bowl

6-9months baby

- Continued breastfeeding is recommended
- If not breastfed formula milk is the most acceptable alternative
- At 6 months introduce iron rich foods
- Introduce one new food at a time with an interval of 2-7 days before introducing another to allow the infant acquire the new taste and make it easier to identify the cause of an allergic reaction
- Start small serving sizes
- Provide complementary foods initially 2-3 times a day
- Infants will indicate hunger or satiety. Forced feeding may promote negative associations with eating
- Meal time environment should be free of distractions such as television
- Offer foods with more texture progressing from puree to mashed and then soft finger foods
- Provide vitamin A supplement (as per national guidelines)
- Coffee, tea and hot chocolate should not be given

9-12 months

- Continued breastfeeding is recommended
- Increase frequency of feeding to 3-4 times a day
- Encourage self feeding
- Include baby at table for family mealtimes
- Mealtimes should be free of distractions like TV and activities

12-18 months

- Continued breastfeeding is encouraged
- Whole cow's milk can complement breast milk
- Encourage children to feed themselves at the beginning of the meal when they are hungry but help if they tire later in the meal
- Child should be included at family meal times
- Continue to provide 3-4 meals a day with snacks in between
- By 12 months, babies should be eating a variety of foods from each of the food groups
- De-worm (as per the national guidelines)
- Development of healthy eating skills is a shared responsibility: parents/caregivers should provide selection of nutritious age appropriate foods and decide when and where food is eaten; babies and children should decide how much they want to.

Qualities of complementary food

The weaning foods should be:

- Liquid at starting then semisolid and solid foods to be introduced gradually
- Clean, fresh and hygienic so that no infections can occur
- Easy to prepare at home with the available food items and not costly
- Easily digestible, easily acceptable and palatable for the infants
- High in energy density and low in bulk viscosity and contains all nutrients necessary for the baby
- Based on cultural practices and traditional beliefs
- Well-balanced, nourishing and suitable for the infant.

Principles of introduction of weaning foods

- Breast milk remains the main food for the infant, so the additional foods should provide extra requirements
- A small amount of new foods to be given in the beginning then increased gradually in the course of the week
- New food to be placed over the tongue of the baby to get the taste of the food and to feel the consistency. A single weaning food is added at a time.
- Additional food can be given in the day time
- New foods should be given when the infant is hungry, but never force the child to take the feeds
- Observe the problems related to weaning process e.g. indigestion, pain in abdomen, weaning diarrhea, skin rash & psychological upset.
- Weaning to be started at 6 months but breastfeeding to continue up to 2years

Complications of late complementary feeding

- Delayed weaning result in malnutrition and growth failure
- Complementary feeding should not be delayed beyond six months of age as this increases the risk of nutrient and energy deficiencies
- Iron deficiency anaemia is more common in infants weaned after six months

Case study

Alex is a 12 months old baby. His birth weight was 4kg, current he weighs 15kg. His mother complains of him having poor appetite and being a poor feeder. From the 24 hr food recall the mother gives a lot of carbohydrates and less vegetables and fruits.

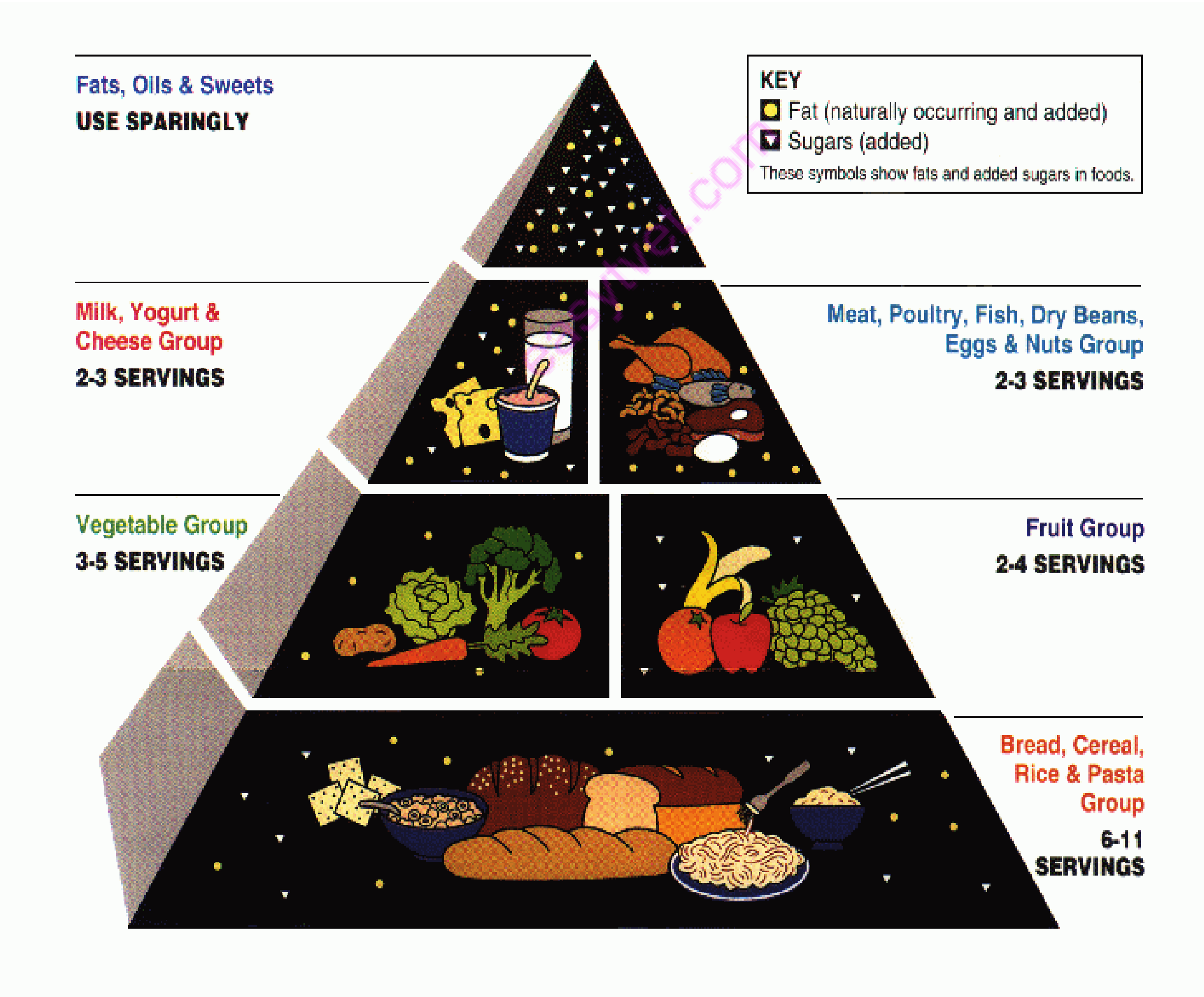
1. Determine his nutritional status ,
2. Give nutritional counselling on right choice of food with the right nutrients
3. Prepare a meal plan for Alex.

13.3.4.3 Self-Assessment

1. Define commentary feeding
2. An infant is expected to double their birth weight by;
3. 1 month of age
4. 3 months of age
5. 1 year
6. 6 months of age
7. According to WHO, infants aged 6-8 months should receive complementary foods at a frequency of
   A. 1-2 Times per day
   B. 3-4 Times per day
   C. 2-3 Times per day
   D. 6-8 times per day
8. Honey should never be given to an infant because
   A. It could be contaminated with clostridium botulinum
   B. It could be contaminated with clostridium perfringens
   C. It contains too much sugar and may cause tooth decay
   D. It may cause the infant reject other foods
9. To help prevent iron deficiency, the diet should include the following:
   A. Protein rich foods (peas, beans, maize, soy beans and milk)
   B. Juices such as black currant beverages, ribena and lucozade
   C. Iron-rich foods (meat, fish, well-cooked eggs, pulses [beans, peas, lentils], nut butters or pastes of finely ground nuts and vegetables)
   D. Foods such a crisps, candies and sodas
10. Foods rich in vitamin C support the absorption of;
    A. Iron
    B. Calcium
    C. Zinc
    D. Selenium
11. Explain the importance of continued breastfeeding for up to 2 years
12. Describe the principles of introducing complementary foods to infants
13. Discuss some of the foods which are contraindicated during complementary feeding
14. Discuss the stages of weaning, stating the types of feeds given to the infants in each stage.

13.3.4.4 Tools, Materials and resources

1. WHO guidelines
2. MOH guidelines
3. Stationery
4. Skills lab
5. Use of LCDs, video clips, charts and other teaching aids
6. Invitation of competent expertise
7. Workplace procedure manuals
8. Computers with internet
9. Library and resource centre
10. Maternal and child nutrition guidelines
11. Food pyramid guide



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13.3.5 Learning Outcome 4: Manage challenges in maternal child nutrition

13.3.5.1 Learning Activities

Learning activity	Specific instructions
i) Address macro and micro nutrients deficiency	➢ Observe client privacy ➢ Establish a good rapport with the client ➢ Counsel pregnant women about healthy eating habits that will prevent any nutrient deficiency
ii) **Monitor Food intake**	➢ Take clients diet history e.g. 24 hour food recall ➢ Apply both prospective and retrospective direct methods of dietary assessment ➢ Evaluate the client's dietary intake using the food pyramid ➢ Determine the nutrient adequacy during pregnancy
iii) Improve Quality of nutrition	➢ Advice on intake of important nutrients that are lacking in clients diet
iv) Address Food malnutrition	➢ Educate the client on possible disorders that can occur due to over taking or under taking of calories, carbohydrates, protein, vitamins or minerals
v) Control Infections	➢ Encourage primary prevention and counsel on safe sex, family planning, self-care and preparing for the future ➢ Advise pregnant mothers not to travel to regions experiencing outbreak of infections ➢ Provide mothers with deworming and information on prevention of hookworm infestations.
vi) Address Nutrition related disorders	➢ Educate on common disorders that may result from poor nutrition and how to avoid them
vii) Address Congenital disorders	➢ Advice on intake of nutrients that would cause function anomalies both to mother and child

13.3.5.2 Information Sheet

Definitions

- **Maternal child nutrition** – it refers to the first 1000 days after birth .it also focuses on 2-5 years of age and adolescents.
- **Congenital disorders**: structural or functional anomalies (for example, metabolic disorders) that occur during intrauterine life and can be identified prenatally, at birth, or sometimes may only be detected later in infancy, such as hearing defects.
- **Cretinism**: congenital disease due to absence or deficiency of normal thyroid secretion, characterized by physical deformity, dwarfism, and mental retardation, and often by goiter.

- **Cleft lip**: an opening or a split in the upper lip that occurs when developing facial structures in an unborn baby don't close completely.
- **Cleft palate**: a birth defect in which a baby's palate (roof of the mouth) doesn't form completely and has an opening in it.

Importance of promoting maternal child health

- Ensure the birth of a healthy infant and expectant mother
- To promote the healthy growth and development of children
- Ensure birth of healthy child
- Identify health problems in mother and child
- Prevent malnutrition in mother and children
- Promote family planning services
- To prevent communicable and non-communicable diseases in mother and child
- To educate the mother on improvement of their own and their children health.

Challenges facing maternal and child nutrition

- Maternal malnutrition due to inadequate food intake poor nutritional quality of diet, frequent infections and short inter-pregnancy intervals.
- High rates of HIV infections which compromise maternal nutritional status.
- Sub optimal infant feeing practices, poor quality of complimentary foods, frequent infections and micro nutrient efficiencies.

Dietary assessment for pregnant women

Assess for the following for effective counseling of the mother on her nutrition:

- Eating patterns e.g. food regularly consumed, frequency of meals
- Locally available and affordable foods
- Any existing dietary problems
- Physical activity
- Utilization of micronutrient supplements and alternative practices
- Psychosocial factors which may contribute to inadequacy of intake e.g. stigma, depression etc
- Food aversions and intolerances
- Living environment and functional status (housing, access to food, income, amenities to cook, attitude regarding nutrition and food preparation)
- Food handling practices

The following laboratory tests will also help to assess the nutritional status of a pregnant woman;

- Serum albumin
- Evaluation of anemia (Iron, Vitamin B12, and folate status)
- Urinalysis (for proteinuria)

Indicators of good nutritional status during pregnancy

The following are the signs that a pregnant is well nourished;

- Weight gain within 11.5-16kg
- Hemoglobin level $\geq$11g/dl
- Absence of clinical signs of micronutrient deficiencies

Essential Nutrition Actions include:

- Healthy Maternal Nutrition
- Exclusive Breastfeeding for Infants 0-6 months and continued breastfeeing upto 2 years
- Healthy Complementary Feeding for Children 6-35 months
- Proper Feeding a Sick Child, during and after Illness
- Control of Iodine Deficiency Disorders (IDD)
- Control of Iron Deficiency Anaemia (IDA)
- Control of Vitamin A Deficiency (VAD)

Congenital anomalies

It is estimated that 303000 neonates die within 4 weeks of birth annually, worldwide as a result of congenital anomalies. These problems can contribute to long-term disability, which may have significant impacts on individuals, families, health-care systems, and societies. Heart defects, neural tube defects and Down syndrome are among the most common severe congenital disorders. Some of the contributing factors to congenital disorders include genetic, infectious, nutritional and environmental factors. Preventive measures can be put in place such as adequate intake of folic acid or iodine through fortification of staple foods or supplementation. Some of the congenital disorders include:

- cleft lip and cleft palate
- cerebral palsy
- Down syndrome
- spina bifida
- cystic fibrosis
- heart conditions

Causes and risk factors of congenital disorders

i. Genetic factors

ii. Socioeconomic factors: could lead to a possible lack of access to sufficient, nutritious food by pregnant women, poor access to healthcare and screening.

iii. Demographic factors: maternal age is a risk factor for abnormal fetal development e.g mothers who are advanced in age may cause chromosomal abnormalities like down syndrome in the fetus

iv. Environmental factors: if a pregnant mother is exposed to certain pesticides and chemicals or even exposure to some medications, tobacco, alcohol and radiation, she has a high risk of having a neonate with congenital anomalies.

v. Infections: syphilis and rubella virus can cause congenital disorders if the mother is infected.

vi. Maternal nutritional status: an insufficiency of maternal folate can increase her risk of having a baby with neural tube defects (e.g. spina bifida and hydrocephalus) while hypervitaminiosis A may affect the normal development of the fetus.

Ways to prevent congenital anomalies

Important interventions and efforts include:

- Ensuring adolescent girls and mothers have a healthy diet including a wide variety of vegetables and fruit, and maintain a healthy weight;
- Ensuring an adequate dietary intake of vitamins and minerals, and particularly folic acid in adolescent girls and mothers;
- Counseling mothers to avoid harmful substances, especially alcohol and tobacco;
- Pregnant women (and sometimes women of child-bearing age) should avoid travelling to regions experiencing outbreaks of infections known to be associated with congenital anomalies;
- Reducing or eliminating environmental exposure to hazardous substances (such as heavy metals or pesticides) during pregnancy;
- Controlling diabetes prior to and during pregnancy through counselling, weight management, diet and administration of insulin when required;
- Ensuring that any exposure of pregnant women to medications or medical radiation (such as imaging rays) is justified and based on careful health risk–benefit analysis;
- Vaccination, especially against the rubella virus, for children and women;
- Increasing and strengthening education of health staff and others involved in promoting prevention of congenital anomalies;
- Screening for infections, especially rubella, varicella, and syphilis, and consideration of treatment.

Management of infant nutrition challenges

Spina bifida

Spina bifida is a birth defect that involves the incomplete development of the spinal cord or its covering. The term spina bifida comes from latin and literally means split or open spine. Spina bifida occurs at the first month of pregnancy when the two sides of the embryo spine fail to join together leaving an open area. In some cases the spinal cord or other membranes may push through this opening in back. The condition usually is detected before a baby is born and treated right away

Causes of spina bifida

- **Folic acid deficiency**
- Maternal diabetes
- Family history
- Obesity
- Increased body temperature from fever or external sources such as hot tubs and electric blankets may increase the chances of delivery of a baby with a spina bifida.
- Medications such as some anticonvulsants.
- Pregnant women taking Valproic acid have an increased risk of having children with spina bifida
- Genetic basis.

Types of spina bifida

There two forms of spina bifida namely **spina occulta** and **spina manifesta**

Spina difida occulta

It's the mildest form of spina bifida. Occulta means hidden, meaning that the defects is covered by skin and not open. Most children with this type of condition never have health problems and the spinal cord is often unaffected. Some can have symptoms if the hidden defect is severe enough

Spina bifida manifesta

This includes two types of spina bifida;

i. Meningocele: involves the meninges, the membranes responsible for covering and protecting the brain, and spinal cord. If the meninges push through the hole in the vertebrae (the small, ring –like bones that make up the spinal column) the sac is called a meningocele

ii. Myelomeningocele: it's the most severe form of spina bifida

    - It occurs when the meninges push through the hole in the back, and the spinal cord also pushes through
    - Most babies who are born with this type of spina bifida also have **hydrocephalus,** an accumulation of fluid in and around the brain
    - Because of the abnormal development of and damage to the spinal cord, a child with myelomeningocele typically has some paralysis.

Signs and symptoms of spina bifida

Babies who are born with spina bifida occult often have no outward signs or symptoms. The spinal cord does not protrude through the skin although a patch of hair, a birth mark or a dimple maybe present on the skin over the lower spine. But other forms of the diseases have obvious signs.

Babies who are born with the meningocele form have a fluid filled sac visible on the back.

The sac is often covered by a thin layer of skin and can be as small a grape or as large as a grape fruit. Babies with myelomingocele also have a sac-like swelling that bulge from the back but a layer of skin may not always cover it in some cases the nerves of the spinal cord maybe exposed

A baby who also has hydrocephalus will have an enlarged head, the result of excess fluid and pressure inside the skull

Nutritional therapy for spina bifida

- Before and during pregnancy a woman can help prevent spina bifida in her child
- Get plenty of folic acid each day eat foods rich in folic acid such as fortified breakfast cereals and breads ,spinach and oranges, the doctor may recommend one to take folic acid supplement
- Avoid alcohol while pregnant
- High fevers should be treated immediately
- The nutritionist may also recommend one to take folic acid supplements it's also advisable for a pregnant women to avoid alcohol

- People with spina bifida have a risk of obesity due to decreased mobility. Obesity is a major health threat and it has been linked to high blood pressure, diabetes, osteoarthritis, abnormal cholesterol metabolism and heart disease
- Foods should be eaten at regular times that are pleasant and that take enough time for individuals to eat slowly and realize when their hunger has been satisfied
- Treats and snacks should be limited to times when a little extra energy is really needed and should be both nutritionally sound and enjoyable
- Physical activity is important to burn calories and can decrease hunger

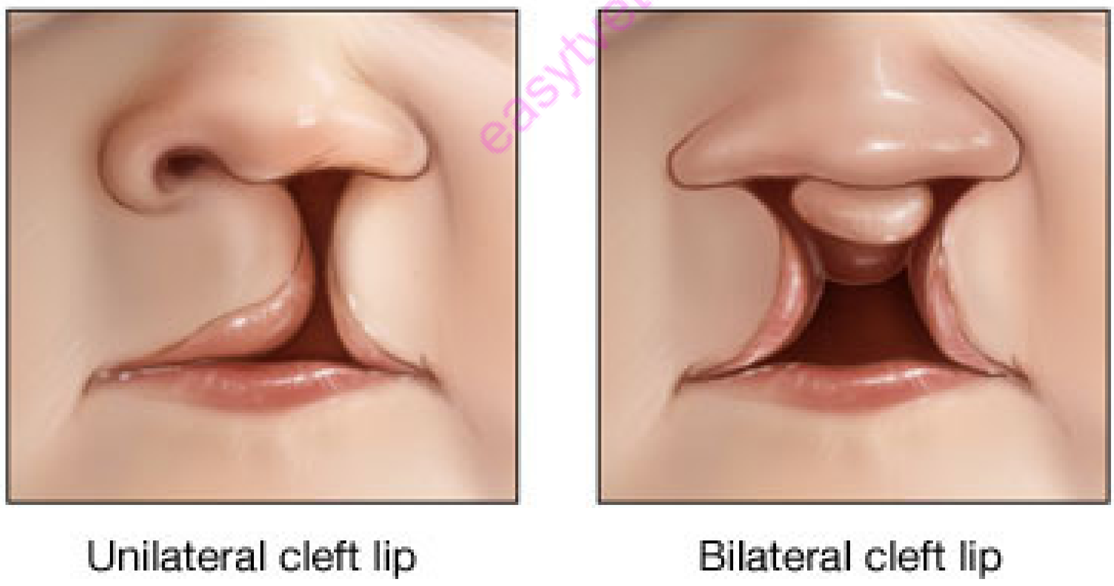
NB once people with spina bifida have become obese it's even harder for them to lose weight than it's for others. However, an individual is motivated to lose weight and limit calorie intake while increasing exercise. Weight can be reduced using a low calorie diet.

Cleft lip/palate

They are two distinct facial defects that can occur singly or in combination. They are largely caused by inadequate intake of folic acid before and during preganancy.

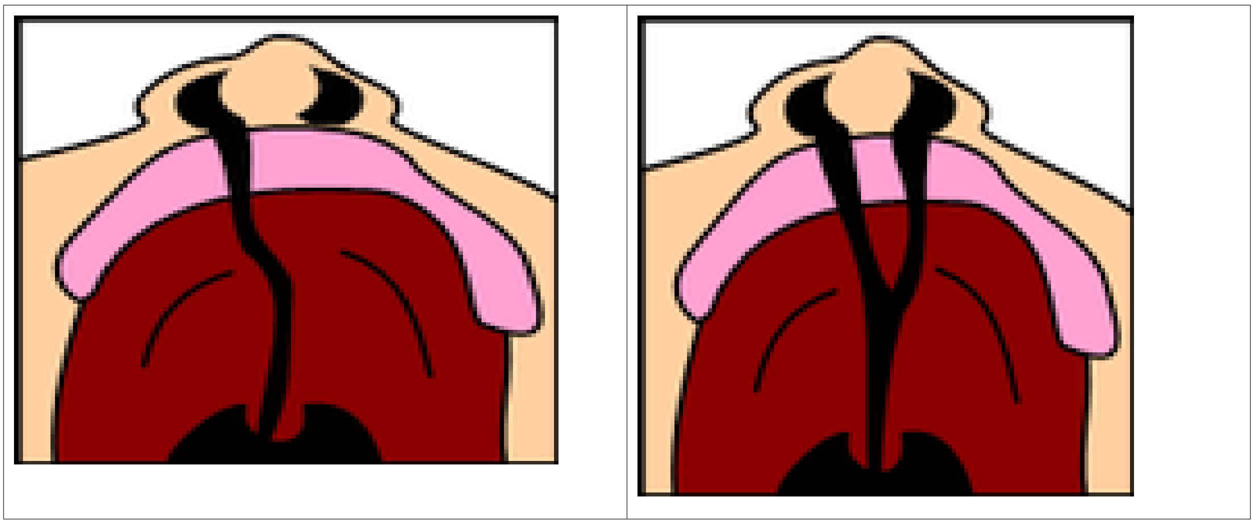
Cleft lip

Cleft lip may be unilateral or bilateral. Babies with cleft lip may also experience a cleft in the roof of their mouths (cleft palate)



Cleft palate

It can involve the hard palate (the bony front portion of the roof of the mouth) and/or the soft palate (the soft back portion of the roof).



Problems caused by cleft

- Feeding problems-foods and liquids can pass through the mouth then back through the nose
- Ear infections and hearing los
- Speech problems
- Dental problems

Prevention of cleft

- Preconception check-up
- Before pregnancy, women should take a multivitamin with 400mcg of folic acid in it every day
- During pregnancy, take prenatal vitamins with 600mcg of folic daily
- Don't smoke nor drink alcohol during pregnancy
- Get regular and prenatal care.

Feeding a child with cleft Due to lack of suction, an infant with a cleft may have trouble feeding.

Feeding should be done in a more upright position. Gravity will help prevent milk from coming through the baby's nose in case of palate. Bottle/nipple with a large hole, crosscut or slit in the nipple, protruding nipple and rhythmically squeezing the bottle insert can result controllable flow to the infant without the stigma caused by specialized equipment.

Gravity feeding equipment

The image below shows a baby being fed using a customized bottle. The upright sitting position allows gravity to help the baby swallow the milk more easily

Cretinism

This condition is also known as congenital hypothyroidism, and it occurs when the diet during pregnancy does not meet the requirements for iodine. It causes impaired neurological function, stunted growth, and physical deformities. The condition may occur because of a problem with the baby's thyroid gland, or a lack of iodine in the mother's body during pregnancy.

A baby's body needs iodine to make thyroid hormones. These hormones are essential for healthy growth, brain, and nervous system development. The child becomes severely stunted with poor physical and mental growth. It is associated with advanced age of the mother and also with late-born children.

Signs and symptoms

- Floppy infant
- Thick, increased tongue
- Poor feeding
- Constipation
- Prolonged jaundice
- Short physique
- Lack of weight gain
- Stunted growth
- Fatigue, lethargy
- Abnormal bone growth
- Excessive sleep
- Mental retardation
- Hoarse voice
- Swelling near the navel (umbilical hernia)
- Pale ski
- Swelling of the skin and neck

Etiology of cretinism

- Hypoplasia and mal-descent of thyroid
- Familial enzyme defects
- too little iodine in the mother's diet during pregnancy (endemic cretinism)
- Intake of goitrogens during pregnancy (cassava, cabbage, cruciferous vegetables, say beans, millets)
- Pituitary defects
- Idiophatic
- radioactive iodine or antithyroid treatment for thyroid cancer during pregnancy
- use of medicines that disrupt thyroid hormone production — such as antithyroid drugs, sulfonamides, or lithium — during pregnancy.

Prevention of cretinism

Consumption of the recommended dietary allowance (RDA) of 150 micrograms of iodine per day. One teaspoon of iodized salt contains about 400 micrograms of iodine.

Because an iodine deficiency in pregnancy can be dangerous to the growing baby, pregnant women are advised to get 220 micrograms of iodine daily. It is recommended that all women who are pregnant or breastfeeding take a prenatal vitamin containing at least 150 micrograms of iodine each day.

Phenylketonuria (PKU)

It is an autosomal recessive inherited disorder of amino acid metabolism that affects the body's utilization of protein. It is marked by the inability to process the amino acid phenylalanine, causing mental retardation & is caused by the absence of the enzyme phenylalanine hydroxylase. Children with PKU have a deficiency of the liver enzyme phenylalanine hydroxylase that normaly breaks down the essential amino acid phenylalanine into tyrosine. As a result, phenylalanine accumulates in the blood, causing a musty body and urine odor, irritability, vomiting, hyperactivity, seizures and eczema like rash.

Dietary management in phenylketonuria

- Diet low in phenylalanine to keep plasma phenylalanine levels between 2 and 6 mg/dl
- The diet must meet the child's need for optimal growth
- High-protein foods (meats and dairy products) are avoided and aspartame are avoided because they contain large amounts of phenylalanine.
- Elemental foods (with phenylalanine removed) can be used.
- The low-phenylalanine diet should be maintained for life
- The low phenylalanine diet is especially good for adolescent females and women prior to conception and during pregnancy to prevent congenital anomalies (low birth weight, mental retardation, microcephaly) in the fetus.

Management of maternal nutrition challenges

Maternal challenges during pregnancy are mostly related to metabolism.

a) Nausea and vomiting

Nausea refers to a feeling of a need to vomit which occurs during the first trimester of pregnancy, commonly known as morning sickness. It occurs in the morning, soon after getting out of bed, especially among primigravidas .This ends when the pregnancy proceeds to the second trimester. The suggestions to relieve nausea include;

i) Eat dry crackers or dry toast before rising

ii) Eat small, frequent meals

iii) Avoid foods with offensive odours.

iv) Avoid liquids at mealtime. Drink water or other liquids between meals to avoid dehydration and acidosis.

v) Reduce fat intake

In rare cases, the nausea persists and becomes so severe that it is life-threatening. This condition is called hyperemesis gravidarum. The mother may be hospitalized and given parenteral nutrition. This means the patient is given nutrients via a vein. This is discussed more fully in Chapter 16. Such cases are difficult, and the patients need emotional support and optimism from those who care for them.

b) Constipation

This is a common ailment caused by atonicity of the gut due to the effect of progesterone, diminished physical activity and pressure of the gravid uterus on the pelvic colon. This results in sluggish bowel function.

Constipation and haemorrhoids can be relieved by eating high-fibre foods, getting daily exercise, drinking at least 8 glasses of liquid each day, and responding immediately to the urge to defecate. The suggestions to prevent/relieve constipation include;

- Eat foods high in fiber (fruits, vegetables and wholegrains)
- Exercise regularly
- Drink at least 8 glasses of liquids a day
- Respond promptly to the urge to defecate
- Use laxatives only as prescribed by a physician; mineral oil should be avoided as it interferes with absorption of fat-soluble vitamins.

c) Acidity and Heartburn

Heartburn can result from relaxation of the esophangeal sphincter and hiatus hernia, related to progesterone. Heartburn is a common complaint during pregnancy. Heartburn results from gastroesophangeal reflux disease (GERD) in almost 10% of all gravidas. As the fetus grows, it pushes on the mother's stomach, which may cause stomach acid to move into the lower esophagus and create a burning sensation there. Heartburn may be relieved by;

- Eating small, frequent meals
- Chewing food thoroughly
- Relaxing and eating slowly
- avoiding spicy or greasy foods
- avoiding liquids with meals
- sitting up while eating (elevate the head while sleeping)
- waiting at least an hour after eating before lying down
- waiting at least 2 hours before exercising

d) Excessive salivation (ptyalism)

Increased secretion of saliva is observed during pregnancy. It may be associated with increased intake of starch, though actual cause is unknown.

Management

This problem is usually self-limiting and may be overcome by decreasing intake of carbohydrates

It is not associated with any adverse pregnancy outcome

e) Cravings (Pica) and aversions

This may be for food or non-food substances. Pica is characterized by an appetite for substances that are largely non-nutritive, such as paper, clay, metal, chalk, soil, glass, or sand.

Encourage the pregnant mother to eat small but frequent meals, offer psychosocial counseling and discourage consumption of non-food substances. These substances may lead to infections further compromising the pregnant woman's nutrition status.

f) Gastrointestinal discomfort

This is also a common complaint during pregnancy. In order to manage this condition counsel expectant mothers experiencing the condition to;

- Take small frequent meals
- Avoid hunger
- Take low fat-protein foods and simple carbohydrate foods
- Drink fluids between meals rather than with meals to avoid delayed digestion
- Avoid consumption of fried foods and spices or other foods that can lead discomfort especially gas forming foods such as beans, peas, etc
- Drink small amount of fresh fruit juice every 1 to 2 hours
- Avoid consumption of alcohol and caffeine containing beverages

g) Oedema

This is accumulation of fluids in the body. For expectant women having edema:

- Sodium restriction or diuretics are not necessary
- Where edema occurs on the legs, ensure that the mother sits with her legs placed on a raised surface

h) Excessive weight gain

When a pregnant woman has excessive weight gain, she should be advised to re-evaluate her diet and eliminate foods such as sweets, cookies, biscuits, chips, rich desserts, salad dressings and sweetened beverages. A bowl of clean, crisp, raw vegetables such as broccoli or cauliflower tips, carrots, celery, cucumber, zucchini sticks, or radishes dipped in a fat-free salad dressing or salsa can provide interesting snacks that are nutritious, filling, satisfying, and low in calories. Fruits and custards made with fat-free milk make nutritious, satisfying desserts that are not high in calories. Broiling, baking, or boiling foods instead of frying can further reduce the caloric intake.

Obesity in pregnancy

Counsel the mother on;

- Controlling kilocalorie intake by restricting fats, sugar and empty calorie intake
- Encourage regular exercise
- Discourage weight reduction regimes

i) Pregnancy induced hypertension (PIH)

This is also known as toxaemia or preeclampsia and it mostly occurs during third trimester. It is characterized by high blood pressure, the presence of albumin in the urine (proteinuria), and oedema. The oedema causes a somewhat sudden increase in weight. If the condition persists and reaches the eclamptic (convulsive) stage, convulsions, coma, and death of mother and child may occur. Pregnant adolescents have a higher rate of PIH than do pregnant adults.

j) Pica

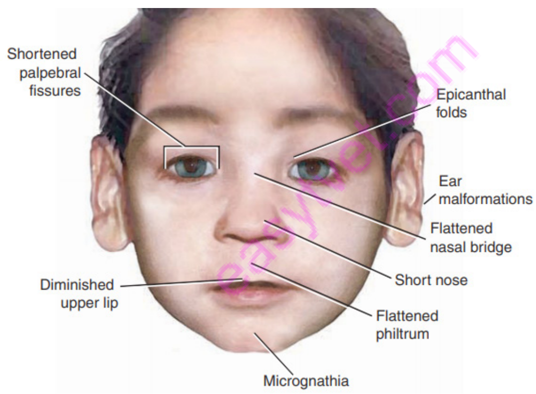
Although both men and women are affected, pica is most common among pregnant women. Some believe it relieves nausea. Others think the practice is based on cultural heritage. The consumption of soil should be highly discouraged. Soil contains bacteria that would contaminate both mother and foetus. Ingesting soil can lead to an intestinal blockage, and substances in the soil would bind with minerals, preventing absorption by the body and thus leading to nutrient deficiencies. If any of the non-food substances replaces nutrient rich foods in the diet, this will result in multiple nutrient deficiencies. Eating laundry starch, in addition to a regular diet, will add unneeded calories and carbohydrates.

k) Anaemia

The patient suffering from anaemia does not receive sufficient oxygen from the blood and consequently feels weak and tired, has a poor appetite, and appears pale. Iron deficiency is its most common form. During pregnancy, the increased volume of blood creates the need for additional iron. When this need is not met by the diet or by the iron stores in the mother's body, iron deficiency anaemia develops. This may be treated with a daily iron supplement. Folate deficiency can result in a form of megaloblastic anaemia that can occur during pregnancy. It is characterized by too few red blood cells and by large immature red blood cells. The body's requirement for folic acid increases dramatically when new red blood cells are being formed. Consequently, the obstetrician might prescribe a folate supplement of 400 to 600 µg a day during pregnancy.

l) Alcohol, caffeine, drugs and tobacco

Many infants with FAS are premature and have a low birth weight. Physical characteristics may include a small head, short eye slits that make eyes appear to be set far apart, a flat midface, and a thin upper lip. There is usually a growth deficiency (height, weight), placing the child in the lowest tenth of age norms. There is also evidence of central nervous system dysfunction, including hyperactivity, seizures, attention deficits, and microcephaly (small head).



Caffeine is known to cross the placenta, and it enters the fetal bloodstream. Birth defects in newborn rats whose mothers were fed very high doses of caffeine during pregnancy have been observed, but there are no data on humans showing that moderate amounts of caffeine are harmful. As a safety measure, however, it is suggested that pregnant women limit their caffeine intake to 2 cups of caffeine-containing beverages each day, or less than 300 mg/day. Drugs vary in their effects, but self-prescribed drugs, including vitamins and mineral supplements and dangerous illegal drugs, can all damage the fetus. Drugs derived from vitamin A can cause fetal malformations and spontaneous abortion. Illegal drugs can cause the infant to be born addicted to whatever substance the mother used and, possibly, to be born with the human immunodeficiency virus (HIV). If a pregnant woman is known to be infected with HIV, her physician may prescribe AZT in an attempt to prevent the spread of the disease to the developing foetus. Tobacco smoking by pregnant women has for some time been associated with babies of reduced birth weight. The more the mother smokes, the smaller her baby will be because smoking reduces the oxygen and nutrients carried by the blood. Other risks associated with smoking include SIDS (sudden infant death syndrome), foetal death, spontaneous abortion, and complications at birth. Smoking during pregnancy may also affect the intellectual and behavioural development of the baby as it grows up.

Dietary requirements for diabetic pregnant women

Diabetes mellitus is a group of diseases in which one cannot use or store glucose normally because of inadequate production or use of insulin. This impaired metabolism causes glucose to accumulate in the blood, where it causes numerous problems if not controlled. (See Chapter 16 for additional information on diabetes mellitus.) Some women have diabetes when they become pregnant. Others may develop gestational diabetes during pregnancy. In most cases, this latter type disappears after the infant is born; however, there is a 40% increased risk of developing type 2 diabetes later in life. Either type increases the risks of physical or mental defects in the infant, stillbirth, and macrosomia unless blood glucose levels are carefully monitored and maintained within normal limits. Every pregnant woman should be tested for diabetes between 16 and 28 weeks of gestation. Those found to have the disease must learn to monitor their diets to maintain normal blood glucose levels and to avoid both hypoglycaemia and hyperglycaemia. In general, the nutrient requirements of the pregnant woman with diabetes are the same as for the normal pregnant woman. The diet should be planned with a registered dietician or a certified diabetes educator because it will depend on the type of insulin and the time and number of injections. Clients with gestational diabetes and diabetic clients who do not normally require insulin to control their diabetes may require insulin during pregnancy to control blood glucose levels. Oral hypoglycemic agents have also been approved for use during pregnancy. Between-meal feedings help maintain blood glucose at a steady level. Artificial sweeteners have been researched extensively and found to be safe for use during pregnancy.

13.3.5.3 Self-assessment

1. Define maternal child nutrition
2. __________________ congenital disease due to absence or deficiency of normal thyroid secretion, characterized by physical deformity, dwarfism, and mental retardation, and often by goiter
    A. Cleft lip
    B. Down syndrome
    C. Cleft palate
    D. Cretinism
3. Spina bifida is a birth defect that involves the incomplete development of the ____________________
    A. Brain
    B. Spinal cord
    C. Head
    D. Bones and joints

4. The most appropriate way to feed babies born with cleft can be successfully is;
   a. Breastfeeding
   b. Bottle feeding
   c. Cup and spoon feeding
   d. Gravity feeding equipment
5. Too little intake of ______________________ in the mother's diet during pregnancy can cause cretinism
   a. Iodine
   b. Folic acid
   c. Calcium
   d. Vitamin D
6. The expectant woman having oedema can be managed by;
   a. Sodium restriction
   b. Potassium restriction
   c. Regular exercises
   d. Elevating the legs on a raised surface
7. Differentiate between cleft lip and cleft palate.
8. Explain the two types of spina bifida.
9. Outline the laboratory tests that will be helpful during the assessment of nutritional status of pregnant women.
10. State the essential nutrition actions during pregnancy.
11. Describe the dietary requirement of diabetic pregnant woman.
12. Discuss the management of the following congenital disorders:
    A. Phenylketonuria
    B. Cretinism

13.3.5.4 Tools, Materials and equipment

1. WHO guidelines
2. MOH guidelines
3. Stationery
4. Skills lab
5. Use of LCDs, video clips, charts and other teaching aids
6. Invitation of competent expertise

7. Workplace procedure manuals
8. Computers with internet
9. Library and resource centre

13.3.5.5 References

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13.3.6 Learning Outcome 5: Provide nutrient supplementation in pregnancy and childhood

13.3.6.1 Learning Activities

Learning activity	Specific instructions
i) Administer macro and micro nutrients • Review WHO guidelines	➢ Administer balanced energy and protein dietary supplementation in undernourished populations. ➢ Give iron and folic acid supplements to pregnant women ➢ Give calcium supplements to pregnant women on need basis ➢ Give vitamin A supplements to infants and children
ii) Follow IMAM guidelines	➢ Provide supplementation for children with acute malnutrition
iii) Administer therapeutic feeding Review WHO standards	➢ Prescribe therapeutic feeds based on the nutrition status ➢ Monitor weight changes during management

13.3.6.2 Information Sheet

Definitions

- **Malnutrition –** It is lack of proper nutrition, caused by not having enough to eat, not eating enough of the right things, or being unable to use the food that one does eat. It may involve calories, protein, carbohydrates, proteins or minerals
- **Micronutrient supplements:** a category of dietary supplements that contain single or multiple vitamins and minerals.
- **Dietary supplement:** a product (other than tobacco) intended to supplement the diet that bears or contains one or more of the following dietary ingredients: a vitamin; a mineral; an herb or other botanical; an amino acid; a dietary substance for use by man to supplement the diet by increasing the total daily intake; or a concentrate, metabolite, constituent, extract, or combination of these ingredients
- **F75** : Special milk for stabilization of severe malnutrition
- **F100** : Special milk for catch up growth for severe malnutrition

A. **Supplementation in pregnancy**

Globally, approximately two billion people, the majority young women and young children, are affected by micronutrient deficiencies, with even high rates during pregnancy.

Risk factors for micronutrient deficiency in pregnancy

- Poor quality diets
- High fertility rates
- Repeated pregnancies
- Short inter-pregnancy intervals
- Increased physiological needs

Indicators for malnutrition in pregnant women include:

- Weight gain of ≤11.5k
- Weight gain ≤1kg per month in the last trimester of the pregnancy
- Mid Upper Arm Circumference (MUAC)<23cm
- Hemoglobin level below 11g/dl
- Presence of goitre
- Presence of clinical signs of micronutrient deficiencies

A healthy diet contains adequate energy, protein, vitamins and minerals, obtained through the consumption of a variety of foods, including green and orange vegetables, meat, fish, beans, nuts, whole grains and fruit.In undernourished populations, balanced energy and protein. Dietary supplementation is recommended for pregnant women to reduce the risk of stillbirths and small-for-gestational-age neonates.

Iron and folic acid supplementation

Folic acid requirements increase in pregnancy because of the rapidly dividing cells in the fetus and elevated urinary losses. World Health Organization (WHO) recommends iron and folic acid supplementation in pregnant women at a dose of 30–60 mg of elemental iron plus 0.4 mg of folic acid daily.

Daily oral iron and folic acid supplementation with 30 mg to 60 mg of elemental iron and 400 g (0.4 mg) of folic acid is recommended for pregnant women to prevent maternal anaemia, puerperal sepsis, low birth weight, and preterm birth. The equivalent of 60 mg of elemental iron is 300 mg of ferrous sulfate hepahydrate, 180 mg of ferrous fumarate or 500 mg of ferrous gluconate. Folic acid should be commenced as early as possible (ideally before conception) to prevent neural tube defects.

Intermittent oral iron and folic acid supplementation with 120 mg of elemental iron (The equivalent of 120 mg of elemental iron equals 600 mg of ferrous sulfate heptahydrate, 360 mg of ferrous fumarate or 1000 mg of ferrous gluconate) and 2800g (2.8 mg) of folic acid once weekly is recommended for pregnant women to improve maternal and neonatal outcomes if daily iron is not acceptable due to side-effects, and in populations with an anaemia prevalence among pregnant women of less than 20%.

Calcium supplementation

In populations with low dietary calcium intake, daily calcium supplementation (1.5–2.0 g oral elemental calcium) is recommended for pregnant women to reduce the risk of pre-eclampsia

Vitamin A supplementation

Vitamin A supplementation is only recommended for pregnant women in areas where vitamin A deficiency is a severe public health problem, to prevent night blindness.

Vitamin A deficiency is a severe public health problem if > 5% of women in a population have a history of night blindness in their most recent pregnancy in the previous 3–5 years that ended in a live birth, or if > 20% of pregnant women have a serum retinol level

Micronutrient supplementation for pregnant and lactating mothers

Micronutrient	Target group	Dosage	Frequency	Timing and schedule
Vitamin A	Pregnant	-	-	-
	Lactating	200,000IU	Single dose	At delivery (should be given within 4 weeks of delivery)
Folic acid	Pregnant	400 µg/0.4mg	Daily throughout pregnancy	From first month of pregnancy or on 1^{st} contact
	Lactating	280 µg		
Iron	Pregnant	60mg	Daily throughout pregnancy (critical for the first 90 days of pregnancy)	From first month of pregnancy or on 1^{st} contact
	Adolescent and adults including pregnant women with anaemia	120mg	Daily	3 months

Source: The Kenya National Technical Guidelines for Micronutrient Deficiency Control (2008)

B. **Supplementation for infants and children**

Vitamin A supplements should be administered to infants from 6months and after every 6 months

Age	Dosage
<6 months	50,000 IU
6-12 Months	100,000 IU
>12 Months	200,000 IU

Supplementation for severely malnourished children

- **Vitamin A Supplementation**

F75, F100, RUTF and locally-developed milk with CMV provide the adequate amount of Vitamin A to manage mild Vitamin A deficiency and to replace low liver stores of Vitamin A during treatment.3 However, many malnourished patients have a serious Vitamin A deficiency, therefore:

- Administer a dose of Vitamin A to all new admissions except:
    - Patients who have received Vitamin A within the last month, or
    - For children admitted with oedema:
        - administer a single dose of Vitamin A at discharge from in-patient facility after completion of Phase 2, or
        - Administer a single dose of Vitamin A on week four of OTP management, when the patient is transferred form in patient to outpatient care.
- If patient has signs of severe vitamin A deficiency (clinical signs such as night blindness, conjunctival xerosis with Bibot's spots, corneal xerosis or ulseration or keratomalacia), give a dose of vitamin A according to Table 1, for two consecutive days, followed by an additional dose two weeks later.
- Administer a dose of Vitamin A to all in-patients on the day of discharge4 (i.e. completion of Phase 2). For patients managed at OTP, including those transfered from in-patients, administer a dose of vitamin A at week four after admission.

Vitamin A systemic treatment

Age	Vitamin A/IU orally on Day 1
6 to 12 months	1 blue capsule 100,000IU=30,000ug
12 months and older	2 blue capsules 200,000IU=60,000ug

Folic Acid

There is sufficient folic acid in F75, F100 and RUTF to treat mild folate deficiency. If a patient shows clinical signs of anaemia give 5mgs of folic acid. Moderate Anaemia is identified by palmer paler (very pale palms of the hands), and/or check conjunctiva colour. A very pale conjunctiva is a sign of moderate or severe anaemia.

- **Iron Supplementation**

High-dose iron tablets are contraindicated as they can increase the risk of severe infection in severe acute malnourished patients due to the presence of free iron in the blood.

If moderate anaemia is identified: For in-patients receiving entire treatment of acute malnutrition in the in-patient health facility: Add iron to the F100 in Phase 2.

Supplemental Suckling Technique

The supplementation is given using a tube the same size as n°8 NGT (a size n°5 tube can be used, but the milk should be strained through cotton wool to remove any small particles that would block the tube). Cut the tip of the NG tube back beyond side ports on the tube, if these ports exist

1. F100 Diluted or formula milk is put in a cup. The mother holds it.
2. The end of the tube is put in the cup.
3. The tip of the tube is put on the breast at the nipple and the infant is offered the breast in the normal way so that the infant attaches properly. Sometimes at the beginning the mothers find it better to attach the tube to the breast with a piece of tape.
4. When the infant suckles on the breast with the tube in his mouth, the milk from the cup is sucked up through the tube and taken by the infant. It is like taking a drink through a straw.
5. At first an assistant needs to help the mother by holding the cup and the tube in place. She encourages the mother confidently. Later the mother nearly always manages to hold the cup and tube without assistance.
6. At first, the cup should be placed at about 5 to 10cm below the level of the nipple so the milk does not flow too quickly and distress the infant, and so the weak infant does not have to suckle excessively to take the milk. As the infant becomes stronger the cup should be lowered progressively to about 30cm below the breast.
7. The mother holds the tube at the breast with one hand and uses the other for holding the cup.

This infant is suckling the breast and also getting the F100 Diluted (130ml/kg/day) by the Supplemental Suckling (SS) technique.
Raising or lowering the cup determines the ease with which the infant gets the supplement: for very weak infants it can be at the level of the infant's mouth. If it is above this level the feed can go into the child by siphonage when there is a danger of aspiration

Supplemental Suckling Technique

Notes:

- It may take one or two days for the infant to get used of the tube and the taste of the mixture of milks, but it is important to persevere.
- By far the best person to show the mother the technique is another mother who is using the technique successfully. Once one mother is using the SS technique successfully the other mothers find it quite easy to copy her.

- The mother should be relaxed. Excessive or officious instructions about the correct positioning or attachment positions often inhibit the mother and make her think the technique is much more difficult than it is. Any way in which the mother is comfortable and finds that the technique works is satisfactory.
- If the formula diet is changed then the infant normally takes a few days to become used to the new taste. It is preferable to continue with the same supplementary diet throughout the treatment.

Nutrition supplements

It is important to have set standards for commercial nutritional supplements for health facilities, to ensure that the supplements procured provide considerable contribution to the nutritional status of the patients/clients. The table below provides a summary of the basic requirements of commercial supplements.

Basic Requirements for Commercial Nutritional Supplements for Hospitals

Type of Nutritional Supplement.	Basic requirements.
Nutritionally complete liquid diets.	Approximately 1 Kcal per ml; 3.8-4.4gm protein per 100 ml; Shelf life of >1yr. Feed with fiber for diabetic pts. High energy protein drink with hydrolyzed protein for pts with GIT disturbances to provide 1.2kcal/ml and 3.5-4.0 gm protein per 100ml The drink should also be milk protein free, fat and lactose free and gluten free. In assorted flavors.
Preterm and low birth weight infant formula.	13-15gm protein per 100g powder; 54-56 gm CHO per 100g powder; 23-25gm fat per 100g powder; Shelf life of >1yr.
Infant formula for infants of normal weight (above 2,500gm) aged below 6 months.	11-12gm protein per 100g powder; 56-58gm CHO per 100g powder; 25-28gm fat per 100g powder; Whey predominant with lactose as carbohydrate source; Shelf life of >1yr.
Pediatric nutritionally complete diet for children 1-10 years.	3.0-4.0 gm protein per 100 ml; 10-20gm CHO per 100ml; 5-7gm fat per 100ml; Enriched with vitamins and minerals; Shelf life of >1yr.
Follow-up infant formula for children above six months with probiotics and iron.	2.2-2.7gm protein per 100 ml; Casein predominant; shelf life of >1yr.
Nutritionally complete balanced diet for Enteral and oral use.	Low osmolarity and isocaloric feed, enriched with insoluble and soluble fiber; 35-40gm protein per liter; 120-190gm CHO per liter; 25-40gm fat per liter; Enriched with micronutrients. Shelf life of >1yr.

Nutritionally complete balanced diet for Enteral tube or oral feeding of patients with hyperglycemia.	• Isocaloric diet enriched with fiber • 0.9-1kcal/ml • 35-40gm protein per liter • 80-115gm CHO per liter • 40-45gm fat per liter • Shelf life of >1yr
High protein and energy sip feed for catabolic patients.	• 8-10gm protein per 100 ml • 1.5-1.7kcal/ml • Shelf life of >1yr
Breast milk fortifier for premature or low birth weight infants.	• To provide 350-400 kcal • 20-25gm protein per 100gm powder • 65-70gm CHO per 100gm powder • Shelf life of >1yr

Care of the mother

The mother who is admitted in the centre with her child receives Vitamin A:

A. If the child is below 1 month old 200.000IU (there should be no risk of pregnancy)

Micronutrients' supplementation must also be given to the mother. The quality of the milk depends upon the mother's nutritional status. It is critical that the mother receives meals while the child is an in-patient. The mother's diet is important for the recovery of the infant from malnutrition.

Therapeutic feeds

There are two main therapeutic feeds used in management of malnourished clients

- F75
- F100
- Ready to use therapeutic foods (RUTF)

1. F75

The formula is used during phase 1 treatment of patients who are initially admitted to an in-patient facility without an adequate appetite and/or a major medical complication. It provides 75kcal for every 100ml of milk and is used during stabilization phase.

This formula (F75) promotes recovery of normal metabolic function and nutrition-electrolytic balance. In Phase 1, the patient receives F75 formula at 100kcal/ kg/day. Rapid weight gain at this stage is dangerous, that is why the quantities and formula are formulated so that patients do not gain weight during this stage. The patient remains in Phase 1 until the medical complications stabilize and until the appetite improves and the patient completes the designated quantity of F75 or equivalent diet at each mealtime.

The milk diet is given at regular intervals throughout the day (approximately every two to three hours). The quantity required for each 24 hour period is determined by the child's weight. To determine the amount per feed, divide the 24-hour required quantity by the number of feeds per day.

In Phase 1 the number of daily feeds is determined by the following:

- In 24-hour care with sufficient trained staff to prepare and distribute the feeds overnight give: eight (8) feeds per day.
- If night feeds are problematic (e.g. limited night staff available for feeds, lack of kitchen equipment) give: five to six (5-6) feeds per day. For example, every three hours from 6am to 9pm.1
- For daycare situations: five to six (5-6) feeds during the day

For severely malnourished patients with severe oedema (+++), reduce the quantity of F75 by up to 20% until the oedema begins to subside.

Quantity of F75 or prepared milk to give during Phase 1, per kg of body weight

Class of Weight (kg)	8 feeds per day (ml for each feed)	6 feeds per day (ml for each feed)	5 feeds per day (ml for each feed)
2.0 to 2.1 kg	**40 ml per feed**	**50 ml per feed**	**65 ml per feed**
2.2 - 2.4	45	60	70
2.5 - 2.7	**50**	**65**	**75**
2.8 – 2.9	55	70	80
3.0 - 3.4	**60**	**75**	**85**
3.5 – 3.9	65	80	95
4.0 – 4.4	**70**	**85**	**110**
4.5 – 4.9	80	95	120
5.0 – 5.4	**90**	**110**	**130**
5.5 – 5.9	100	120	150
6 – 6.9	**110**	**140**	**175**
7 – 7.9	125	160	200
8 – 8.9	**140**	**180**	**225**
9 – 9.9	155	190	250
10 – 10.9	**170**	**200**	**275**
11 – 11.9	190	230	275
12 – 12.9	**205**	**250**	**300**
13 – 13.9	230	275	350
14 – 14.9	**250**	**290**	**375**
15 – 19.9	**260**	**300**	**400**
20 – 24.9	290	320	450
25 – 29.9	**300**	**350**	**450**
30 – 39.9	320	370	500
40 – 60	**350**	**400**	**500**

Breastfed children are always offered breast milk before the diet, and always on demand.

- **Preparation of F75**

If F75 is available, add one packet (410g) of F75 to two (2) litres of water. (Water must be boiled and cooled prior to mixing.) If five or less children are being treated for severe acute malnutrition, less quantities of F75 milk are necessary. Smaller volumes can be mixed using the red scoop (4.1g) included with the F75 package (20 ml water per red scoop/4.1g of F75). Prepare enough milk for the next three hours, not longer, to assure that it will not spoil. If there is access to a refrigerator, milk can be stored for a maximum of 12 hours. When F75 is not available, refer to IMAM guidelines for alternative recipes.

Quantity of F75 or prepared milk to give during Phase 1, per kg of body weight

Class of Weight (kg)	8 feeds per day (ml for each feed)	6 feeds per day (ml for each feed)	5 feeds per day (ml for each feed)
2.0 to 2.1 kg	**40 ml per feed**	**50 ml per feed**	**65 ml per feed**
2.2 - 2.4	45	60	70
2.5 - 2.7	**50**	**65**	**75**
2.8 – 2.9	55	70	80
3.0 - 3.4	**60**	**75**	**85**
3.5 – 3.9	65	80	95
4.0 – 4.4	**70**	**85**	**110**
4.5 – 4.9	80	95	120
5.0 – 5.4	**90**	**110**	**130**
5.5 – 5.9	100	120	150
6 – 6.9	**110**	**140**	**175**
7 – 7.9	125	160	200
8 – 8.9	**140**	**180**	**225**
9 – 9.9	155	190	250
10 – 10.9	**170**	**200**	**275**
11 – 11.9	190	230	275
12 – 12.9	**205**	**250**	**300**
13 – 13.9	230	275	350
14 – 14.9	**250**	**290**	**375**
15 – 19.9	**260**	**300**	**400**
20 – 24.9	290	320	450
25 – 29.9	**300**	**350**	**450**
30 – 39.9	320	370	500
40 – 60	**350**	**400**	**500**

2. F100

This formula replaces F75 as the patient's diet is increased from 100kcal/kg/day to 130kcal/kg/day for children. It provides the client with 100kcal for every 100ml of milk and is used during the transition phase of management of SAM. The quantity of milk remains the same as with F75, but the calorie content changes by changing milk formulas from 75kcal to 100kcal per 100ml of milk. The patient in Transition Phase receives around 30% more calories than when in Phase 1. Daily weight gain can be expected at about 6gm/kg/day. For example, a child who weighs 4kg should gain about 24g a day.

The formula should be administered for two to three days when patients have a good appetite; are tolerating the diet given; have no major medical complications; and oedema is resolved. The patient then moves to phase 2.

- **Preparation of F100**

Prepare F100 by adding a sachet of F100 milk powder to two (2) litres of boiled cooled water. If small quantities of milk are required (few children in need of nutritional rehabilitation), add one (1) red scoop (4.1g) powder milk to 18ml boiled and cooled water. For small quantities of locally made-up milk see recipes in IMAM guidelines

Quantity of F100 to give during Transition Phase, per kg of body weight

Class of Weight (kg)	8 feeds per day	6 feeds per day	5 feeds per day
Less than 3kg	F100 full strength should not be given. Only F100 Diluted is given.		
3.0 to 3.4 kg	**60 ml per feed**	**75 ml per feed**	**85 ml per feed**
3.5 – 3.9	65	80	95
4.0 – 4.4	**70**	**85**	**110**
4.5 – 4.9	80	95	120
5.0 – 5.4	**90**	**110**	**130**
5.5 – 5.9	100	120	150
6 – 6.9	**110**	**140**	**175**
7 – 7.9	125	160	200
8 – 8.9	**140**	**180**	**225**
9 – 9.9	155	190	250
10 – 10.9	**170**	**200**	**275**
11 – 11.9	190	230	275
12 – 12.9	**205**	**250**	**300**
13 – 13.9	230	275	350
14 – 14.9	**250**	**290**	**375**
15 – 19.9	260	300	400
20 – 24.9	**290**	**320**	**450**
25 – 29.9	300	350	450
30 – 39.9	**320**	**370**	**500**
40 – 60	350	400	500

Warning: F100 is never given out for use at home. It is always prepared and distributed in an in-patient unit. F100 is not kept in liquid form at room temperature for more than three hours before it is consumed.

3. Ready to use therapeutic food (RUTF)

This formula is administered in Phase 2 during treatment of SAM when the patient is expected to receive F100 at 200kcal/kg/day or the equivalent in the form of RUTF. Those formulas are designed for patients to rapidly gain weight (more than 8g/kg/ day). Recovered patients are discharged for supplementary feeding if available at the nearest health facility.

Initially RUTF and F100 meals can alternate with RUTF given every other feed (20g of RUTF is equivalent to 100ml of F100). If the RUTF is tolerated, the patient's diet changes to RUTF for the remainder of Transition Phase. Patients may initially refuse RUTF. If this is the case, give the patient the F100 diet and offer RUTF again the next day. Discharge to out-patient treatment of acute malnutrition is only advised when the patient tolerates at least 75% of the amount of RUTF calculated for the individual child

- **Administration of RUTF**

Children who are not taking 75% RUTF are given F100 to make up any deficit in intake. No other food is given to the patient during this period. Patients should drink as much clean water as possible while taking and after consumption of RUTF. If both F100 and RUTF are being given they can be substituted on the basis that about 100ml of F100 = 20g of RUTF.

Quantity of RUTF to give during transition phase, per kg of body weight

Class of weight (kg)	RUTF (Plumpy'nut®)	
	sachet per day	sachets per week
3.0 - 3.4	1 ¼	8
3.5 - 4.9	1 ½	10
5.0 – 6.9	2	15
7.0 – 9.9	3	20
10.0 - 14.9	4	30
15.0 – 19.9	5	35
20.0 – 29.9	6	40
30.0 - 39.9	7	50
40 - 60	8	55

Case study

Mercy, a 14 months old baby has been brought to the MCH for the routine growth monitoring by her mother. She was born at term weighing 3.1kg. She weighs 5 kg, 62 cm long and has a MUAC reading of 9cm. The mother reports that Mercy received vitamin A supplementation once, at 6 months. Upon examination, you confirm that Mercy has severe acute malnutrition. Describe how you will manage Mercy's case.

13.3.6.3 Self-Assessment

1. Define the following terms
   A. Supplementation
   B. F75
   C. F100
2. The following are risk factors for micronutrient deficiency. Which one is not?
   A. Poor quality diets
   B. High mortality rate
   C. Repeated pregnancies
   D. Increased physiological needs
3. ____________________ requirements increase in pregnancy because of the rapidly dividing cells in the fetus and elevated urinary losses.
   A. Calcium
   B. Vitamin a
   C. Proteins
   D. Iron and folic acid
4. The following supplements should be provided to during pregnancy (indicate true/false for each)
   A. Vitamin A
   B. Vitamin D
   C. Folic Acid
   D. Calcium
5. The dosage of vitamin A that should be administered to infants <6 months is
   A. 10,000 Iu
   B. 100, 000 Iu
   C. 200,000 Iu
   D. 50,000 Iu
6. The ratio of mixing F75 with water is____________
   A. 410G to 1 litre of water
   B. 205G to 1 litre of water
   C. 4.1 G to 20 ml water
   D. 2.05g to 20 ml water

7. Explain why pregnant mothers should be supplemented with folic acid
8. Why is vitamin A supplementation contraindicated during pregnancy?
9. Describe the conditions that will necessitate SAM patient to be moved from stabilization phase to transition phase of treatment.
10. Illustrate the WHO recommendations on vitamin A supplementation in infants and children

13.3.6.4 Tools, Equipment, Supplies and Materials

a. Medicines and medical equipment including antibiotics, anthelminitics, minerals and vitamins, NG tubes.
b. Therapeutic milks (F75, F100) or the ingredients required to produce locally-made milks including combined mineral vitamin mix (CMV).
c. Anthropometric equipment: height board, salter scales, infant scales, MUAC tapes, baby scales.
d. Laboratory and diagnostic services is important but not essential.
e. WHO Guidelines
f. MOH Guidelines
g. Stationery
h. Skills lab
i. Use of LCDs, video clips, charts and other teaching aids
j. Invitation of competent expertise
k. Workplace procedure manuals
l. Computers with internet
m. Library and resource centre

13.3.6.5 References

1. The Kenya National Technical Guidelines for Micronutrient Deficiency Control (2008)
2. *https://cdn2.sph.harvard.edu/wpcontent/uploads/sites/32/2018/04/2016WHOAntenatalCareGuidelines-1.pdf*
3. MOH. (2009). *National Guideline for Integrated Management of Acute Malnutrition.*

13.3.7 Learning Outcome 6: Document maternal and child nutrition care

13.3.7.1 Learning Activities

Learning Activities	Specific instructions
i) Obtain mother baby booklet	➢ Check weight and height plotting for growth monitoring
ii) Avail MOH registers	➢ Match each MOH register with its purpose

13.3.7.2 Information Sheet

Definitions

The Maternal and Child booklet; a hand book containing information on safe pregnancy, delivery and child health; and meanwhile serves as a health record.

The Maternal and Child Health Booklet is a revised version and combination of the Antenatal card and Child Welfare Card. The first part contains the mother's full antenatal and post natal profile:

i) ANC

ii) Postnatal

iii) Second part contains the child's details on immunizations and other services delivered to a child before age 5 years that will be detached from the booklet.

In case of multiple deliveries the health worker should initiate a booklet for each child. The health worker is advised to be extra careful while filling the information in the booklet by ensuring that correct information is recorded in the appropriate spaces provided. The growth monitoring charts should be marked progressively as the child grows. Health workers are advised to share the information pertaining to the child with the mother or care taker.

Mother & Child Health Booklet was developed to help relate mothers' obstetrical history to infants' healthcare providers to facilitate follow-up and timely management.

Pregnant women receive the Mother & Child Health Booklet at their first antenatal care (ANC) visit, use it for home reference, and share information with families during pregnancy and child rearing. For healthcare personnel, the booklet is a critical health record, documenting and monitoring the services provided, a point-of-care information resource enhancing clinical decision-making ability, and helping clients understand takeaway messages.

The booklet contains information on the mother's pregnancy, delivery and postpartum course and her child's growth and development, immunization, nutrition and other data need to monitor the child to 5 years of age. It replaced three separate record clinical cards. . It ensures continuity of care and provides health education to parents. As such it has proven to be an effective tool in promoting and protecting the health of mothers and children.

The components of maternal & child health include:

i) maternal care during pregnancy and childbirth (tetanus toxoid injections; ANC appointments; professional delivery care);

ii) childcare (vitamin A intake);

iii) feeding practices (exclusive breastfeeding for 6 months, complementary feeding after 6 months); and

iv) anthropometric measurement of child and mother- hence used as an instrument for growth monitoring

MOH registers

The ministry of medical services has the following data collection and reporting tools which are used during maternal, infant and child health care;

a) Registers

Antenatal Care Register	MOH 405
Child welfare clinic Register	MOH 511
Family planning service Register	MOH 512
Maternity Register	MOH 333
Immunization permanent Register	MOH 510
Post natal Care Register	MOH 406

b) The ministry also does have **summary forms** such as Immunisation services uptake summary (MOH710) and Integrated Reproductive and Child Health Summary (MOH 711).

c) Tally sheets that are used in the MCH clinic include

i)	OPD summary for under 5 years	(MOH 701A)
ii)	OPD summary for over 5 years	(MOH 701B)
iii)	Immunisation tally sheets	(MOH 702)
iv)	CHANIS Tally sheet	(MOH 704)

GENERAL GUIDELINES FOR FILLING THE SUMMARY FORMS:

1. The first step in completing data reporting forms is to ensure that all the identification particulars are filled in before completing the particular form. These are the names of the province, district, constituency, facility and the period for which the report is covering.
2. Specific ages should be reported within the appropriate age classification.
3. In forms where data is disaggregated by sex, the appropriate data should be filled in the correct column or spaces provided.

4. Care must be taken to separate new or first visits and re-visits or re-attendances. . Note: New or first visit –these are patients/clients who come to your facility for the First time. While Revisit or Re-attendance- these are patients/clients who make subsequent return visits after the first visit.
5. Where there is a provision to show totals, they MUST be aggregated.
6. While making entries in the forms, accuracy MUST be maintained to avoid errors or transposition of figures.
7. While reporting, completeness MUST be observed. No spaces should be left blank and no dashes. You are instead encouraged to practice zero reporting.
8. The name of person preparing the report, the date the report is being completed and the commitment signature MUST be filled in.
9. Once the reports are completed, they are supposed to leave your facility before the 5th of the following month to the District Health Information System (DHIS).
10. At the district, once all the reports from the health facilities have been received, summaries should be promptly made.
11. The district MUST maintain a checklist of all reports and all facilities and check the reports against the facilities to ensure completeness and timeliness.
12. Using a copy of the summaries made, districts MUST analyze and share the information at their level.
13. Districts should submit the summaries to the province or national level on or before 15th of the following month and give feedback to the health facilities. Health Sector Indicator and Standard Operating procedures manual for Health workers May 2008 57
14. The province collects all the district reports, make copies (manual or electronic) do the analysis and use the information as they make arrangement to transmit the summaries to the national level before 21st of the following month if data flows through the province inform of hard copies.
15. Likewise, provinces should make and maintain a checklist of the reports and districts to ensure timeliness and completeness. They must give feedback to the districts and share the report at that level.
16. To maintain accuracy in recording data collected through tally sheets, health workers should tally from the registers on daily basis.
17. The national level data repository (HIS) should acknowledge receipt, process and analyze the data and give feedback to the lower levels and share the information horizontally and vertically.
18. All levels are encouraged to prepare annual reports that will encompass all activities, outputs and in-puts.
19. For communicable diseases that are for immediate reporting, such should be reported without further delay using the appropriate tools and channels for example using case based investigation forms.
20. Using the File Transfer Protocol (FTP), the district should upload their data to the FTP site on or before 15th of the following month.

How to handle the tally sheets

Tally sheets are working sheets on which data is recorded to facilitate ease of count at the time of making summaries. Proper understanding of the content of each tally sheet is essential. The proper way of making a tally is to slash a zero with forward slash (Killing one zero at ago) for example 0 Tallies are normally made immediately a clinician is through with a patient/ client before attending to the next and at the end of the day or early next morning from the register. This depends on circumstances at the facility.

How to handle the Summary sheets

Summary sheets will be completed at the end of the specified period, either from tally sheet or registers or any other source documents. As the health facility submits the summaries to the next level, a copy must remain in the health facility.

For more details on and samples of the data collection and reporting tools, visit *http://publications.universalhealth2030.org/uploads/moh_health_indicator_manual_2008.pdf*

13.3.7.3 Self-Assessment

1. What do you understand by the term tally sheet?
2. The following details are found within section 1 of the mother and child health booklet (indicate true/false)
   A. Anc
   B. Delivery
   C. Postnatal care
   D. Child's details on immunization
3. Match the following MOH registers with their titles

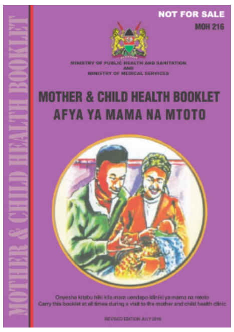
MOH 511	Maternity register
MOH 510	Antenatal Care register
MOH 333	Child welfare clinic register
MOH 405	Immunization permanent register

4. ________________ is the tally sheet found in the MCH department which covers the OPD summary for over 5 years
   A. MOH 701A
   B. MOH701B
   C. MOH 702A
   D. MOH 702B

5. Once reports are completed, they should leave the specific facility to;
    A. DHIS
    B. MOH
    C. Office of director of medical services
    D. Archives
6. State the components of maternal and child health booklet
7. Which is the first step in completing data reporting forms?
8. Discuss how tally sheets are handled

13.3.7.4 Tools, Equipment, Supplies and Materials

1. WHO guidelines
2. MOH guidelines
3. Stationery
4. Skills lab
5. Use of LCDs, video clips, charts and other teaching aids
6. Invitation of competent expertise
7. Workplace procedure manuals
8. Computers with internet
9. Library and resource centre
10. Mother and child health booklet



Various MOH registers

Tally sheets

Sample summary sheets

13.3.7.5 References

1. *http://www.mchhandbook.com/mchhandbooks/*

2. *http://kenbright.co.ke/downloads/Mother%20%20Child%20Health%20 Handbook%20MOH%2016032017.pdf*

3. *https://academic.oup.com/jpubhealth/article/41/1/170/4793391*

4. *http://publications.universalhealth2030.org/uploads/moh_health_indicator_ manual_2008.pd*

CHAPTER 14:

NUTRITION EDUCATION AND COUNSELLING

14.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to manage nutrition and dietetic services It includes: assessing concepts of counselling, evaluating patients' response to nutritional care plan, exploring dietary modifications and supporting the client with acceptance of nutrition care plan

14.2 Performance Standard

By the end of this unit of learning/competency, the trainee should demonstrate ability to assess concepts of counselling as per workplace procedures; observe ethical principles of counselling in line with workplace policy; evaluate patient's response to nutrition care plan based on workplace policy; interpret nutrition assessment data and explore dietary modifications in accordance with SOPs and workplace procedures; and, support the client to accept nutrition care plan as per the workplace policy and SOPs.

14.3 Learning Outcomes

14.3.1 List of the Learning Outcomes

1. Asses concepts of counselling
2. Evaluate patients' response to nutritional care plan
3. Explore dietary modifications
4. Support the client with acceptance of nutrition care plan

14.3.2 Learning Outcome 1: Assess concepts of counselling

14.3.2.1 Learning Activities

Leaning activity	Special instructions.
i) Identify nutritional counselling techniques	➢ Listen to understand client's messages ➢ Seek clarification ➢ Provide personal support to the client ➢ Create a partnership with the client ➢ Direct client on relevant activities ➢ Advice on appropriate course of action ➢ Provide feedback
ii) Identify nutritional counselling environment • Identify appropriate communication method • Identify communication barriers • Identify appropriate teaching resources/materials	➢ Establish counselling environment ➢ Create client rapport ➢ Decode non-verbal communication
iii) Observe ethical principles of counselling	➢ Respect client privacy ➢ Demonstrate empathy ➢ Maintain confidentiality ➢ Avoid harm to the client ➢ Provide fair and impartial service ➢ Foster self-knowledge and care for self ➢ Demonstrate honesty ➢ Promote client's autonomy

14.3.2.2 Information Sheet

Definitions

Nutrition education: any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food- and nutrition-related behaviours conducive to health and well-being.

Nutrition counselling: The process of guiding a client towards a healthy nutritional lifestyle by meeting normal nutritional needs and solving problems that are a barrier to change.

Goal of Nutrition Counselling

The ultimate goal of nutrition counselling is to enable the client to take suitable action for a healthier lifestyle and promote self-reliance.

Importance of nutrition counselling

Nutritional counselling helps people to;

- Set achievable health goals
- Maintaining the goals throughout their lifetime.
- It reduces susceptibility to illness and disease

Nutrition Counselling Techniques

Clarification: A counsellor should ask for clarification on information provided by the client. This ensures accuracy and prevents assumptions and misunderstandings.

Encouraging: This technique helps build client confidence and fosters respect. It helps the client to see their strengths, which is helpful motivation in behaviour change.

Listening Skills: The counsellor should show attentiveness while the client is speaking. This technique should be matched by appropriate body language.

Paraphrasing: This technique confirms to the client that the counsellor is being attentive. It is also a good way to clarify information.

Working Alliance: A counsellor should seek to create a working partnership with the client. The client is actively involved in decision making and this is also a form of encouragement that they are capable of providing solutions to their own problems.

Self-Disclosure: This technique involves the counsellor sharing their personal experiences or thoughts on the issue. This helps improve the clients' emotional state and can also be a source of motivation.

Counselling environment and requirements

Choosing a suitable counselling environment is a vital step in counselling. An appropriate environment fosters efficiency and efficacy of the counselling sessions.

Characteristics of a Good Counselling Environment:

The counselling environment should be;

- welcoming (e.g. greet clients appropriately, show them where to sit)
- Comfortable (e.g. have comfortable seats, sit at the same level as the client)
- A place with minimal distractions
- A place where privacy and confidentiality can be maintained (no other people around)
- Non-threatening (e.g. a place where people can feel relaxed and comfortable).

Competencies for effective intercultural counselling

i. Respect for the client:
   - Having trust in the client and his or her capability of making choices and decisions, and solving problems

ii. Genuineness
   - The counsellor is a real person, not an all-knowing, objective expert

iii. Empathic understanding
   - The ability to convey empathy in a culturally consistent and meaningful manner

iv. Communication of empathy, respect and genuineness to the client
   - The conditions must felt, recognized, and perceived by the client if they are to be effective

v. Structuring
   - The counsellor should define and structure his or her role to the client; there should be an indication of what, how, and why he or she intends to do the proposed interaction or program.

Principles of Nutrition Counselling

The following principles are applied in the practice of nutrition counselling. This is in pursuit of quality, client-centered nutrition care

1. **Confidentiality and Privileged Communication:** Any information provided by the client must be kept private. Divulging client information could cause mistrust, which is one of the main hindrances in counselling.
2. **Autonomy:** Clients must be allowed the freedom to choose based on alternatives provided by the counsellor. This should be done without any constraints. Encourage the client to think independently and discourages the counsellor from manipulating the client into making a preferred decision.
3. **Beneficence:** All actions taken must be in the best interest of the client, as seen in improving a client's condition.
4. **Non-maleficence**: The counsellor commits to avoiding harm to the client. This includes avoiding any form of financial, sexual and emotional exploitation. This supports the well-being of the client.
5. **Justice:** The counsellor needs to treat all individuals with fairness, regardless of their race, gender, religion or social class.
6. **Empathy:** This is the ability to identify with a person without necessarily showing sympathy. A counsellor puts themselves in the client's position and shares their feelings.
7. **Self-Respect:** A counsellor is required to take care of their own welfare too through personal and professional development. This enhances competency and efficiency in service delivery.

Steps in nutrition counselling

GATHER is an acronym for the basic steps that should be followed during a counselling session:

G = Greet client in a friendly, helpful, and respectful manner.

A = Ask client about needs, concerns, and previous trials.

T = Tell client about different options and methods.

H= Help client to make decision about choice of method s/he prefers.

E= Explain to client how to use the method.

R = Return: Schedule and carry out return visit and follow-up of client

Key messages for nutrition education and counselling

Key messages are nutrition messages that health professionals give to their clients with careful consideration to the types of the clients.

Examples of key messages are;

- Exclusive breastfeeding
- Complementary feeding starting
- Appropriate nutrition care of sick and malnourished children
- Adequate intake of vitamin A for women and children
- Adequate intake of iron for women and children
- Physical activity
- Hygiene and sanitation.

14.3.2.3 Self-Assessment

1. Discuss the nutrition counselling techniques
2. Explain the GATHER approach
3. Describe the nutritional counseling environment
4. _____ is the process of guiding a client towards a healthy nutritional lifestyle by meeting normal nutritional needs and solving problems that are a barrier to change

   A. Diet therapy

   B. Nutrition counselling

   C. Diet planning

   D. Nutrition education

5. Match the following principles of nutrition counselling with their meanings:

Principle of diet counselling	Meaning
A. Confidentiality and Privileged Communication	A. This is the ability to identify with a person without necessarily showing sympathy.
B. Non-maleficence:	B. The counsellor needs to treat all individuals with fairness, regardless of their race, gender, religion or social class.
C. Justice	C. The counsellor commits to avoiding harm to the client.
D. Empathy	D. All actions taken must be in the best interest of the client, as seen in improving a client's condition.
E. Autonomy	E. Any information provided by the client must be kept private.
F. Beneficence	F. Clients must be allowed the freedom to choose based on alternatives provided by the counsellor.

14.3.2.4 Tools, Equipment, Supplies and Materials

- Food models
- Food charts
- Flip charts
- Food samples
- Counselling cards
- Brochures
- Data collection forms
- Referral forms
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

14.3.2.5 References

Basic Nutrition Counselling Skill Development: A Guideline for Lifestyle Management, Kathleen D. Bauer, Carol A. Sokolik

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14.3.3 Learning Outcome 2: Evaluate patients' response to nutritional care plan

14.3.3.1 Learning Activities

Leaning activity.	Special instructions.
1. Assess client dietary compliance	• Conduct 24 hour food recall • Inspect client food diary
2. Test client knowledge on recommended diet a. Review client knowledge on recommended diet	• Observe change in behaviour
3. Monitor counseling goals a. Determine anthropometric Measurement Outcomes b. Determine biochemical data, medical tests, and procedure outcomes c. Establish variance from expected nutrition goals outcomes	• Measure and record anthropometric parameters • Interpret biochemical data • Interpret variance from expected outcome

14.3.3.2 Information Sheet

Definitions

- **Monitoring:** an ongoing review of nutrition intervention outcomes to assess the process of achievement of the goals set at planning. It assesses progress by measuring pre-determined indicators.
- **Evaluation:** Evaluation is the systematic process of assessing the relevance, effectiveness, efficiency and impact of a nutrition intervention against set goals. The outcome helps to make the decision to discharge the client or to modify the care plan.

For interventions to be effective the counsellor needs to do careful planning by. The first step to take in an intervention is interviewing. Skills in knowing how to elicit information about eating habits are key as the assessment of the client's diet continues. The most important thing in obtaining vital information that will later dictate treatment strategies involves initially establishing a rapport with the client.

Interviewing

The nutrition counsellor interviews the client with the purpose of obtaining information. He/she should ask a series of questions in a nonthreatening manner to obtain background information that will guide the session. The session is opened with appropriate introductions of all individuals to one another. The client states why he or she is there. The counselor usually begins with broad, open ended questions and closes the interview with closed-ended, follow-up questions. First Session The first session is an important time to establish the counseling relationship. The environment should be conducive to privacy, and there should be a plan for reduction of interruptions (e.g., no telephone calls, staff, or other patients knocking on the door). The counsellor should be seated in a manner that reflects interest in the client, such as sitting directly across from one another in chairs without a desk as a barrier.

Nutrition monitoring and evaluation

Monitoring and evaluation in nutrition involves monitoring, measuring and evaluating nutrition care indicators.

Through monitoring and evaluation, a nutritionist is able to determine whether or not a certain intervention is effective. Effectiveness is achieved when the goals of the nutrition intervention are achieved.

Data on the nutrition outcome indicators are collected and analyzed, after which the findings are compared to initial nutritional status, goals set for the intervention, as well as reference standards. It helps assess the impact of a nutrition intervention as well as identify gaps in the care process.

Client compliance to prescribed nutrition care is assessed through:

- Evaluation of anthropometric outcomes such as weight, height, BMI, MUAC etc.
- Biochemical parameters such as urinalysis, electrolyte level, blood glucose level , serum albumin levels, hemoglobin level
- Physical parameters such as muscle wasting, edema, jaundice, dehydration

Importance of Monitoring and Evaluation

- Helps to establish the progress of a nutrition intervention
- Determines if an intervention is in line with objectives and when alterations may be necessary
- A means of assessing quality of activities involved in a nutrition intervention
- Monitoring and evaluation can be used as proof of an intervention
- Demonstrates the impact of an intervention
- Monitoring and evaluation provides crucial data which is helpful in future planning of nutrition programmes. Policy makers, donors and implementers utilise this data in decision making

Case study

Ann is a twenty three year old woman and has presented with complain of excessive sweating, fatigue, nausea, blurred vision, tingling sensation on the peripherals, slurred speech, trauma, confusion and palpitation. Random blood sugar was 3.8mmol/L she was referred to nutrition clinic where she was advised on recommended diet, importance of diet adherence and was reassured. Ann revisit to the clinic showed RBS of 7mmol/L and an increase in weight.

a) State the tools that you will use to assess Ann diet compliance

b) Discuss whether the Ann's recommended diet was effective

14.3.3.3 Self-Assessment

1. Describe how a nutritionist can establish client dietary compliance
2. Describe how you would monitor the outcome of nutritional counselling goals
3. ______an ongoing review of nutrition intervention outcomes to assess the process of achievement of the goals set at planning.

   A. Evaluation

   B. Assessment

   C. Monitoring

   D. Nutrition intervention
4. The following are indicators used to assess compliance except:

   A. Evaluation of anthropometric outcomes

   B. Biochemical parameters

   C. Writing a nutrition diagnosis statement

   D. Physical parameters such as muscle wasting, edema, jaundice
5. Which one of the following is a biochemical parameter?

   A. Edema

   B. BMI

   C. Diet history

   D. Serum albumin level
6. ____ is the systematic process of assessing the relevance, effectiveness, efficiency and impact of a nutrition intervention against set goals. The outcome helps to make the decision to discharge the client or to modify the care plan.

   A. Evaluation

   B. Diet plan

   C. Intervention

   D. Monitoring
7. Which one of the following is not an anthropometric outcome?

   A. Weight B. Height

   C. MUAC D. Calcium level

14.3.3.4 Tools, Equipment, Supplies and Materials

- Diet history data
- Biochemical results
- Calculator
- Anthropometric measurements
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

14.3.3.5 References

Lee, R., & Nieman, D. (2012). *Nutritional Assessment: Sixth Edition* (6th ed., pp. 166-365). New York, NY: McGraw-Hill Higher Education.

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https://www.andeal.org/vault/2440/web/files/20140602-NME%20Snapshot.pdf

14.3.4 Learning Outcome 3: Explore dietary modifications

14.3.4.1 Learning Activities

Leaning activity	Special instructions.
1. Observe critical nutrition actions	• Give a nutrition diagnosis • Choose appropriate nutritional intervention
2. Give diet recommendation a. Determine appropriate mode of feeding b. Choose appropriate diet	• Calculate client daily nutritional needs • Formulate appropriate diet plan
3. Interpret result of nutrition assessment a. Interpret anthropometric Measurement Outcomes b. Interpret biochemical data, medical tests, and procedure outcomes c. Interpret physical finding outcomes	• Determine client nutritional status

14.3.4.2 Information Sheet

Definitions

- **Dietary modifications:** Changes made on patient/ client diet during its preparation, processing, and consumption to increase the bioavailability of micronutrients and reduce micronutrient deficiencies

How is a Diet Modified?

A diet may be modified in various ways, a decision which is informed by a client's factors such as:

- Disease symptoms
- Severity of the symptom or disease (Condition of the patient)
- Nutritional status of the patient
- Metabolic changes involved
- Client physiological state

The purpose of dietary modification is to meet a client's special nutritional need, necessitated by diseases and disorders that affect food intake, digestion and utilization. Modification is done in line with the principles of diet planning to ensure the clients nutritional needs are sufficiently met, as well as helping to manage the existing condition.

A diet may be modified in the following ways:

- Modification in consistency
- Modification in energy composition
- Modification in fibre content
- Modification in nutrient content

Feeding Methods

There are three main feeding methods:

- Oral feeding
- Tube feeding
- Parenteral feeding

There are indications and contraindications of each feeding method. Use of these methods ensures that clients meet their nutritional needs, regardless of their health status.

Purpose of Dietary Modification

- To provide nutrients to the patient according to his physical requirements.
- To provide nutrients to enhance the immunity of the patient.
- To provide sufficient rest to the body particularly to the affected organs, e.g., to give total liquid diet to a diarrhea patient in place of fibrous foods, to provide rest to the liver by not giving fat rich foods to a patient of jaundice.:
- To increase or reduce body weight according to the requirement.
- To change the diet of a person according to his capacity of digestion, absorption and metabolism.
- To change the liquidity of foods according to the requirements-liquid, semi- liquid or soft foods.
- To remove the deficiency this may have occurred in the body

When carrying out diet modification you will need to put into consideration;

- Medical condition of the client
- Food safety
- Cultural, social, economic factors
- Age, sex, nutrition, behaviour, physical activity and diseases of the person

CASE STUDY

Jack a 44year old man was referred to the nutritionist for management of high output enterocutaneous fistula following explorative laparotomy for intestinal adhesions. Initially he was able to feed orally but currently jack is presenting with complains of dehydration, weight loss, fatigue, reduced appetite, general body weakness.

a) Identify the appropriate feeding method for jack considering his condition

b) Modify jacks diet to suit his current condition.

14.3.4.3 Self-Assessment

1. Outline the purposes of modification of diet during illness
2. Explain diet modification.
3. ______changes made on patient/ client diet during its preparation, processing, and consumption to increase the bioavailability of micronutrients and reduce micronutrient deficiencies

   A. Diet plan
   B. Dietary modifications
   C. Dietary intake
   D. Nutrition intervention
4. The following are factors that determine dietary modification except:

   A. Disease symptoms
   B. Severity of the symptom or disease
   C. Marital status of the client
   D. Metabolic changes involved
5. Which one of the following is not a type of dietary modification?

   A. Modification in consistency
   B. Modification in energy composition
   C. Modification in nutrient excretion
   D. Modification in nutrient content
6. Indicate whether the following statements are true or false about the purpose of dietary modification:

   A. To provide nutrients to the patient according to requirements.
   B. To change client food habits
   C. To provide nutrients to enhance the immunity of the patient.
   D. To heal chronic diseases
   E. To provide sufficient rest to the body particularly to the affected organs
   F. To increase or reduce body weight according to the requirement.

14.3.4.1 Tools, Equipment, Supplies and Materials

- Diet history data
- Biochemical results
- Calculator
- Anthropometric measurements
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

14.3.4.1 References

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https://www.longdom.org/open-access/how-can-we-assess-the-nutritional-status-of-an-individual-2155-9600-1000640.pdf

14.3.5 Learning Outcome 4: Support the client with acceptance of nutrition care plan

14.3.5.1 Learning Activities

Leaning activity	Special instructions.
1. Report the client acceptability, tolerance and consumption of meals • Report like and dislike of patients • Consider patient allergic reactions, intolerance, palatability and mal-absorption • Confirm adequacy of dietary intake	➢ Follow up on client ➢ Document client progress ➢ Identify barriers to efficacy of diet plan ➢ Modify diet plan to deal with emerging issues
2. Report client's problems which may lead to poor acceptance and/or tolerance of the nutrition care plan	• Provide support
3. Provide the client with information regarding nutrition care plan • Report the nutrition care process to the patient • Consider patient confidentiality, consent.	• Teach the client the fundamentals of recommended nutrition care plan
4. Provide feedback about changes to food preferences and nutrition care to catering/ food services and to dietitians a. Consider patients social, economic status, route of administration, age, sex	• Document recommended dietary change and meal patterns • Liaise with other relevant care providers e.g catering • Report on dietary necessary adjustments • Decide between discharge and continuation of nutrition care

14.3.5.2 Information Sheet

Definitions

- **Intolerance:** Difficulty digesting certain foods, which can lead to abdominal pain, diarrhea and intestinal gas
- **Allergic reaction:** An abnormal response towards a particular food, triggered by an immune response

Nutrition care of patients requires selection of personalized care plans to cater for their individual needs. This involves choosing an appropriate intervention, planning for the intervention, implementation, monitoring and evaluation.

For an effective nutrition intervention, the nutritionist must apply the principles of diet planning, while being keen on the client's special nutritional needs.

Upon evaluation of care, critical thinking must be applied in determining discharge or continuation of care.

Steps in Conducting a Nutrition Education Session

- Identify problems
- Prioritize the problem
- Identify the target group/person
- Build consensus about the problem with the individual or group
- Identify blocks e.g. lack of resources, beliefs
- Select appropriate communication channel of communication (e.g. demonstration, songs, poems).

Activities that facilitate behaviour change

The following six steps are important when working with individuals who struggle with behaviour change:

- Express empathy
- Understand cultural factors
- Develop discrepancy
- Avoid arguments or defensiveness
- Roll with resistance
- Support self-efficacy.

Expressing empathy

When a counsellor accepts what a client feels in times of turmoil, can often result in change. Acceptance facilitates change. A woman wrote a letter to her nutritionist saying that she wanted to stop working on her dietary changes. Life was too complicated, and the dietary changes were more than she could handle. The nutritionist reviewed potential scenarios to assist in solving this problem. One certainly was to take the woman's word seriously and allow her to drop out of the diet intervention process. Another was to immediately call the woman to discuss the letter, always indicating acceptance of the woman's concerns. Beyond this acceptance is a skilful form of reflective listening, which allows the woman to describe her thoughts and feelings, while the nutritionist reflects back understanding. Many clients have no one with whom to discuss problems in their lives. This opportunity to have someone listen and understand the emotions behind the words is crucial to eventual dietary change. The intensity of reflective listening skills far outweighs the detail of knowledge about a nutrition topic and will result in greater levels of dietary change. As clients review situations in their lives and lack of time for dietary changes, the counsellor will hear ambivalence. On the one hand, clients want to make changes; on the other hand, they want to pretend that change is not important. Ambivalence (uncertainity) is normal.

Example;

Client: I feel totally worthless. On one hand I want to follow this new eating pattern, and on the other I want to eat spontaneously, not worrying about decreasing my fat intake.

Nutrition Counsellor: Your feelings are normal. You are having a difficult time merging new and old habits. This happens to many people

Avoiding Arguments or Defensiveness

Every counsellor should know that arguments are counterproductive. A counsellor's argument may appear like he/she is defending one's own ideas, which is interpreted by the client as defensiveness. When a client resists, the counsellor should look for ways to change strategies.

Example;

Client: I just can't do everything right now. I just can't.

Nutrition Counsellor: You are the best judge of what you can do. Perhaps we need to step back and wait for things in your life to calm down. Let's talk about what you can do and eliminate those things that are too difficult at this time. We can look at ways to meet your goals in the future. Now is the time to take care of pressing issues.

Rolling with Resistance

The nutrition counsellor should invite new perspectives avoiding any sign of imposing them. The client is a very important resource in finding solutions to nutritional problems. The counsellor should understand that his/her role is support the process of shifting perceptions. For example, a client who is wary of describing why s/he is not ready to change may become much more open to change if she sees openness to her resistive behaviours. When it becomes okay to discuss resistance, the rationale for its original existence may seem less important.

Example;

Client: I just feel that my level of enthusiasm for following the diet is low. It all seems like too much effort.

Nutrition Counsellor: I appreciate your concerns. Many people feel the same way at this point in following a new diet. Tell me more about your concerns and feelings.

Supporting Self-Efficacy

Belief in the possibility of change is an important motivator. The client is responsible for choosing and carrying out personal change. Hope exists when there are alternative approaches to a problem.

Example

Client: I just feel hopeless sometimes when I try to follow the diet.

Nutrition Counsellor: Look at the progress you have made in 6 months. Your food records are a testimony to how much you have been able to change your eating habits. You can learn from your limitation and do better in the future. These concepts, along with other intervention models, shape the content of each contact described in the following motivational intervention model.

Stages of change

1. Pre-contemplation: This is the point at which the patient has not even contemplated having a problem or needing to make a change. A person in the precontemplative stage needs information and feedback to raise his or her awareness of the problem and possibility of change. Nutrition advice for eating changes is counterproductive at this point.

Contemplation: Once some awareness of the problem arises, the person enters a period of ambivalence: the contemplation stage. The contemplator seesaws between reasons to change and reasons to stay the same. At this stage the counsellor works with the patient on advantages and disadvantages of making dietary changes.

Preparation: The preparation stage is a window of opportunity that either allows the patient to move forward or fall back into contemplation. At this point, the patient needs help in finding a change strategy or goal that is acceptable, achievable, and appropriate.

Action: The patient engages in actions that bring about change. At this point the goal is to produce a change in the problem area.

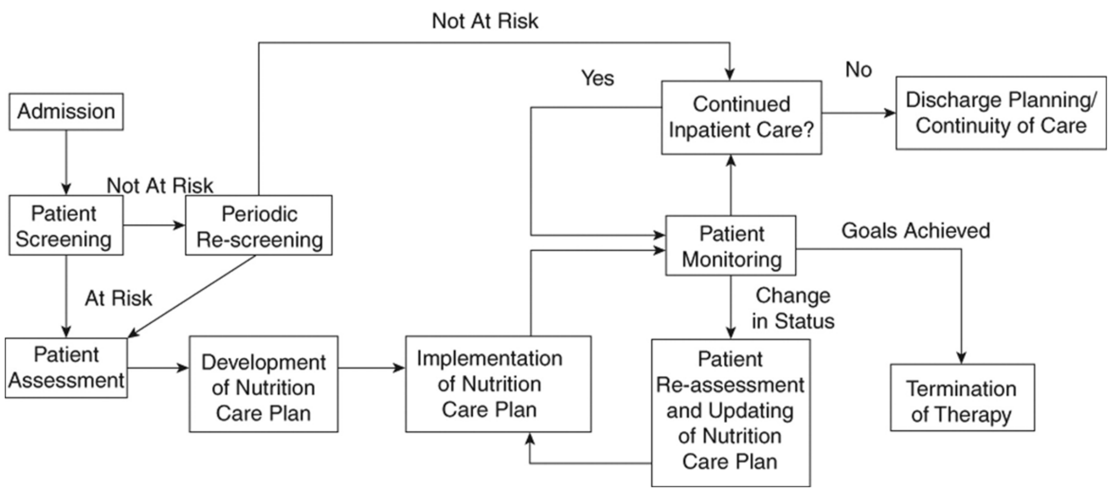
Maintenance: During this stage, the challenge is to sustain the change accomplished by previous action and to prevent relapse.

Relapse: If relapse occurs, the individual's task is to start the change process again rather than become stuck in this stage. Slips and relapses are normal, expected occurrences as a person seeks to change any long-standing pattern of behaviour. The goal is to resume action efforts

Factors that May Hinder Efficacy of Diet Plan

- Language barrier
- Cultural differences
- Patient allergic reactions and intolerances
- GIT complications e.g. mal-absorption, vomiting, diarrhoea, constipation

Criteria for Discharge and Continuation of Nutrition Care



Nutrition care algorithm

Case study

Ann is a twenty three year old woman and has presented with complain of excessive sweating, fatigue, nausea, blurred vision, tingling sensation on the peripherals, slurred speech, trauma, confusion and palpitation. Random blood sugar was 3.8mmol/L She was referred to nutrition clinic where she was advised on recommended diet, importance of diet adherence and was reassured. RBS has remained at 10mmol/L and random blood sugar is at 4mmol/L. She no longer experiences the stated signs and symptoms. She reports slight weight gain too

a) Identify the nutrition problem of concern in this case

b) Advise whether the patient is ready for discharge. Explain

14.3.5.3 Self-Assessment

1. Outline the factors that may hinder efficacy of diet plan
2. List factors that can hinder client/ patient acceptance of nutrition care plan
3. Outline the factors should to consider before termination of clients diet therapy
4. Match the following stages of behaviour change with their correct description

A. Pre-contemplation:	A. Client falls back and resumes undesirable behaviour.
B. Contemplation	B. During this stage, the challenge is to sustain the change accomplished by previous action and to prevent relapse.
C. Preparation	C. The patient engages in actions that bring about change.
D. Action	D. This is the point at which the patient has not even contemplated having a problem or needing to make a change.
E. Maintenance	E. The patient needs help in finding a change strategy or goal that is acceptable, achievable, and appropriate.
F. Relapse	F. The person is in a period of ambivalence where they are conflicted between reasons to change and reasons to stay the same.

14.3.5.4 Tools, Equipment, Supplies and Materials

- Diet history data
- Biochemical results
- Anthropometric measurements
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

14.3.5.5 References

Lee, R., & Nieman, D. (2012). *Nutritional Assessment: Sixth Edition* (6th ed., pp. 166-365). New York, NY: McGraw-Hill Higher Education

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CHAPTER 15:

DIET THERAPY 1

15.1 Introduction of the Unit of Learning / Unit of Competency

This unit addresses the unit of competency: provide diet therapy in diseases states involving GIT disorders; diarrhoea, nausea and vomiting, constipation, peptic ulcers, gastritis, diverticular disease, hiatal hernia, celiac disease. Febrile disorders; malaria, pneumonia, coughs, TB, measles and cancers.

15.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to describe the relationship between nutrition and disease as well as apply diet planning principles as per resource materials, policies and guidelines; provide nutritional management of GIT disorders in accordance with policies and guidelines; provide nutritional management of the respiratory and febrile disorders in line with resources materials, policies and guidelines; manage different types of cancers with nutrition as per the clients requirements, resource materials and policies and guidelines; provide nutrition interventions in HIV/AIDs in line with MOH/ WHO guidelines, material resources and patient requirements; and provide nutritional management of childhood disorders based on client's diagnosis, resource materials, and policies& guidelines.

15.3 Learning Outcomes

15.3.1 List of the Learning Outcomes

i. Identify terminologies in diet therapy I

ii. Demonstrate understanding in nutrition management of GIT disorders

iii. Demonstrate understanding in nutrition management of the respiratory and febrile disorders

iv. Demonstrate understanding in nutritional management of cancers

v. Demonstrate understanding in nutritional management of HIV and AIDS

vi. Demonstrate understanding in nutritional management of childhood disorders

15.3.2 Learning Outcome 1: Identify terminologies in diet therapy I

15.3.2.1 Learning Activities

Learning Activities	Special instructions
1. Identify terminologies under diet therapy I as per resource materials, policies and guidelines	• Use terminologies related to diet therapy
2. Illustrate the relationship between nutrition and disease and the roles of nutrition in disease management as per resource materials, policies and guidelines	• Consider the relationship between nutrition and disease
3. Identify and describe diet planning principles and objectives of diet therapy as per resource material, policies and guidelines	• Apply diet planning principles

15.3.2.2 Information Sheet

Definitions

Nutritional care: application of the art and science of nutrition in helping people select or obtain food for the primary purpose of nourishing their bodies in health or disease throughout their **lifecycle.**

Therapeutic diets: It is a diet that is modified from a normal diet to meet the requirements of the ill/ sick individual.

Normal diet: It consists of any and all foods eaten by the person in health. It satisfies the nutritional needs of most patients and serves as the basis for planning modified diets.

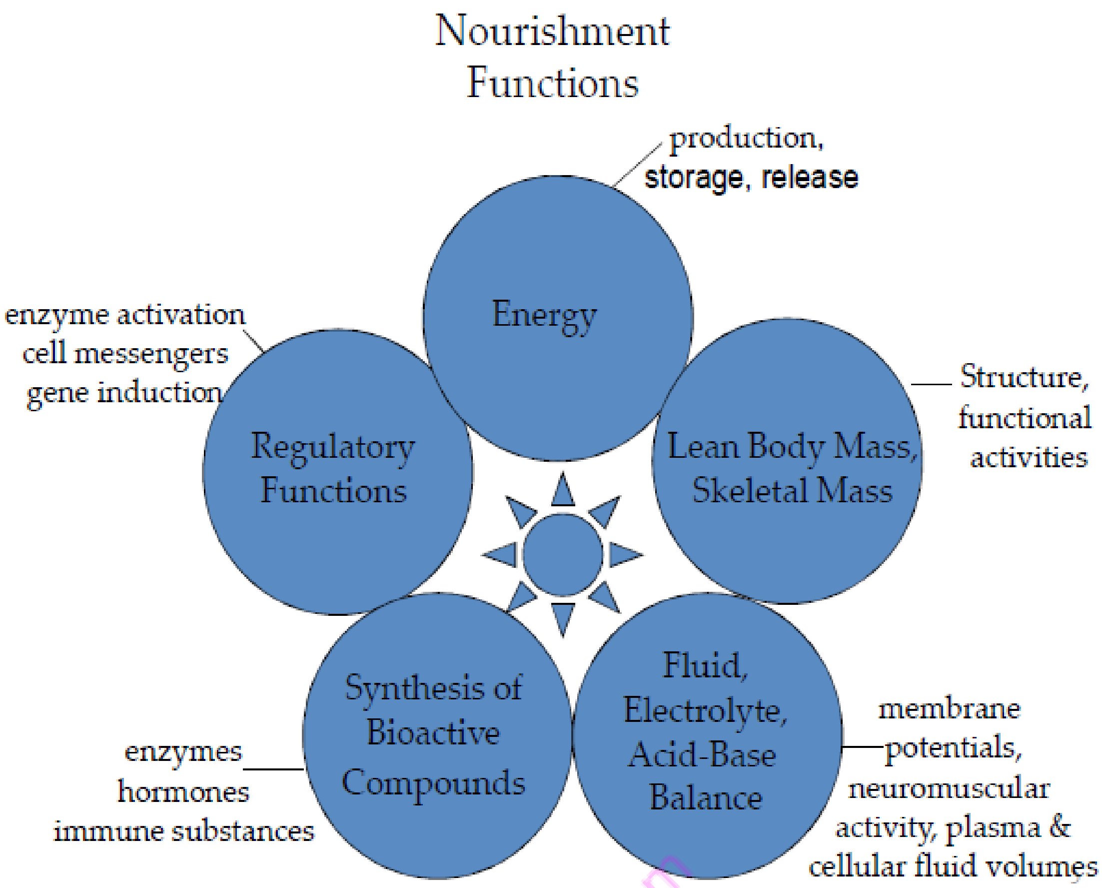
Diet modification: It refers to the action of adjusting a normal diet to change its consistency/ texture, flavor and nutrient contents.

Relationship between Nutrition and Disease

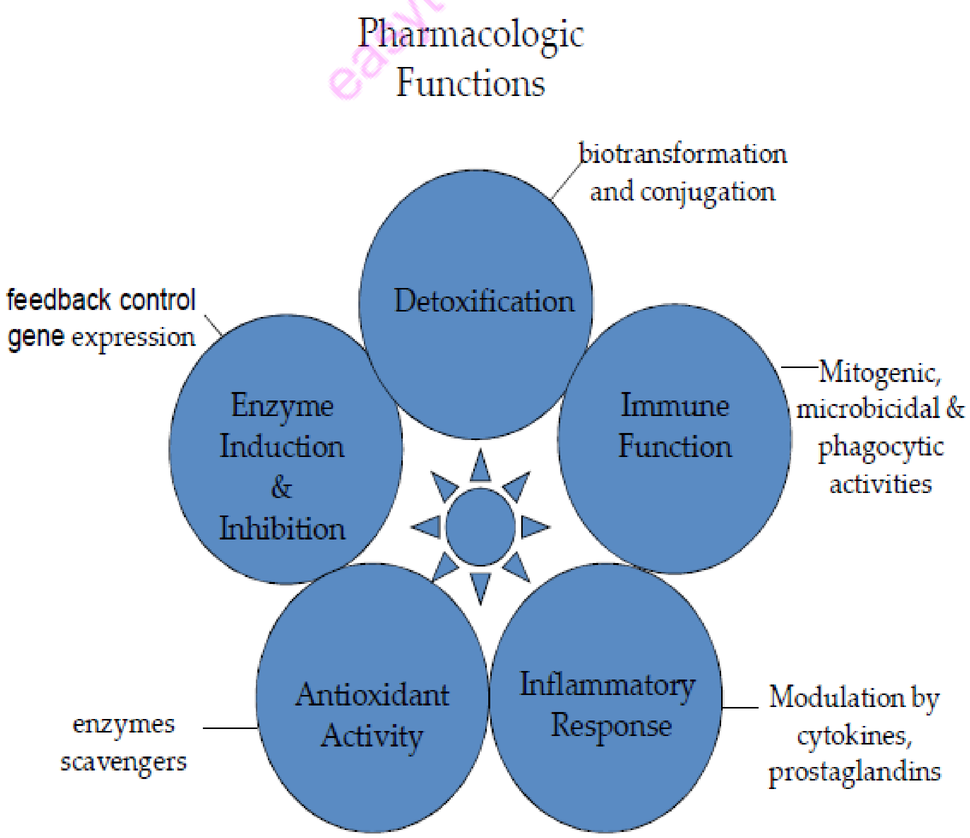
Food provides required raw materials for normal cellular activity. Nutrient deficiency impairs this activity and results to disease. Deficiency may be as a result of inadequate nutrient intake, malabsorption, increased requirement or increased excretion/nutrient loss.

Nutrients have nourishment and pharmacologic function and so they are directly involved with disease prevention. Examples:

- Zinc, Vitamin A, Vitamin B6 and folate support immune function
- Vitamin C, Vitamin E, selenium and carotenoids are antioxidants
- Iron, Vitamin A, zinc and Vitamin Care involved in tissue synthesis.



Nourishment functions



Pharmacologic functions

The Goals of Nutrition in Disease Prevention

1. To optimize cellular activity and tissue/organ function
    a) Provide sufficient amounts to satisfy daily demands of adequacy, balance and variety in food choices
    b) Maintain adequate reserves for intermittent increased demand through habitual diet and dietary patterns
2. To reduce the metabolic burden imposed on cardiac, pulmonary, renal, hepatic, musculoskeletal systems by environmental factors
    a) Minimize workload of organ systems by reducing stress on organs involved in

    transport, metabolism and elimination of nutrients and metabolic waste.
    b) Eliminate compensatory responses required to maintain normal function
3. To support cellular defenses that protects tissue integrity
    a) Maintain immune system competence
    b) Promote efficiency of detoxification systems by controlling levels of reactive chemical intermediates
    a) Prevent oxidative damage that is involved in pathogenesis of most chronic diseases and reduction of efficiency of immune cells

Diet Planning Principles:

When planning a healthy diet the following concepts are key:

- **Adequacy:** Ensuring that the diet contains all nutrients in adequate amounts
- **Balance**: This principle requires that not too much of any type of a nutrient is provided in a diet. Intake of a particular nutrient should be equal to individual needs.
- **Calorie control:** Calorie control calls on one to ensure that amount of energy consumed is equal to energy expenditure. Not too many or too few calories are consumed.
- **Moderation:** Requires that no particular food will be consumed in excess. One food should not crowd the diet.
- **Variety:** Nutrients should be sourced from a variety of foods. There's no superfood as different types of foods contain different amounts of each nutrient.

15.3.2.3 Self-Assessment

1. Outline the goals of nutrition in disease prevention
2. _______ is the application of the art and science of nutrition in helping people select or obtain food for the primary purpose of nourishing their bodies in health or disease throughout their lifecycle.
   - A. Nutrition
   - B. Nutritional care
   - C. Diet therapy
   - D. Modified diet
3. ________refers to the action of adjusting a normal diet to change its consistency/ texture, flavour and nutrient contents.
   - A. Balance
   - B. Diet modification
   - C. Diet
   - D. Variety
4. The following nutrients are antioxidants except:
   - A. Vitamin c
   - B. Vitamin e
   - C. Selenium
   - D. Vitamin D
5. ________requires that no particular food will be consumed in excess. One food should not crowd the diet.
   - A. Adequacy
   - B. Moderation
   - C. Variety
   - D. Balance
6. The following are pharmacologic functions of nutrients except:
   - A. Detoxification
   - B. Immune function
   - C. Antioxidant activity
   - D. Growth and development

15.3.2.4 Tools, Equipment, Supplies and Materials

- Charts
- Food models
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

15.3.2.5 References

1. Anyang'Nyong'o, H. P. P., & EGH, M. Kenya National Clinical Nutrition And Dietetics Reference Manual First Edition.

2. Cederholm, T., Barazzoni, R., Austin, P., Ballmer, P., Biolo, G., Bischoff, S. C., ... & Jensen, G. L. (2017). ESPEN guidelines on definitions and terminology of clinical nutrition. Clinical Nutrition, 36(1), 49-64.

15.3.3 Learning Outcome 2: Demonstrate understanding in nutrition management of GIT disorders

15.3.3.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under GIT disorders as per resource materials, policies and guidelines	• Use terminologies related to GIT disorders
2. Identify and describe disorders the upper GIT and nutrition management as per resource materials, policies and guidelines	• Apply knowledge of the examples of upper GIT disorders • Apply knowledge of pathophysiology of upper GIT disorders in diet therapy • Determine how upper GIT disorders affect nutrition • Plan a diet for upper GIT disorders
3. Identify and describe disorders of the lower GIT and nutrition management as per resource materials, policies and guidelines	• Apply knowledge of the examples of lower GIT disorders • Apply knowledge of pathophysiology of lower GIT disorders in diet therapy • Determine how lower GIT disorders affect nutrition • Plan diet for lower GIT disorders

15.3.3.2 Information Sheet

1. PEPTIC ULCERS

Peptic ulcer is the general term given to an eroded mucosal lesion in the central position of the gastro intestinal tract. The areas affected include the lower portion of the esophagus, the stomach and the first part of the duodenum. A bacteria helicobacter pylori is the biggest cause of peptic ulcers; the second leading cause is the use of non-steroidal anti-inflammatory drugs (NSAIDS) that may damage the stomach lining.

Gastric normally occur in adults 45-60 and duodenal occur at age 20-30.

Causes

- Factors that disrupt the mucosal barrier, permitting hydrogen ions to diffuse into the mucosal tissue where they cause damage that leads eventually to cell distraction and subsequent ulceration
- Enteral gastritis from Helicobacter pylori

- Defect in the pyloric sphincter resulting in reflux of the duodenal content in to the antrum of the stomach where the detergent effect of bile salts reduces mucosal resistance
- NSAID's (non-steroid anti-inflammatory drugs) e.g. aspirin, brufen, diclofenac, paracetamol, dramatically increase the risk of ulcers
- Increased acid secretion
- Increased gastric acid emptying rate
- Reduced ability of the duodenum to handle an acid load
- Stress or nervous tension which causes vasoconstriction or reduce blood supply to the gastric mucosa leaving it unprotected.

Symptoms of peptic ulcers

- Pain
- Vomiting
- Haemorrhage

Relationship of food to gastric irritation

- Hydrochloric acid and pepsin breaks down food proteins
- Mucus protects lining of stomach from being digested by HCL and pepsin
- Ulcer develops when acid pepsin reaction overpowers mucus protection action
- Food causes stomach to expand
- Expansion signals release of hormone that stimulates acid secretions
- Proteins stimulate and neutralize gastric acidity
- Products that result from breakdown stimulate gastric secretions that are responsible for pain experienced 1 to 3hrs after a meal
- Chemical irritants e.g. caffeine and theobromine irritate gastric mucosa
- Stimulants are found in spices, alcoholic beverages, aspirin, tobacco and some other drugs and so should be restricted

Nutritional implications of peptic ulcers

It could lead to:

- Anaemia
- Altered food and nutrient intake

Aims of nutrition management of peptic ulcers

- Reducing and neutralizing stomach acid secretion
- Maintaining acid resistance of gastro-intestinal epithelial tissue

- Limiting patient's discomfort and reliving their pain
- To provide continuous neutralization of gastric acid
- To promote healing and reduce irritation of GIT
- Restoring good nutrition status
- To reduce mechanical, thermal and chemical irritation to the gastric mucosa

Dietary management

- The patient with peptic ulcer disease should:
- Eat three regular meals daily
- Eat small meals to avoid stomach distension
- Eat slowly
- Use in moderation easily digested fats like fat of whole milk, egg yolk, cream and butter
- Avoid drinking excess coffee and alcohol
- Cut down on or quit smoking
- Avoid using large amounts of aspirin, other NSAID's or other drugs known to damage the stomach lining
- Avoid foods or drinks that cause discomfort
- Eat meals in a relaxed atmosphere as possible
- Take antacids one and three hours after meals and before bedtime

Foods to avoid

- Fatty and tough meat
- Fried foods
- Sour foods
- Unripe citrus fruits like oranges and sweet lime
- Garlic
- Ginger
- Strongly flavoured vegetables
- Strong spices and condiments
- Chillies
- Pickles
- Strong tea and coffee
- Alcoholic beverages

Foods recommended for use:

- **Cabbage**: fresh juice, fermented or raw has anti inflammatory effects
- **Potatoes**: nutritious, anti acid, soothing and sedating
- **Other vegetables**: carrots, peas, okra, other leafy vegetables that are tolerated

- **Fruits:** orange juice, apples, ripe bananas, avocadoes, pears, pawpaw, apricots, cherimoya and guava
- **Okra:** contain mucilage capable of protecting gastric mucosa
- **Cereals:** porridge, oatmeal, semolina, macaroni products, spaghetti, rice, chapatti and matoke
- **Desserts**: custards, ice creams, cakes
- **Oils:** use polyunsaturated fatty acids
- **Beverages**: buttermilk, malted milk
- **Eggs:** boiled, poached, scrambled
- **Roast beef and lamb**, stewed or baked should be used in moderations because they
- contain purines (non-protein substances that stimulate gastric mucosa)

2. ACUTE GASTRITIS

This is a temporary inflammation of the gastric mucosa, usually self-limiting caused by the indigestion of infectious or corrosive substances e.g. aspirin, food poisoning, radiation therapy, metabolic alcoholism, acute alcoholism and uremia.

Causes

- Acute gastritis is mainly caused by over eating,
- Over use of alcohol and tobacco
- Chronic or excessive doses of aspirin or non-steroidal anti-inflammatory agents (NSIA)
- Trauma
- Surgery
- Renal failure
- Burns
- Radiation therapy

Symptoms

- Nausea
- Vomiting
- Malaise
- Anorexia
- Headache
- Haemorrhage
- Pain

Nutrition implications

- Anaemia
- Loss of nutrients
- Increased metabolism

Aims of nutrition management

- Relieve pain
- Manage dietary deficiencies

Dietary management

- To allow the stomach time to rest and heal, withhold food for 24 to 48hrs or longer, depending on whether there is bleeding or pain
- Give fluids intravenously during this period
- Add fluids as tolerated following the resting period
- Increase number of feeds according to the patient's tolerance, until a full regular diet is achieved
- Avoid seasoned foods

3. DUMPING SYNDROME

This is a complication of gastric surgeries in which the pyloric sphincter is removed, bypassed or disrupted. This causes partially digested food to rapidly enter the jejunum, it is quickly digested and creates a hyperosmolar load. Fluid from the intestinal capillaries enters the jejunum, diminishing blood volume and stimulating peristalsis, resulting into low blood pressure and diarrhoea.

Causes

Gastric surgery (post-gastrotomy, hypoglycaemia caused by: pyloroplasties, vagotomies, total gastrotomy, and gastric by-pass surgery)

Symptoms

- Sweating
- Weakness
- Diarrhoea
- Rapid pulse rate
- Dizziness
- Paleness
- Crampy abdominal pain

Nutritional implications

- Loss of nutrients
- Weight loss

Aims of nutrition management

- Provide adequate energy and nutrients to support tissue healing
- Prevent weight loss
- **·Correct hypoglycaemia in the short term**

Dietary Management

After surgery the following should be done:

- All fluids and foods by mouth should be withheld for 3 to 5 days and the patient fed by nasogastric tube
- Warm water, cold water or Ice chips should be held in mouth or small, infrequent sips of water should be given as tolerated
- Low carbohydrates, clear liquids such as soups, or diluted unsweetened fruit juices should be given and limited to ½ to 1 cup servings, however, at least 6 cups of fluids should be consumed daily to replace losses resulting from diarrhoea.
- Carbonated beverages and milk are not recommended in the initial stages of the diet
- The post-gastrotomy diet then begins with gradual progression to a general diet as tolerated. Bland foods should be started first, but a more important priority is offering the patient foods he/she likes and can tolerate. By the 5th to 7th day most patients can tolerate solid foods
- For persons near desirable body weight about 1.5g to 2g protein should be given (35Kcal

  to 45Kcal/kg)
- Pectin, a dietary fibre found in fruits and vegetables maybe helpful in treating dumping syndrome. Pectin delays gastric emptying, slow carbohydrate absorption and reduces glycemic response, though small dry meals are of more benefit
- Vitamin and mineral supplementation maybe necessary depending on the extent of surgery and whether the symptoms of dumping syndrome persist
- Generally, liquids are served between meals rather than with meals to slow the passage of the food mass.
- Limit simple carbohydrates. Lie down immediately after eating to help slow the transit of food to the intestines.
- Clients who experience reflux should not lie down after eating. Beware that lactose intolerance may develop and produce discomfort in relation to milk and milk products

4. INFLAMATORY BOWEL DISEASE (IBD)

This refers to inflammation of the bowel. There are two conditions under IBD namely:

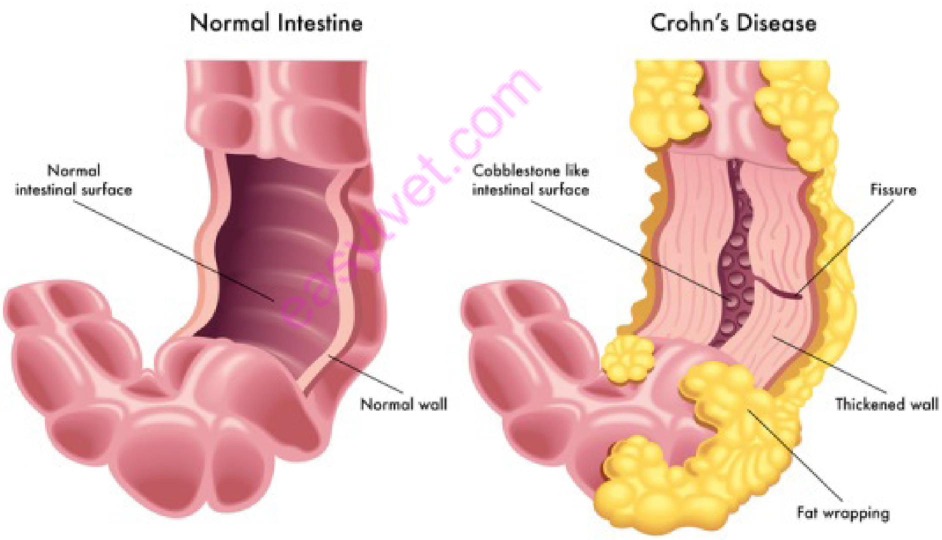
i. Crohn's disease

ii. Ulcerative colitis

iii. Crohn Disease

Crohn disease is a chronic inflammation of the digestive tract which can affect any part of the digestive tract. Usually, it involves the terminal part of the small intestines, the beginning of the colon and around the anus. The inflammation may cause extensive damage to the digestive tract as ulcers can form in the areas affected by inflammation. The lining of the small intestines may be damaged to the extent of causing malabsorption. Impaired absorption can lead to malnutrition, dehydration, mineral and vitamin deficiencies. As a result of inflammation, the intestinal wall becomes thicker, causing the intestinal lumen to narrow. A narrow lumen is susceptible to obstruction, which can be permanent.

Crohn's disease may also cause anal fissures, fistulas and abscess.



Crohn's disease

Causes

- Inadequate food intake
- Loss of protein in to the gut lumen
- Fever
- Low grade but chronic intestinal obstruction
- Malabsorption or mal-digestion of fat and protein
- Possibly zinc deficiency

Symptoms

- Fatigue
- Anorexia
- Variable weight loss
- Right lower quadrant pain or cramping
- Diarrhea
- Fever
- Stricture formation may precipitate bowel obstruction.

Nutrition implications

- Inadequate food and nutrient intake
- Malabsorption and mal-digestion
- Increased nutrient needs

Aims of nutrition management

- Restoration of good nutritional status
- Relief of discomfort

Dietary management

- During acute flare-ups bowel rest and parenteral nutrition is recommended
- Later in patients who cannot tolerate whole foods elemental oral formula maybe useful
- Energy and protein content of the diet should be high to promote healing and restore weight. Provide 40 – 50Kcal/Kg, and for protein 1 – 1.5g/Kg
- Give a low fiber diet to minimize bowel stimulation
- Give small frequent meals that are better tolerated than three large meals, this may help
- maximize intake
- Assess status of calcium, magnesium and zinc since steatorrhea promotes their loss

ii. **Ulcerative Colitis**

The disease is characterized by inflammation and ulceration of the large intestines that always begins in the rectum.

Cause

It is likely that intestinal allergy caused by some foods like milk maybe responsible for the disease in some cases.

Symptoms

- Passage of loose stool with mucus and blood accompanied by pain and spasms
- Loss of appetite
- Rectal bleeding
- Fever
- Ulcerative lesions in the mucosa of the large intestines
- Dehydration
- Electrolyte imbalance
- Anorexia
- Malnutrition

Nutrition implications

- Anaemia
- Increased nutrient needs
- Fluid imbalance
- Food mal-digestion and nutrient malabsorption

Aims of nutrition management

- To relieve pain and inflammation
- To restore and maintain optimal nutritional status

Dietary management

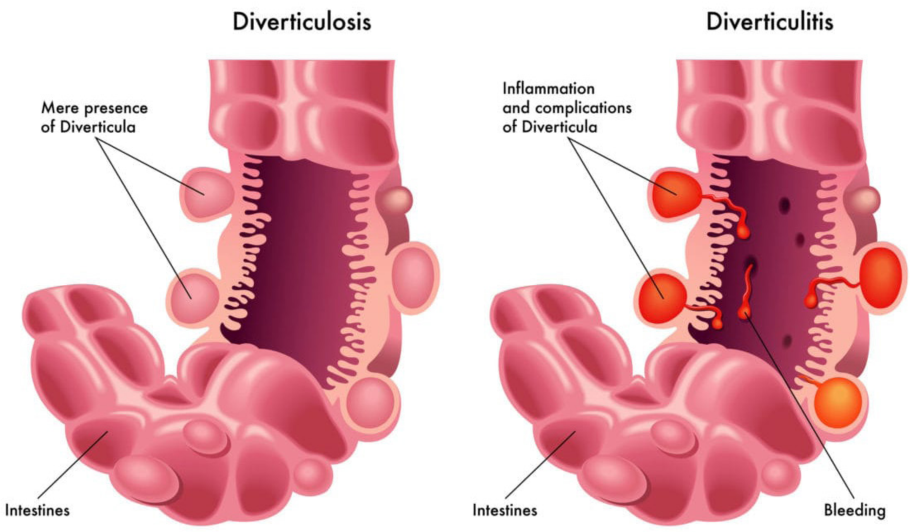
Dietary management is the same as in Crohn' disease. However, no dietary interventions seem to lessen disease activity. And unlike Crohn's disease where intestinal surgery fails to cure the disorder, removal of the colon and the rectum does cure ulcerative colitis

.

5. DIVERTICULAR DISEASE

Diverticular refers to the small out pouching in the gastrointestinal tract. These pouching may occur in the oesophagus as well as in the lower intestine. It is caused by increased pressure within the intestinal lumen, which may be related to chronic constipation and long term low fibre diets. Diverticular usually occur in the weakened areas of the tissue resulting from such factors as tissue irritation, secretory or muscular malfunctioning.

Diverticulitis refers to inflammation of the Diverticular.



Diverticulosis

Causes

- Aging
- Low fibre diets

Symptoms

- Gross bleeding
- Low Hb and albumin levels
- Ulceration or even perforations of the lower intestine
- Dysphagia
- Cramping
- Alternating periods of diarrhoea and constipation
- Regurgitation
- Bad breath and foul taste in the mouth
- Low grade fever

Nutritional implications

- Anaemia
- Increased nutrient needs

Aims of nutrition management

- To restore nutritional status
- To relieve pain and enhance healing

Dietary management

- In chronic cases, provide a moderately fiber restricted diet
- In acute cases, provide clear liquid diet with progression to a very low-residue diet
- Ensure high calories diet to cater for the increased calories needs, except in overweight
- cases where normal calories requirement may be provided to check on the weight
- High protein is needed for repair of worn out tissues
- Ensure that the diet is of low fats

6. GASTROESOPHAGEAL REFLUX DISEASE (GERD)/OESOPHAGITIS

This is a condition that produces indigestion and heartburn from the backflow of acidic gastric juices onto the lower oesophageal mucosa.

Causes

- Irritation of the oesophageal mucosa
- Stress
- Ingestion of an irritating agent
- Viral inflammation
- Fungal infection
- Intubation
- Aging
- Radiation such as for lung cancer treatment
- Medication that gets stuck in oesophagus e.g. tetracycline

Chronic or reflux esophagitis is a result of recurrent gastroesophageal reflux owing to a hiatal hernia, reduced Lower Oesophageal Sphincter (LES) pressure, increased abdominal pressure and recurrent vomiting.

Symptoms

- Heartburn
- Regurgitation
- Dysphagia
- Bleeding

Nutrition implication

- Indigestion
- Anaemia

Aims of nutritional management

- Prevent irritation of the oesophageal mucosa in the acute phase
- Prevent oesophageal reflux
- Decrease the irritating capacity or acidity of gastric juice

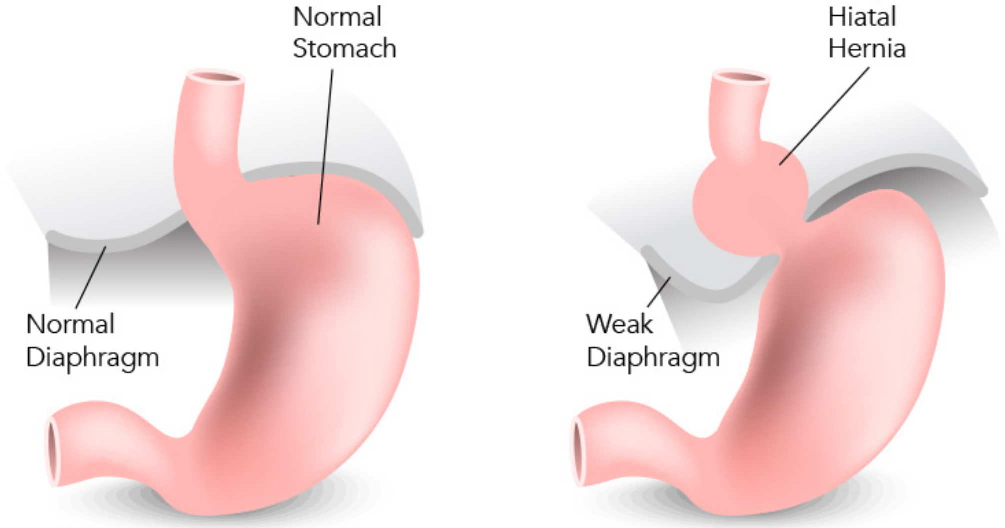
Dietary Management

- In acute phase give liquid diet that is less abrasive to the oesophagus
- Avoid acidic foods e.g. citrus fruits, tomato products, coffee, carbonated beverages, alcohol and spices (all of which lower LES) according to individual tolerance.
- Provide low fat foods and small frequent meals
- Timing of the evening meal is important. The patient should consume nothing except water for 3 hours before lying down
- Avoid or quit smoking as it also triggers acid production
- Elevate the head of the bed when sleeping
- Avoid clothing that is tight on the abdominal area and maintain upright posture during and after eating.
- Reduce weight if overweight.

7. HIATAL HERNIA

Refers to anatomical abnormality in which part of the stomach protrudes through the diaphragm into the chest; that is an out pouching of a portion of the stomach in to the chest through the esophageal hiatus of the diaphragm.

Usually the stomach is completely below the diaphragm (the sheet of muscle that separates the lungs and chest from the abdomen). But in some people, part of the stomach or the sphincter can slide up into the chest cavity. This is called a hiatus hernia. It's quite common, but in some people it may cause heartburn due to reflux of stomach acid.



Hiatal hernia

Causes

Larger than normal oesophagi hiatus (opening in the diaphragm through oesophagus passes from the chest into the abdomen)

Symptoms

- Discomfort after heavy meals
- Stomach distension
- Difficulty in breathing, lying down and bending

Dietary management

- In acute phase provide liquid diet that is less abrasive to the oesophagus
- Avoid acidic foods e.g. citrus fruits, tomato products, coffee, carbonated beverages, alcohol, spices (all of which lower LES) according to individual tolerance
- Provide low fat foods and small frequent meals
- Timing of the evening meal is important. The patient should consume nothing except water for 3 hours before lying down
- Avoid or quit smoking as it also triggers acid production
- Elevate the head of the bed when sleeping
- Avoid clothing that is tight on the abdominal area and maintain upright posture during and after eating
- Reduce weight if overweight.

15.3.3.3 Self-Assessment

1. Distinguish between ulcerative colitis and Crohn's syndrome
2. Outline the symptoms of dumping syndrome
3. List the food recommended for people suffering from gastroesophageal reflux disease
4. Which one of the following is not a cause of peptic ulcers?

   A. Enteral gastritis from helicobacter pylori

   B. Defect in the pyloric sphincter resulting

   C. Increased acid secretion

   D. Reduced gastric acid emptying rate
5. Which one of the following is an implication of acute gastritis?

   A. Weight gain B. Anaemia

   C. Vomiting D. Pain

6. Which of the following statements is not true about gastroesophageal reflux disease
   A. Provide low fat foods
   B. Patient should consume nothing except water for 3 hours before lying down
   C. Increase caffeine intake
   D. Avoid or quit smoking
7. _____ is an anatomical abnormality in which part of the stomach protrudes through the diaphragm into the chest
   A. Diverticular Disease
   B. Crohn's Disease
   C. Hiatal Hernia
   D. Oesophagitis
8. Chronic or reflux esophagitis may result from _______
   A. Weight loss
   B. High fibre diet
   C. Medication such as asprin
   D. Reduced Lower Oesophageal Sphincter (LES) pressure

15.3.3.4 Tools, Equipment, Supplies and Materials

- Food models
- Charts
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

15.3.3.5 References

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15.3.4 Learning Outcome 3: Demonstrate understanding in nutrition management of respiratory and febrile disorders

15.3.4.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under respiratory and febrile disorders as per resource materials, policies and guidelines	• Use terminologies in respiratory and febrile disorders • Apply knowledge of the respiratory system in respiratory disease management
2. Identify and describe disorders of upper, lower respiratory tract, febrile disorders and their nutrition management as per resource materials, policies and guidelines	• Plan and implement a diet plan for respiratory and febrile disorders • Apply existing guidelines and policies and in management I management of respiratory and febrile disorders

15.3.4.2 Information Sheet

Cough

Cough is caused by foreign or irritating substances in the bronchial tubes. It is the body's defense mechanism to expel foreign or irritating substances from the bronchial tubes. It is the most common symptom of a respiratory disease.

Aim of nutrition management

- To boost the body's immune system
- relieve the cough

Nutrition Management of Coughs

- Intake of lemon juice with honey which is a traditional remedy for coughs is recommended
- Provide foods rich in Vitamin A as it is vital for healthy bronchial mucosa and helps relieve cough
- Provide foods rich in vitamin C as it boosts body's immunity to effectively fight infections
- Reduce intake of salt as it may cause fluid retention in the respiratory system hence aggravate cough

- Reduce intake of dairy products as they may increase mucous production in the respiratory tract which can trigger or aggravate cough

Bronchitis

This is the inflammation of the mucosa lining the bronchial passages. Bronchitis is caused by infections and is exacerbated by inhalation of irritant fumes such as tobacco smoke.

Symptom

- Cough and expulsion of mucus

Aim of Nutritional management

- To aid expulsion of mucous
- To relieve the cough

Nutritional Management

- Use of mucolytics such as onions, leek and radishes is recommended
- Provide emollients such as okra, dates and figs as they soften and reduce inflammation in the respiratory mucosa
- Use of foods with antibiotic and antiseptic properties such as garlic and propolis is recommended as they combat bacteria and viruses that cause or aggravate bronchitis
- Encourage intake of lemon juice with honey which is a traditional remedy for coughs
- Provide foods which are rich in vitamin A as it is vital for healthy bronchial mucosa and helps relieve cough

TUBERCULOSIS (TB)

Tuberculosis (TB) is caused by bacteria known as *Mycobacterium typhi.* TB can affect several body parts including lungs, spine, and bones among others. Nutrition is a principal determinant of morbidity and mortality from tuberculosis. TB increases as one passes from well-to-do to poor populations. There is good epidemiological and clinical evidence that malnutrition contributes up to 60% of both the incidence and severity of tuberculosis. Together with poverty, overcrowding and HIV, poor nutrition has contributed to a global problem of TB "TRIPPLE TROUBLE", i.e. Malnutrition, TB and HIV.

Symptoms associated with TB

- Cough lasting 2 weeks or more
- Fever/night sweat-which increase calorie requirement (10% extra calorie per every 1°c rise in body temperature
- Loss of appetite-compromises nutrient intake leading to poor nutritional status

- Weight loss-compromise health and nutritional status predisposing the clients to frequent, prolonged and severe infections due to impaired immunity
- Blood in the sputum-increase energy demand and loss of blood/iron predisposing the clients to anaemia and other infections
- Oozing matted lymph nodes or enlarged lymph nodes-increase protein/micronutrients requirement for tissue repair
- Breathlessness and fatigue – pulmonary effusion, pericarditis-increases energy need

Nutrition implications of TB

- Reduced protein synthesis and metabolism
- Nutrient deficiency
- Reduced immunity
- Reduced food and nutrient intake
- Increased nutrient requirements

Note: *Nutrition status is a principal determinant of morbidity and mortality from tuberculosis*

Objectives of Nutrition Care and Management of TB patients

The general objectives in nutritional care and management of TB patients are;

- Maintain good nutrition status
- Prevent and control body wasting and weakness
- Correct nutritional deficiencies which may have occurred during the disease
- Modify diets to the body's ability to metabolize nutrients during TB disease
- Accelerate healing process

Nutrient Requirements and Dietary management

Energy

Most patients with chronic tuberculosis are malnourished, energy needs are increased in order to minimize weight loss and achieve a desirable weight. An additional 300- 500 kcal (35 -40 kcal per ideal body weight) is recommended. This will help in protein sparing.

Protein

An intake of 1.2- 1.5 g of protein per kg body weight is required to generate serum albumin levels per day, due to tissue wasting and repair of worn out tissues.

Fats/ oils

These should provide 25-30% or less of the total energy requirements of an individual.

Vitamins and minerals

The body should be provided with liberal amounts of vitamins and minerals. In TB conversion of beta carotene to retinol is affected in the intestinal mucosa. The client should be supplemented with vitamin A (as per the National Vitamin A supplementation schedule) and encouraged to eat vitamin A rich foods.

Patients on isoniazid should ideally be supplemented with 10mg of pyridoxine B6 daily since the drug inhibits its absorption. Additional amounts of vitamin C is recommended in the diet to facilitate healing of lesions. Other antioxidants (Vit A, C, and E, folic acid, zinc and selenium) neutralize free radicals and prevent the production of peroxides from lipids.

Water

At least 8 glasses (250ml) or more of safe drinking water per day

Food/Nutrient Based Interventions for TB Patients

Without malnutrition or with mild malnutrition; provide nutrition education and counseling on good nutrition practices (CNP), follow-up and closely monitor

Moderate malnutrition; provide nutrition education and counseling, food and multiple micronutrients and conduct regular monitoring and follow-up

Severe acute malnutrition without complications; provide therapeutic feeds, nutrition education and counseling and close monitoring and follow-up (weekly)

Severe acute malnutrition with complications; admit for in-patient stabilization and management of severe malnutrition and close monitoring and follow-up (Daily)

Other interventions in nutrition management of TB include; regular de-worming, vitamin A supplementation as per national schedule, targeted multiple micro nutrient supplementations, health and nutrition education and counseling along CB-DOTS

Side Effects related to TB drugs and food intake recommendations to minimize them

Drug name	Food recommendation	avoid	Possible side effects
Rifampicin	To be taken I hr before or 2 after food. I hr before antacids	Alcohol	Nausea, vomiting, appetite loss
Isoniazid	Taken 1 hr before or 2 hrs after food. Give 10mg B_6 daily	Alcohol	Interferes with
Ethambutol	May be taken with food	Avoid alcohol	
Streptomycin	Increase fluid intake		Taste changes, taste of food, nausea
Pyrazinamide	May be taken with food		
Ethionamide	Take with or after meals(Supplement with Vit B_6)	Alcohol	Abdominal discomforts, nausea
Ofloxacin	Take 2hrs before or after food	Antacids, milk products	

Kanamycin	Can be taken without regard to food		
Capreomycin	Increase fluid intake, take with foods high in potassium (bananas, avocados)		
Para-aminosalicylic acid (PAS)	Take with or immediately after food. Increase fluid intake	Alcohol	
Cycloserine	Supplement with vitamin B_6	alcohol	

ASTHMA

This is a condition which manifest with attacks of dyspnea (difficult breathing) accompanied by wheezing, cough, expectoration and chest pressure. Asthma is caused by allergic reactions.

Symptoms/implications

- Cough
- Wheezing
- Expectoration
- Chest pressure

Aim of nutrition management

- To relieve and prevent asthma attack

Nutrition Management

- Provide antioxidants such as vitamins A, C and E as they enhance bronchial tubes' ability to withstand free radicals coming from environmental pollution
- Provide honey as it contains some pollen which can desensitize the body against environmental pollen
- Encourage consumption of onions. Onion is a bronchial dilator and antispasmodic which can relieve and prevent asthma attacks
- Reduce intake of food additives, salt, wine, beer and fish. Fish contains histamine which provokes all allergic reactions

15.3.4.3 Self-Assessment

1. Describe the nutritional management of chronic cough
2. Outline the symptoms of asthma
3. Explain the nutrition implications of asthma
4. Foods which are rich in _____as it is vital for healthy bronchial mucosa and helps relieve cough
   A. Vitamin A
   B. Calcium
   C. Vitamin E
   D. Zinc
5. The following are nutrition implications of TB except:
   A. Nutrient deficiency
   B. Reduced immunity
   C. Reduced food and nutrient intake
   D. Reduced nutrient requirements
6. Which one of the following is a side-effect of Rifampicin in management of TB?
   A. Taste changes
   B. Nausea
   C. Vitamin loss
   D. Abdominal discomforts
7. Which one of the following is not true about the nutritional management of asthma?
   A. Consume food rich in antioxidants such as vitamins a, c and e
   B. Avoid honey
   C. Encourage consumption of onions.
   D. Reduce intake of food additives, salt, wine, beer and fish.
8. ______is the inflammation of the mucosa lining the bronchial passages.
   A. Asthma
   B. Bronchitis
   C. Tuberculosis
   D. Cough

15.3.4.4 Tools, Equipment, Supplies and Materials

- Food exchange list
- Reference manual
- Drug diet interaction reference
- Calculator
- Stationery (Pen, Paper, referral notes, File)
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

15.3.4.5 References

Anyang'Nyong'o, H. P. P., & EGH, M. Kenya National Clinical Nutrition And Dietetics Reference Manual First Edition.

15.3.5 Learning Outcome 4: Demonstrate understanding in nutritional management of cancers

15.3.5.1 Learning Activities

Learning Activities	Special instructions
• Identify and describe terminologies in cancers as per resource materials, policies and guidelines	• Use terminologies related to cancer
• Identify and describe pathophysiology of cancers as per resource materials, policies and guidelines	• Consider the pathophysiology of cancers
• Identify and describe types of cancers as per resource materials, policies and guidelines	• Observe how different types of cancers affect nutrition
• Identify and describe etiology of cancers as per resource materials, policies and guidelines	• Consider nutritional and non-nutritional factors associated with cancer
• Identify and describe cancer treatment and nutrition implications as per resource materials, policies and guidelines	• Consider cancer treatment options and their effect on nutrition and health • Observe nutritional implications in cancer • Plan diet for cancer patient

15.3.5.2 Information Sheet

Definition of common terms

Cancer: abnormal division and reproduction of cells that can spread throughout the body, crowding our normal cells and tissues

Carcinoma: type of cancer that develops from the epithelial cells of the skin and the tissue lining internal organs like liver & kidneys

Neoplasm: a new and abnormal formation of tissue that serves no useful function; new growth

Sarcoma: a malignant tumour of connective tissue (such as fat and muscle). or other non-epithelial tissue such as bones and connective tissue

Tumor: a solid cancer that causes a swelling or a lump; commonly defined as a malignant neoplasm; it is also a swelling caused by neoplasm

Cancer cachexia: weight loss and lessening of the body's fat and muscle stores that accompany advanced cancer, even with adequate nutrition; may be related to elevated levels of tumor necrosis factor

Carcinogen: an agent (physical, chemical, or viral) that induces cancer in humans and animals

Chemotherapy: the use of chemical agents (rytotoxics, immunologic preparations, hormonals) or medications to prevent the development, maturation, or spread of neoplastic cells

Radiation therapy: use of high-energy rays (ionizing radiation) in multiple fractionated doses to cure, control, or palliate cancer

Metastasis: growth of malignant tissue that spreads to surrounding tissues or organs

Mutation: a permanent change in the gene sequence either due to mistakes when the DNA is copied or as the result of environmental factors such as UV light and cigarette smoke

Benign neoplasm: one which is restricted by its capsule- doesn't spread to other parts of the body

Malignant neoplasm: one which spreads to different parts of the body

Cancer is a general name for more than 100 different diseases in which abnormal cells multiply and divide uncontrollably in the body.

These abnormal cells form malignant growths called tumors.

The common point about all these different diseases is that a particular cell of the body is growing out of control.

Cancer cells do not know "what to do, and when to do"

This division uses up all the resources required by other cells of the body

How Cancer Develops

It's a disease that results from abnormal cell division. The genes in a healthy body work together to regulate cell division and ensure that each new cell is a replica of the parent cell

In this way the healthy body grows releasing dead cells and repairing the damaged ones

Cancers develop from mutations in the genes that regulate cell division. These mutations silence the gene that ordinarily monitors the errors created by replicating DNA. The affected cells thereby lose their built –in brakes for halting cell division.

Cancer is generally named for whatever body part it originates in or the type of tissue it first infects. For instance:

- Adenocarcinomas: found in glandular tissue.
- Sarcomas: found in connective tissue.
- Adenosarcomas: can be found in both gland tissues and connective tissues.
- Leukemias: cancers that affect blood cells.
- Lymphomas: affect the lymph nodes.

Types of Cancer

1. **Throat cancer**

This refers to cancerous tumors that develop in the throat (pharynx), voice box (larynx) or tonsils.

They include;

- **Nasopharyngeal cancer begins in the nasopharynx** : the part of the throat just behind your nose.
- **Hypo pharyngeal cancer (laryngopharyngeal cancer)**: begins in the lower part of the throat, just above the esophagus and windpipe.
- **Glottis cancer:** begins in the vocal cords.
- **Supra glottic cancer** begins in upper portion of the larynx & includes cancer that affects the epiglottis (that blocks food from going into the windpipe).

2. **Ovarian cancer**

It is the most common type of adenocarcinomas that starts from epithelial cells –gland forming cells. Other adenocarcinomas include; those found in the breast, colon, lung, prostate, uterus, sometimes cervix

3. **Breast Cancer**

It is a cancer that develops from breast tissues. In this cancer, cells in the breast grows out of control.

4. **Colon cancer**

This is cancer of the large intestine (colon), the lower part of your digestive system.

5. **Rectal cancer**

It is cancer of the last several inches of the colon.

6. **Colorectal cancer**

It is a cancer that starts in the colon or the rectum. These cancers can also be named colon cancer or rectal cancer, depending on where they start.

7. Ce**rvical cancer**

A malignant tumor deriving from cells of cervix uteri, which is the lower part, the neck of the womb, the female reproductive organ.

Causes of Cancer Development

1. **Mutation or genetic factors**: all cancers have a genetic component in that a mutation causes abnormal cell growth but some cancers have a genetically inherited components as well e.g a person with a family history of colon cancer has a greater risk of developing cancer than a person without such genetic predisposition. This does not mean however the person will develops cancer only that the risk is greater.

2. **Radiation**: Ultraviolent radiation in sunlight and tanning lamps is most likely responsible for the dramatic increase seen in skin cancer in the past several years. Another natural source of radiation is radon gas

3. **Onchogenic Viruses:** DNA viruses such as hepatitis B virus, Epstein-Bar virus and human Papillomavirus - have been linked to human cancer. In china for example almost all people have been infected with the hepatitis B virus and this correlates with the high incidence of liver cancer in that country.

4. **Organic chemicals**: examples of organic chemical that can be carcinogenic include pollutants, certain hormones, food, and tobacco smoke.

   a) **Tobacco smoke:** Tobacco smoke is contains several organic chemicals referred to as carcinogens. Smoking is linked to the development of various forms of cancer such as cancer of the pancreases, kidney, bladder, larynx and mouth. The higher the number of cigarette an individual smokes per day, the earlier the habit starts and the higher the tar content the more likely it is that cancer will develop

   A combination of smoking and alcohol drinking increases the risk of developing cancer. Furthermore, inhalation or passive smoking of other people tobacco smoke is dangerous and it is a probable cause of a few thousands deaths every year.

   b) **Foods (fast foods) and hormones**

   Scientific experimentation involving animal testing on certain food additives such as red dye II when used in high doses cause cancer. In humans, fats and salty food appear to contribute significantly to cancer.

   Furthermore, some studies investigating hormone replacement therapy are suggesting that it is playing a role in the development of breast and uterine cancer in women who have used the hormone for a period of 5 to 10 years.

   Cooking (charring) of meat produces two types of carcinogens;

   i) Polycyclic aromatic hydrocarbons (PAHs)

   ii) Heterocyclic amines (HCAs).

   c) **Pollutants**

   Industrial chemical such as benzene and carbon tetrachloride and industrial materials such as vinyl chloride and asbestos.

5. **Stress factors:** Physiological stress refers to the emotional and physiological relation experienced when an individual confronts a situation in which the demands go beyond their coping resources e.g. stressful situations like marital problems death of loved ones health problems and financial crisis. The body responds to stress by releasing stress hormones such as epinephrine (Adrenaline) Cortison (hydroecortision). The body produces these stress hormones to help a person react to a situation with more speed and strength. Stress hormones increases BP, heart rate and blood sugar levels. Stress that is chronic increases the risk of obesity heart disease depression and various other illnesses. Stress can also lead to unhealthy behavior such as overeating smoking or abusing drugs or alcohol that affects the cancer risks

6. **Obesity:** obesity has been associated with increased risk for colon, rectum, esophagus, liver, pancreas, kidney, gall bladder, uterus, postmenopausal breast, cervical, ovary, stomach and prostate cancers..

Lifestyle factors associated with increased cancer risk

Dietary Factor	Cancer
Overweight & Obesity	Esophagus, pancreas, colorectal, breast (postmenopausal), endometrial, kidney
Alcohol	Oral cavity, esophagus, Liver, colorectal, breast
Salted foods	Stomach, nasopharynx
Red meat	Colorectal
Aflatoxin	Liver
Griled/BBQ Foods	Colorectal, stomach
Very hot foods & drinks	Oral cavity, esophagus

Signs and symptoms of cancer

- Evident adjustment in bowel and bladder habits.
- Visible sore that seem not to heal
- A lump or thickening in any part of the body
- Swallowing difficulties or chronic indigestion
- Variation in a wart or mole
- A continuous cough or consistent hoarse voice

Nutritional implications/consequences of cancer

Two major effects;

i) Changes in eating habits and eating behavior
    - Patient may eat less
    - Alteration of taste hence some foods are less appealing
    - Aggravated dietary problems e.g. food sensitivity

ii) Alteration in the manner in which the body utilizes nutrients. This may be due to;
    - Certain medication
    - Side effects of treatment
    - Body response to tumor

Implications of Cancer

i) **Complications:** Tumor's impingement on surrounding tissues

ii) **Cancer cachexia:** severe malnutrition, anorexia, muscle wasting, weight loss, anemia, and fatigue

iii) **Metabolic changes:**

- Enhanced turnover rates of protein but decreased muscle protein synthesis
- Muscle: used for glucose production
- Elevated serum lipids

iv) Anorexia and reduced food intake due to:

- Chronic nausea and early satiety
- Fatigue
- Pain
- Mental stress
- Gastrointestinal obstructions

Effects of cancer therapies

Cancer-related Defects in nutrient metabolism. The way body uses nutrients is sometimes changed in people with cancer. These changes may be caused by the;

- Body's response to the tumor
- Side effects of treatment
- Certain medications
- Combination of the above reasons
- Cancer-related defects in carbohydrate metabolism
- Glucose intolerance
- Insulin resistance
- Abnormal insulin secretion
- Delayed glucose clearance
- Increased glucose production
- Cancer-related defects in fat metabolism
- Excess body fat depletion relative to protein loss/ increased lipolysis
- Decreased free fatty acids, and glycerol turnover/decreased lipogenesis
- Hyperlipidemia
- Decreased serum lipoprotein lipase activity
- Cancer-related Defects in Protein metabolism

- Increased whole-body protein turnover
- Persistent muscle protein breakdown/increased catabolism
- Decreased plasma branched-chain amino acids
- Decrease in protein synthesis
- Negative nitrogen balance
- Malnutrition and cancer

Cancer and its associated oncological treatment cause symptoms that increase the likelihood of a patient to suffer from malnutrition. The resultant effects have negative effects on patients health. Some of these effects include:

- A decline in patient's quality of life
- Minimizing tolerance to the oncology treatment
- Rising the number of complications

Malnutrition is a common problem in cancer patients that has been recognized as an important component of adverse outcomes, including;

- Increased morbidity and mortality
- Decreased quality of life
- Diminished tolerance to therapy
- Lower survival rates
- Longer hospitalization

Management of Cancer

1. **Medical Management**
    - Surgery
    - Radiation
    - Chemotherapy
    - Immunotherapy
    - Marrow transplantation
2. **Nutrition Management**
    - Prevent or correct nutrition deficiency
    - Minimize weight loss
    - Oral feeding
    - Enteral tube feeding
    - Parenteral feeding.

Nutrition care support for cancer patients

Individuals living with cancer have three main goals:

i) Maintaining a healthy weight

ii) Select and eat healthy diets that provide the body with nutrients and fuel needed for healing and repairing

iii) To avoid reappearance of cancer and the emergence of second malignancy

Nutrition care support for cancer patients

Good nutrition practices can help cancer patients to:

- Maintain weight
- Maintain body's nutrition stores
- Improving quality of life.

Nutrition support plays a major goal in two main areas:

i) Curative oncology care

ii) Palliative care.

In curative oncology care, nutrition contributes to:

i) Reduced postoperative infection rate

ii) Better control of cancer-related symptoms

iii) Shortened length of hospital stay

iv) Improved tolerance to treatment

In palliative care, the nutritional intervention focuses on controlling symptoms, thus improving quality of life.

Treatment

Cancer cells are our cells. Killing them=killing ourselves. The main treatments available include

i) Surgery – recurs

ii) Chemotherapy – damages normal cells

iii) Radiotherapy – damages nearby cells. Still, prevention is cure

iv) Limiting tobacco exposure

v) Limiting alcohol intake

vi) Modifying diet

vii) Limiting exposure to UV rays

viii) Screening programs - When abnormal tissue is found early stage, it may be possible to treat it completely.

How cancer treatment may affect nutrition

1. **Surgery:** Often the preferred treatment for tumors that haven't spread. Tumor and any nearby tissue that may contain cancer cells are removed. The surgery decision depends on type of cancer, location and the extent it has spread to other body parts. Surgery can cause temporary or permanent nutritional challenges.

Nutritional considerations for surgery

• The operation itself will increase the need for calories to do the extra work of healing

- Increase caloric and protein intake for healing
- Address the issues of long term nutritional problems in case of GI resection
- Address any challenges of chewing and swallowing as well as poor absorption of nutrients in the intestines

2. **Radiation Therapy:** High nervy waves are used to damage cancer cells inhibiting their inability to multiply. Common problems associated with this form of treatment include;

    - Irritation of the mouth, tongue and throat
    - Milk intolerance
    - Nausea
    - Vomiting
    - Diarrhea

    Later problems include:

    - Dry mouth
    - Narrowing of esophagus
    - Malabsorption of nutrients
    - Abdominal discomfort
    - Diarrhea
    - Constipation

3. **Chemotherapy:** It uses of drugs to destroy cancer cells by disrupting their ability to grow and multiply. However, it is systematic in that it can affect the whole body rather than a given part. Some of its major effect include

    - Nausea
    - Vomiting
    - Hair loss
    - Fatigue

    Other effects include:

    - Constipation or diarrhea
    - Change in taste
    - Infection
    - Bleeding
    - Anemia

Several factors that adversely affect nutrition include:

- The cancer itself
- The treatment modality prescribed (including chemotherapy, radiation therapy, and surgery)
- The current health and nutrition status of the individual.

Every years, scientific data reveal that a third of cancer death in united states are attributed to lifestyle and nutritional behaviors such as alcohol use, obesity, overweight, physical inactivity and poor diet. Furthermore, tobacco user and cigarettes smoking is also attributed to another third of cancer deaths

Common mineral and vitamin deficiencies experienced by cancer patients include:

- Folate
- Copper
- Zinc
- Vitamin A
- Iron
- Calcium
- Vitamin C
- Magnesium
- Vitamin D

Diet recommendations for cancer survivors

Cancer survivor may harbor undetected primary or disseminated cancer cells. A "cured" cancer patient is at increased risk for other primary cancers in the same organ or other organ. General dietary guidelines are also appropriate for recovering cancer patient. Dietary regimens should avoid stimulating growth, spread of remaining tumor cells, and provide maximum prevention against new primary tumors. Diet recommendations for cancer survivors include:

- Limit total fat intake to 15-20% of total calories. Monounsaturated fats are preferred.
- Aim for 10-12 daily servings of a variety of whole vegetables and fruits.
- Consume 4-6 servings of whole grains daily.
- Breast cancer patients should eliminate or severely restrict alcohol intake
- Consider a Vitamin E supplement of 200 IU/day to replace deficit from reduced fat intake
- Standard dose multivit daily (not to exceed 100% RDA). This does not replace cancer fighting foods
- Exercise moderately (30 minute daily walk, for example)
- Maintain desirable body weight
- Enteral and parenteral nutrition support

In general, parenteral and tube feedings nutrition are not continuously recommended to adequately nourished cancer patients unable to eat. Nonetheless these approaches are vital to retain status when a patient is thoroughly malnourished or anorexia persist and is about to undergo serious cancer remedy.

How To Help Patients Handle Food Related Problems

In people with cancer, many different problems can interfere with their eating. Health care providers should try to identify the specific problems that patients are having and offer appropriate solutions such as explaining why eating appropriately can help to improve their health. Not all of the suggestions will work for each patient but you should encourage patient's to experiment and find the ones that work best

Problems & solutions

1. **Lack of appetite**: Take small frequent meals, indulge in favorite foods throughout the day, take fruits, serve foods attractively, eat most food at time of day you feel the best, eat with family and friends in a relaxed environment.

2. **Taste alterations**: Brush your teeth or use mouth wash before you eat, add sauces and seasonings to meats, and experiment with herbs and spies

3. **Nausea and vomiting**: Take small but frequent meals, avoid fatty or greasy foods, and suck lemon when you feel nausea. When you experience vomiting, use clear liquids like broths and juices to replace lost electrolytes. If nauseated from chemotherapy, avoid eating at least 2 hours before treatment to avoid vomiting. Chewing and swallowing- take soft diet by changing consistency to the one that suits best. Drink fluids with meals to ease chewing and swallowing. Add sauces and gravies to dry foods. Tilt the head forward and backward to see if one can swallow easily with the head positioned differently.

4. **Mouth sores**: Avoid irritating foods i.e. hot or spicy foods use cold or frozen foods because they are often soothing e.g. ice cream, milk shakes, bananas, mashed potatoes macaroni and cheese. Avoid foods like seeds that can be tracked in the sore and raw vegetables and toast use a straw for drinking liquids to bypass the sores.

5. **Dry mouth**: Rinse their mouth with warm salty water or mouthwash frequently and drink liquids between meals. Use sour candy or gum to stimulate the flow of saliva brush your teeth and floss to prevent cavities and oral infections

6. **Diarrhea**: Patients should be encouraged to drink enough fluids to replace lost fluids and electrolytes e.g. salty soups, broths diluted fruit juice, and sport drinks are good choices for severe diarrhea. Try commercially prepared ORS. Avoid high fat foods and foods made with sugar and fructose. Eat smaller meals but frequently take lactase enzyme replacement when you use milk because you may also experience lactose intolerance while you are having diarrhea or take low fat yoghurt

7. **Constipation**: Take foods rich in fiber eat wholegrain breads and cereals nuts, fresh fruits and raw vegetables. Avoid refined CHO e.g. white bread, white rice and pasta avoid use laxatives e.g. ENO or Actal, instead, take plenty of fluids, exercise regularly

Gastric dumping syndrome or gastric emptingit is a condition where ingested foods bypass the stomach too rapidly and enter the small intestines largely indigested. It happens when the small intestines expands too quickly due to the presence of hyperosmolar (having increased osmolarity) food from the stomach.

Guidelines for cancer prevention

- Select a diet that is inclusive of a variety of plant-based foods.
- Eat plenty of fruits and vegetables
- Be physically active and maintain a healthy weight
- Drink alcohol only in moderation, if at all.
- Select foods low in fat and salt.
- Limit intake of red meat and avoid processed meat
- Prepare and store food safely. Avoid mouldy grains or legumes
- Aim to meet nutritional needs through diet alone rather than supplements
- Mothers to breastfeed; children to be breastfed

- For cancer survivors: follow the recommendations for cancer prevention
- Patients should be advised to avoid using tobacco in any form.

CASE STUDY

Design a diet plan for a cancer patient, aged 42 years who was diagnosed with CA oesophagus, who is feeding through gastrostomy tube. She weighs 54 kg.

I. Describe the process of tumor formation

II. Discuss factors that contribute to cancer development

III. What is cancer cachexia?

IV. Explain how cancer and its treatments can cause alterations in food intake and metabolism and possibly lead to malnutrition

V. Discuss the elements of medical nutrition therapy for cancer as well as strategies that can improve food intake

15.3.5.3 Self-Assessment

1. Identify five signs of cancer
2. List common mineral and vitamin deficiencies experienced by cancer patients
3. Discuss the management of the following nutrition related problems:
   A. weight loss and loss of appetite
   B. weight gain
   C. diarrhea
   D. constipation
   E. nausea
   F. food odors
   G. vomiting
4. ________ is a type of cancer that develops from the epithelial cells of the skin and the tissue lining internal organs like liver & kidneys
   A. Tumor
   B. Carcinoma
   C. Sarcoma
   D. Carcinogen

5. State whether the following statements are TRUE or FALSE
   A. Family history of cancer does not increase the risk of developing cancer
   B. Smoking and alcohol drinking increases the risk of developing cancer.
   C. Adjustment in bowel and bladder habits maybe a symptom of cancer
   D. One should limit intake of red meat and avoid processed meat to prevent cancer

15.3.5.4 Tools, Equipment, Supplies and Materials

- Charts
- Food models
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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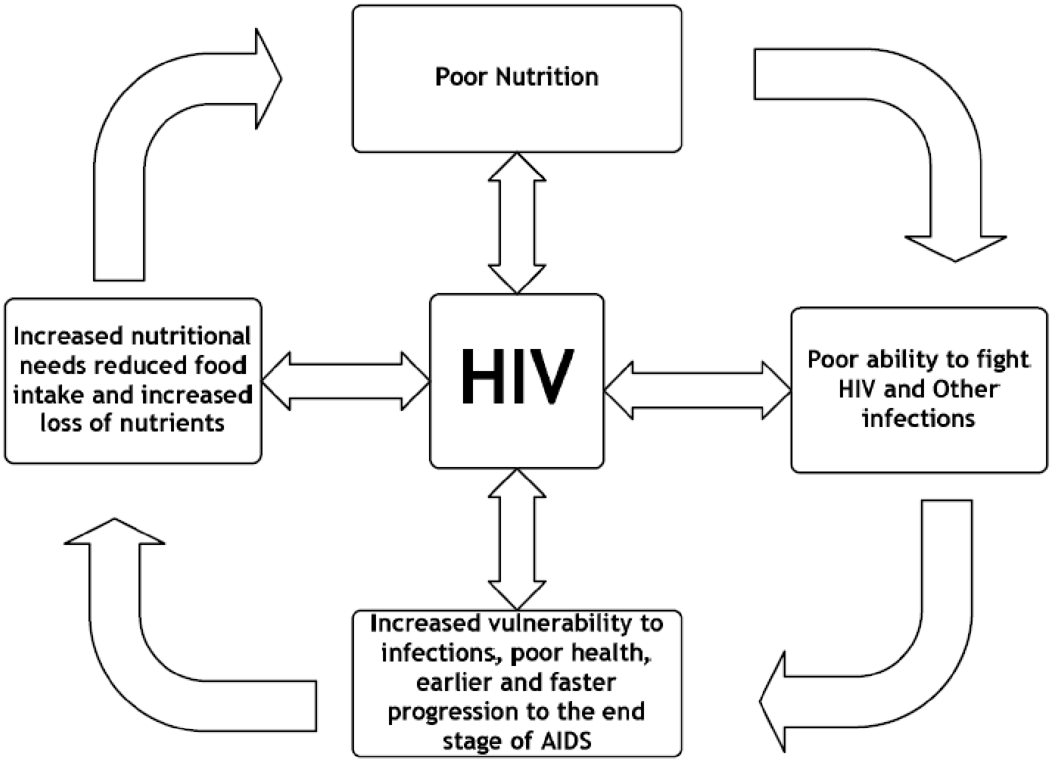
15.3.6 Learning Outcome 5: Demonstrate understanding in nutritional management of HIV and AIDS

15.3.6.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies in HIV and AIDS as per resource materials, policies and guidelines	• Use terminologies in HIV/AIDS
2. Identify and describe the relationship between malnutrition and HIV and AIDS, and the roles of nutrition in management of HIV and AIDS Terminologies in cancers as per resource materials, policies and guidelines	• Consider the relationship between malnutrition and HIV/AIDS • Consider the role of malnutrition in HIV and AIDS management • Prevent malnutrition in people living with HIV/AIDS • Manage malnutrition in HIV/AIDS
3. Identify and describe oopportunistic infections and their nutritional management as per resource materials, policies and guidelines	• Consider opportunistic infections and their implications on nutrition • Plan a diet for the management of opportunistic infections
4. Demonstrate knowledge on Infant and young child feeding in the context of HIV and AIDS per resource materials, policies and guidelines	• Apply guidelines for infant and young child feeding in the context of HIV and AIDS
5. Demonstrate knowledge on nutrient drug interactions in ART as per resource materials, policies and guidelines	• Manage nutrient drug interactions • Modify diet to mitigate food-drug interactions

15.3.6.2 Information Sheet

HIV/AIDS and nutrition are strongly interrelated. Malnutrition can quicken the progression of HIV and HIV can lead to malnutrition. A vicious cycle is created by the relationship between HIV/AIDS and malnutrition because HIV weakens immune system. In turn, this results in more infections. Infections have ability to cause anorexia and increase energy needs. Furthermore, high levels of infections (in severity and number) result in inadequate food intake, loss of appetite and finally malnutrition. Malnourished individuals are at a higher more risk of infections exposing them to HIV and the cycle continues.



The Cycle of Nutrition and Infection in the context of HIV/AIDS

In light of the HIV and nutrition vicious cycle, it is imperative that nutrition interventions are put in place to slow disease progression and improve the individual's immunity.

HIV can be transmitted through various ways such as:

- Transfusion of blood infected with the virus
- Having unprotected sexual intercourse with an infected person
- Use of contaminated needles and injections/skin pricking instruments
- Vertical transmission from infected mothers to child during pregnancy,
- delivery or through breastfeeding

Implications

- Suppressed body immunity
- Increased susceptibility to infections
- Altered metabolism-high catabolic rate
- Decreased body cell mass
- Malnutrition
- Altered body weight (overweight or underweight)

Aims of Nutritional Management

- Maintain and improve nutrition status of a person living with HIV/ AIDS thus delay the progression from HIV to AIDS related diseases
- Ensure adequate intake of all nutrients thus preventing development of nutritional deficiencies
- Preservation of lean body mass
- Maintain body weight and fitness
- Improve performance of immune system
- Replenishment of nutrient losses incurred during infection
- Minimizing symptoms of malabsorption
- Regeneration of glycogen stores
- Maintain laboratory values within normal limits
- Control side effects due to medication—refer to the section on drug-nutrient interaction

An efficient support and nutritional program improves the quality of life for PLWHA by:

- Maintaining body strength and weight
- restoring lost minerals and vitamins
- Enhancing the role of body's ability to fight infection and the immune system.
- Lengthening the duration from infection to development of the AIDS disease.
- Enhancing response to medication by reducing money and time spent on health care.
- Sustaining HIV infected individuals active by giving them an opportunity to take care of themselves, their children and family.

Nutrient requirements for PLHIV

People living with HIV exhibit increased nutrients need due to:

- Nutrient malabsorption
- Increased resting energy equilibrium (REE)
- Viral load
- Opportunistic infections (OIs) that extend energy need

Nutrition Requirements in HIV/AIDS

Energy Requirements by Disease Stage

Population group	HIV phase	Energy requirements
Adult	Asymptomatic	10% (200-260kcal)increase (eq. to 1 mug thick enriched porridge)
	Symptomatic	20-30% (420-630kcal) increase (eq. 2-3 mugs of thick enriched porridge).
Pregnant/lactating women	Asymptomatic	10% increase
	Symptomatic	20-30% increase
Children	Asymptomatic	10% increase
	Symptomatic (with no weight loss)	20-30% increase
	Symptomatic (with weight loss)	50-100% increase

Protein Needs

The World Health Organization maintains that HIV infected people should not increase their protein intake. Rather, they have similar protein intake just like healthy non-HUIV infected adults. Generally, for a healthy non-HIV infected adult, the recommended protein intake is 12-15% of the total energy or 0.85g/Kg for males and 0.8g/Kg for females. However, there are certain factors that are likely to increase protein need such as pressure, ulcers, trauma, infection, surgery or illness. Hence, it is a necessity to consider initial and concurrent protein deficiencies.

Furthermore, proteins are used to provide body with energy on condition that energy intake is not limited. This implies that the body will have fewer protein required to strengthen and maintain muscle tissue while children will have less protein necessary for development and growth. Hence, having enough energy intake is important at all times specifically during infections. In this manner, proteins may be utilized in maintaining and building lean muscles as well as strengthening the immune system

Fat Needs

The World Health Organization maintains that HIV infected persons should not have an increased fat intake than the one recommended for healthy non-HIV infected people. Dietary fats is a good origin of concentrated energy, vitamins and essential fat. Furthermore, fat plays an important role to in catering for increased energy requirements provide that the patient is not having diarrhea and fat malabsorption. However, the World Health Organization Technical Advisory Group on nutrition and HIV/AIDS observed that personalized advice concerning fat intake is necessary on person with persistent diarrhea and ones on anti-retroviral therapy. In general, the recommended fat intake for healthy adult should be less than 30% of the total energy required

Micronutrients

Individuals infected with HIV have micronutrients deficiency in mineral such as selenium, iron zinc and Vitamin A, C, E, B6, B12 and folate due to excessive loss in urine. Rectifying these deficiencies when they exist play a major role in slowing down the progression of the disease

Critical Nutrition Interventions for PLWHA

1. Advise the patient to have occasional nutritional assessment status specifically of their weight; after every 2nd month for symptomatic patients and after every 4th month for asymptotic patients
2. Counsel and educate PLWHA about the heightened energy requirements for their disease stage and the necessity of consuming balanced diets. Patients with serious malnutrition should be supported with therapeutic supplementary diets
3. Support and educate patients on the need to always maintain high degrees of food hygiene, sanitation and safety
4. Advice the patients to maintain engage in positive living behaviors such as practicing save sex, avoiding non-prescribed drugs and cigarettes as well as use moderate or avoid alcohol
5. Encourage patients to engage in physical exercises or activities in order they improve their health, increase their appetite and build their muscles
6. Encourage patients to drink plenty of safe water and use clean and safe water while taking their medication
7. Advise patients to seek immediate treatment incase on opportunistic symptoms and infections especially those that inhibit their food intake
8. Advise those under medication (ARV) on the need to manage the food-drug interaction and the reactions that can be managed by nutrition and food interactions

Management of Common problems on Food intake in HIV/AIDS

Condition	Management
Loss of appetite	• Minimize foods with strong odors. • Try different foods until you find those that you like and try to have a mixed diet • Encourage intake of small frequent meals more often • Use spices and seasonings to improve food aroma and taste. Squeeze some lemon juice over it or add spices such as cardamom, fennel, coriander and cinnamon • Encourage patients to eat food in relaxed atmosphere • Use calorie dense supplements/foods • Take light exercise such as walking outdoors • Eat in a well ventilated room away from cooking or unpleasant smells • Avoid alcohol, it reduces appetite, weakens the body and interferes with medicines Avoid fizzy drinks, beer and foods such as cabbage, broccoli and beans that create gas
Nausea and Vomiting	**General** • Sit up when eating, try not to lie down until 1hr or 2hrs after eating • Try not to prepare food yourself to avoid smell which may worsen nausea • Encourage small frequent meals. Alternating dry and fluid feeds • Drink plenty of fluids after meals • Chew food thoroughly and slowly **Recommended** • Keep drinking small amounts of water, soups and spice teas, eat soft foods and go back to solid foods when the vomiting stops • You may relieve the feeling by smelling fresh orange or lemon peel or drinking lemon juice in hot water or a herbal or ginger tea • Eat dry and salty foods such as toast, crackers and cereals • Eat promptly when hunger is first felt • Fluids should be drunk after 30 minutes after meals rather than with meals **Foods to avoid** • Fats, fatty foods and greasy foods • Highly seasoned foods • Very sweet foods • Eliminate one food at a time from the diet to see if it makes a difference
Change in taste	• Ensure your mouth is clean by brushing with a soft brush and rinsing often. Rinse your mouth before eating • Enhance taste attitude by using peppermint or sour candy • Refrain from coffee, chocolate, fried or greasy foods, and red meat

	• Use trial and error method to determine the food that taste good and the one that is not acceptable. Note that your list of acceptable and unacceptable may temporally change • Ensure that you serve food in an attractive manner with different textures and colors to enhance appearance • You should find options to enhance the appeal and flavor for your food by using different spices
Malabsorption	• In severe malabsorption parenteral nutrition is recommend • Treat underlying cause • Based on patient's tolerance provide low fat, lactose free or low lactose caffeine free diet
Heartburn and indigestion	• Have 5 to 6 meals in a day • Put on loose clothing around the waist • Rather than lying down after meal, walk • Abstain from fried, fatty, spicy foods and beverages and foods with caffeine
Anorexia	• Refer to a counselor or psychiatrist if it is related to depression or any other psychological conditions • Use calorie dense supplements/foods
Early satiety	• Avoid serving liquids during meals. Can be taken one hour before or after meals
Diarrhea	• Encourage fluids to replace losses • Minimize insoluble fiber intake and increase soluble fiber • Refrain from using alcoholic beverages, caffeinated drinks, juices and citrus fruits • ORS may be considered to cater for electrolyte imbalance. • If severe parenteral nutrition is recommend • Treat underlying cause
Oral sores	• Use bland, cold, soft/liquid diets • Avoid acidic foods and fizzy drinks
Lactose intolerance	• Avoid milk and milk products
Fat malabsorption	• Avoid fats and fatty foods. Encourage low fat diets • Use preparations with medium chain triglycerides
Anemia	• Treat for malaria in case it is the underlying cause • If on Zidovudine hemoglobin assessment at least every 3 months is recommend • Consumption of tea & coffee should be 1 hour after or before meals • Recommend foods rich in both Iron and vitamin C
Fever	• Treat underlying cause • Encourage intake of plenty of fluids and safe water • Encourage intake of energy dense food • Ensure that you rest in a well-ventilated room with fresh air

Muscle wasting	• In case of > 10% weight loss refer the client for assessment for ARVs • Treat underlying cause • Monitor weight monthly

Effects of HIV/AIDS on Nutrition

- Decrease in amount of food consumed. This caused by:
    - o Mouth and throat sores
    - o Reaction from medication
    - o Poverty and food insecurity in a household
- Impaired nutrient absorption, caused by:
    - o HIV infection of intestinal cells
    - o Frequent diarrhea and vomiting
    - o Opportunistic infections
- Changes in metabolism. This is caused by:
    - o Increase in energy (10-15%) requirements
    - o Infection increases demand for and utilization of antioxidant vitamins (A, C & E) and minerals (zinc, selenium, iron)
    - o Insufficient antioxidants from increased utilization causes oxidative stress

    This increases HIV replication
- Weight loss associated with HIV infection, disease progression, and mortality. This is caused by :
    - o Poor absorption of fats that affects use of fat-soluble vitamins such as A &E.
    - o Some nutrient deficiencies (Vitamins A, B12, and E, selenium and zinc) associated with HIV transmission, disease progression and mortality
    - o Leads to higher viral loads

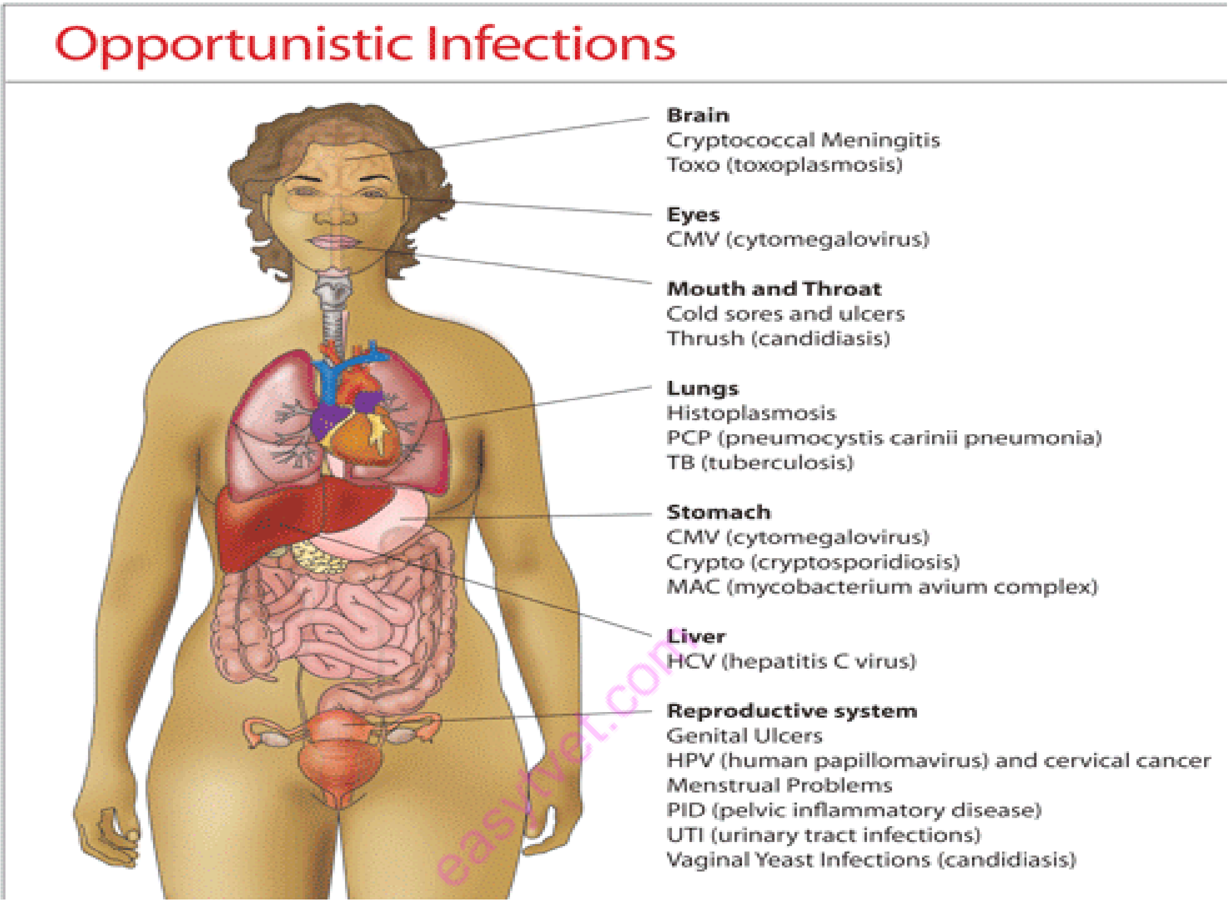
Opportunistic Infections

People with advance HIV infection are vulnerable to infections and malignancies that are called ‘opportunistic infections’ because they take advantage of the opportunity offered by weakened immune system.

Common opportunistic infections include;

- Bacterial diseases such as tuberculosis, bacterial pneumonia and septicemia (blood poisoning)
- Protozoal diseases e.g. toxoplasmosis, histoplasmosis micrporidiosis and penicilliosis
- Viral disease e.g. those caused by cytomegalo visus, herpes simplex, and herpes zoster virus

- Fungal diseases such as PCP, candidiasis, cryptococcosis and penicilliosis
- Parasites e.g. giardia, toxoplasma, strongyloides, cryptosporidium, cyclosprora
- HIV-associated malignancies e.g. Kaposi's sarcoma, lymphoma and squamous cell carcinoma.



TUBERCULOSIS (TB)

Tuberculosis (TB) is caused by bacteria known as Mycobacterium typhi.It can affect several body parts including lungs, spine, and bones among others.

It is the leading HIV-associated opportunistic infection (OI) in developing countries.

Risk of developing active TB among PLWHA is 30-50% higher than people infected with TB alone.

The bacteria are spread through air.

Effective treatment with a proper combination of anti-TB drugs makes the individual non-contagious, which prevents further spread of the TB germ.

Complete cure takes 6 to 8 months and uses a combination of antibiotics.

Isoniazid preventive therapy is recommended as a health-preserving measure for HIV-infected persons at risk of TB, as well as for those with latent TB infection.

Nutrition is a principal determinant of morbidity and mortality from tuberculosis.. There is good epidemiological and clinical evidence that malnutrition contributes up to 60% of both the incidence and severity of tuberculosis. Together with poverty, overcrowding and HIV, poor nutrition has contributed to a global problem of TB "TRIPPLE TROUBLE", i.e. Malnutrition, TB and HIV.

Symptoms Associated With TB

- Cough lasting 2 weeks or more
- Fever/night sweat-which increase calorie requirement (10% extra calorie per every 1 rise in body temperature
- Loss of appetite-compromises nutrient intake leading to poor nutritional status
- Weight loss-compromise health and nutritional status predisposing the clients to frequent, prolonged and severe infections due to impaired immunity
- Blood in the sputum-increase energy demand and loss of blood/iron predisposing the clients to anaemia and other infections
- Oozing matted lymph nodes or enlarged lymph nodes-increase protein/micronutrients requirement for tissue repair
- Breathlessness and fatigue – pulmonary effusion, pericarditis-increases energy need.

Nutrition Implications of TB

TB affects nutrition in the following ways:

- Reduced protein synthesis and metabolism
- Nutrient deficiency
- Reduced immunity
- Reduced food and nutrient intake
- Increased nutrient requirements.

Note: Nutrition status is a principal determinant of morbidity and mortality from tuberculosis.

Objectives of Nutrition Care and Management of TB Patients

The general objectives in nutritional care and management of TB patients are;

- Maintain good nutrition status
- Prevent and control body wasting and weakness
- Correct nutritional deficiencies which may have occurred during the disease
- Modify diets to the body's ability to metabolize nutrients during TB disease
- Accelerate healing process.

Nutrient Requirements and Dietary Management

Energy:

Most patients with chronic tuberculosis are malnourished, energy needs are increased in order to minimize weight loss and achieve a desirable weight. An additional 300- 500 kcal (35 -40 kcal per ideal body weight) is recommended. This will help in protein sparing.

Protein:

An intake of 1.2- 1.5 g of protein per kg body weight is required to generate serum albumin levels per day, due to tissue wasting and repair of worn out tissues.

Fats/ oils:

These should provide 25-30% or less of the total energy requirements of an individual.

Vitamins and minerals:

The body should be provided with liberal amounts of vitamins and minerals. In TB conversion of beta carotene to retinol is affected in the intestinal mucosa. The client should be supplemented with vitamin A (as per the National Vitamin A supplementation schedule) and encouraged to eat vitamin A rich foods.

Patients on isoniazid should ideally be supplemented with 10mg of pyridoxine B6 daily since the drug inhibits its absorption. Additional amounts of vitamin C is recommended in the diet to facilitate healing of lesions. Other antioxidants (Vitamin A, C, and E, folic acid, zinc and selenium) neutralize free radicals and prevent the production of peroxides from lipids.

Water:

At least 8 glasses (250ml) or more of safe drinking water per day

Side Effects related to TB drugs and food intake recommendations to minimize them

Drug name	Food recommendation	avoid	Possible side effects
Rifampicin	To be taken I hr before or 2 after food. I hr before antacids	alcohol	Nausea, vomiting, appetite loss
Isoniazid	Taken 1 hr before or 2 hrs after food. Give 10mg B_6 daily	Alcohol	Interferes with
Ethambutol	May be taken with food	Avoid alcohol	
Streptomycin	Increase fluid intake		Taste changes, taste of food, nausea
Pyrazinamide	May be taken with food		
Ethionamide	Take with or after meals (Supplement with Vit B_6)	Alcohol	Abdominal discomforts, nausea
Ofloxacin	Take 2hrs before or after food	Antacids, milk products	
Kanamycin	Can be taken without regard to food		
Capreomycin	Increase fluid intake, take with foods high in potassium(bananas, avocados)		

Para-aminosalicylic acid(PAS)	Take with or immediately after food. Increase fluid intake	Alcohol	
Cycloserine	Supplement with vitamin B_6	alcohol	

Infant and Young Child Feeding in the Context of HIV/AIDS

An infant is a child from birth to 12 months of age. There are two main options of feeding HIV exposed infants:

- o Breastfeeding
- o Alternative feeding

Breastfeeding is with appropriate use of anti-retroviral drugs for mother and baby is the best option for overall well-being and survival of HIV exposed children

All HIV positive pregnant women should be put on ART and the exposed child receives prophylaxis for 6 months

Once ARV is started, it is taken for life

Exclusive breastfeeding: Mother gives her infant only breastmilk, not even water, except for drops or syrups consisting of vitamins, mineral supplements, or medicines (when indicated).

MTCT and Breastfeeding

- ARV treatment and prophylaxis can reduce MTCT of HIV by at least 50%.
- ARV prophylaxis does not provide long-term protection for breastfed infant.
- Without interventions (ARV prophylaxis or therapy) 5–15% of infants born to mothers infected with HIV can become HIV-infected during breastfeeding.
- Mothers living with HIV should breastfeed for at least 12 months or longer while being supported for ART adherence

Infant Feeding Options

1. Exclusive breastfeeding
2. Exclusive with early cessation
3. Wet nursing- baby is nursed and cared for by a different mother from the biological one.
4. Expressing and heat-treating
5. Replacement feeding

Guidelines for feeding infants & young children

1. HIV negative mothers should exclusively breastfeed for the first 6 months and continue

breastfeeding with appropriate complementary feeding after 6 months and continue breastfeeding for at least 24 months

2. HIV infected mothers to exclusively breastfeed for 6 months, introduce complementary feeding at 6 months and continue breastfeeding for 12 months.
    - Mother should be on retroviral treatment while the infant should be on prophylaxis
3. Reactive mums who choose not to breastfeeding should be guided to choose AFASS (Affordable, Feasible, Acceptable, Safe and Sustainable) food for exclusive replacement feeding (e.g. infant formula). The infant should be on prophylaxis for 6 weeks.
4. The counseling on exclusive replacement feeding should be in line with Breast Milk Substitute Regulation and Control (BMS) act.
5. If HIV infected mum should stop breastfeeding gradually and prophylaxis should continue for a week after stopping.
6. If mother and infant are HIV infected, exclusive breastfeeding shall be practiced with introduction of complementary feeding at 6 months but baby and mother should be put on ART.

Benefits of Breastfeeding

- Adequate nutrition
- Best source of food security for infant
- Brest milk provides nutritional needs for up to 6 months
- Provides enough water (contains aprox. 87%)-no additional water required
- Easily digested & its composition changes to meet developmental needs of the growing infant
- Contains enzymes which help complete digestion of fat
    - o Breastfeeding is natural and most economic method of feeding the infant
- Protection against infections
    - o Colostrum contains high levels of immunoglobulin, essential for immune system
    - o Milk provides vital protection against deadly childhood infections e.g. diarrhea & respiratory infections
    - o Breast milk protects the baby against viruses, bacteria and allergy

Benefits to the mother

- o Promotes bonding between the mother and baby
- o Exclusive breastfeeding has no demands on the mother
- o May help prevent the mother from getting pregnant

- Helps the uterus to contract after delivery and reduces postpartum bleeding
- Reduces the risk of breast, ovarian and other reproductive cancers

Benefits to the community

- Cost effective
- Lowers morbidity and infant mortality rate

- Whatever infant feeding choice a mother makes, she should be supported

Advantages and Disadvantages of Exclusive breastfeeding in the Context of HIV/AIDS

Advantages:

- Easily digestible
- Nutritious, complete
- Always available
- No special preparation needed
- Reduces mother's risk of breast cancer
- Increases birth spacing
- Protects from diarrhoea, pneumonia, other infections/diseases
- Compared to mixed feeding, lowers risk of HIV
- Promotes bonding

Disadvantages:

- Risk of passing HIV to baby
- Increased risk if mother has breast infection
- Increases risk of death in immunosuppressed women
- Mother requires additional calories to support breastfeeding
- Requires feeding on demand.

Management of Early Cessation

- Express enough breastmilk to prevent engorgement and reduce discomfort.
- Encourage early practice of cup or cup and spoon feeding with expressed breast milk.
- Enlist family members to assist with feeding and comforting of the infant.
- Alternate warm/cold compresses to reduce breast discomfort and swelling.
- Provide assurance that challenges are time-limited.

Replacement Feeding

This refers to when a child who is not breastfed is provided with an alternative that provides all the nutrients that the child needs. This can be in the form of:

- Commercial infant formula
- Home-modified formula with micronutrient supplements

Important considerations to make include:

- Cost and sustained availability
- Reliable sources of animal milk products and multinutrient supplements
- Education in safe preparation and storage

Cup feeding is recommended over bottle feeding

Advantages of Replacement feeding

- No risk of transmitting HIV to the infant
- Contains most nutrients needed by infant
- Other family members can help feed the infant

Disadvantages of Replacement Feeding

- Expensive
- Contains no antibodies to protect infant
- Can increase risk of diarrhoea
- May not contain all the nutrient requirements for the infant
- Can be more difficult to digest
- Must be carefully prepared and stored

Replacement feeding should be:

- A-Acceptable
- A-Affordable
- F-Feasible
- S-Sustainable
- S-Safe

- **Acceptable**
    - o The mother perceives no barrier, cultural or social, to replace feeding and has no fear of stigma. She will be able to cope with pressure from family and friends to breastfeed.

- **Feasible**
    - o The mother has adequate time, knowledge, skills and other resources to prepare the replacement food and feed the infant up to 12 times in 24 hours.
    - o Need for reasonable home infrastructure and family support, especially for night feeds
    - o Availability of electricity, electric kettle, bottle cleaning brush, flask to store boiled water etc

- **Affordable**
    - o The mother and family can purchase formula, including all ingredients, fuel, clean water, soap and equipment, without compromising the health and
- **Sustainable**
    - o Availability of a continuous and uninterrupted supply and dependable system of distribution of formula for as long as the infant needs it
    - o If provided for free, will supply system be able to cope?
    - o Will mother always be able to find it when needed
- **Safe**
    - o Replacement foods are correctly and hygienically prepared and stored, and fed in nutritionally adequate quantities, with clean hands and clean utensils, preferably by cup
    - o Is there a safe water supply?
    - o Can water be hot each time?
    - o Nutrition of the family and also possible increased medical costs

Expressing and Heat Treating Breast milk

Mothers known to be living with HIV may consider expressing and heat-treating breast milk as an interim feeding strategy. Expressing breast milk is necessary in the following circumstances:

- In special circumstances, such as when the infant has low birth weight or is otherwise ill in the neonatal period and unable to breastfeed
- When the mother is unwell and temporarily unable to breastfeed or has a temporary breast health problem such as mastitis
- To assist mothers in stopping breastfeeding
- If ARV drugs are temporarily not available.

Nutrition Care for HIV Infected Children

The child's diet should contain sufficient amounts of fluids, calories, proteins, fats, carbohydrates, vitamins, minerals and salts to meet their daily nutritional requirements.

- Energy
  - o Calorie requirements depend upon body size and surface area, rate of growth, physical activity, food habits & climate
  - o In a balanced diet, 50% calories from CHO, 15% from proteins, and 35% from fats
  - o For HIV infected children, the energy increase is 10% (asymptomatic), 20-30% (symptomatic with no weight loss), 100% (symptomatic with weight loss)
- Proteins
  - o Essential for synthesis of body tissues in growth, and during maintenance and repair
  - o Requirements are same as shown in the table (next slide).
- Carbohydrates
  - o Main source of energy and supply bulk in the diet.
  - o Requirements increase similar to the energy

- Micronutrients
  - o Vitamins- organic substances and essential micronutrients for maintenance of normal health
  - o Minerals – inorganic elements, required by human body for growth, repair and regulations of vital body functions
  - o Micronutrient requirements are the same as those for uninfected child
- Nutrition assessment and growth monitoring should be done frequently
- Assess feeding practices and dietary intake with every contact
- If growth is faltering;
  - o Carry out physical exam to rule out infections & health related problems e.g. poor appetite
  - o Support the caregiver to ensure the child receives the adequate amount of energy, protein and micronutrients to meet increased demand.
- If the child is losing or has lost Lean Body Mass (LBM), it is possible he/she is having symptoms of AIDS and the following actions should be taken;
  - o Provide oral nutritional supplementation
  - o Refer the child for ARV assessment and recruitment to the treatment program, if they meet the national criteria.

Management of HIV Infected Malnourished Child

- Nutrition care for HIV infected malnourished child is accomplished in 2 phases;
  - o Stabilization phase – acute medical conditions are managed
  - o Rehabilitation phase- to help catch up growth
- There are ten essential steps for management of severely malnourished children. They are:
  - o Treat/Prevent hypoglycemia
  - o Treat/Prevent hypothermia
  - o Treat/Prevent dehydration
  - o Correct electrolyte imbalance
  - o Treat/Prevent infection
  - o Correct micronutrient deficiencies
  - o Start cautious feeding
  - o Achieve catch-up growth
  - o Provide sensory stimulation & emotional support
  - o Prepare for follow up after recovery

A nutritional action for a malnourished child includes;

- Stabilizing blood sugar levels
- Rehydration and correction of electrolyte imbalances
- Micronutrient supplementation
- Nutritional rehabilitation by nutritionist
- Provision of community based therapeutic support
- Advise to caregivers about the importance of seeking care immediately from a healthcare provider for a child with signs of malnutrition
- Advise caregivers on the importance of taking children for growth monitoring and seeking health care and support.
- Refer severely malnourished children with HIV/AIDS who are not on ARVs to providers of ART services
- HIV exposed or infected children with weight-for-height of less than -3 Z score should be managed for malnutrition for 7 days and supported with therapeutic food for not less than a month
- They should also receive vitamin A, presumptive deworming, and all vaccines as required.
- They should be given a suitable multi-micronutrient supplement daily at one RDA.

Nutrient-Drug Interaction in ART

- Antiretroviral drugs (ARVs) are drugs used to manage HIV by lowering the viral load and thus reducing morbidity and mortality.
- These drugs can influence the utilization of food and nutrients by the body. Likewise, food can affect the way the medicines work.
- Combination ARV therapy (cART) is referred to as highly active ART(HAART).
- HAART can reduce the amount of HIV in someone's body and restore their immune system

Food and drug interactions may be positive or negative but primarily fall into the following categories:

1. Drugs may alter nutrient absorption, metabolism, distribution and excretion thus affecting nutritional status of the patient.
2. Food may affect efficacy of medications due to altered absorption, metabolism, distribution and excretion.
3. Some drugs may lower food intake and/or absorption. For instance, most drugs have diet restrictions (e.g. avoiding milk and milk products when taking Tetracycline drugs).
4. Common OIs such as TB, malaria, diarrhoeal diseases, pneumonia, mucosa and skin infections, and the drugs used to treat them, may cause dietary constraints.
5. The interaction of food and drugs, along with the nutritional status of the patient, affects drug efficacy, tolerability and adherence to recommended drug regimens.

ARV Related Complications

ARV can interact with food and nutrition in a variety of ways, resulting in both positive and negative outcomes.

It is thus critical to understand the specific ARV-nutrient interactions and implications to enable effective management of the resulting condition.

- Some food ingredients affect the efficacy of certain ARVs and other drugs by affecting their absorption, metabolism, distribution and excretion. As a result those foods can either enhance or reduce the efficacy of some ARVs.
- A high energy, high fat and high protein meal decreases absorption of the PI indinavir; while a high fat meal increases the bioavailability of the NRTI tenofovir.
- Certain protease inhibitors such as ritonavir and nelfinavir, can cause changes in metabolism of lipids (fats), resulting in an elevation of blood cholesterol and triglyceride levels leading to increased risk of coronary heart disease
- It has been established that vitamin A and riboflavin influence metabolic activities in the body. Riboflavin, in particular, has been linked with effectiveness of some *antineoplastic drugs* and drugs which are used to treat malaria.

- A high-fat meal increases the bioavailability of the Tenofovir, but the same lowers absorption of Amprenavir.

  High protein foods reduce absorption of Indinavir, but increase that of Nelfinavir.
- Grapefruit juice may inhibit intestinal enzymes that metabolize ARVs, especially protease inhibitors, resulting in poor bioavailability and slow cleansing of the drug from the body.
- Garlic may reduce the efficacy of Saquinavir.

15.3.6.3 Self-Assessment

1. Identify three ways in which HIV/AIDS can be transmitted
2. Outline the health and nutrition implications of HIV/AIDS
3. Explain five objectives of nutritional management of HIV/AIDS
4. Outline the advantages of breastfeeding in the context of HIV/AIDS
5. Indicate whether the following statements are TRUE or FALSE about HIV/AIDS management

   A. HIV can be transmitted from a mother to a child through breastfeeding

   B. People living with HIV/AIDS have an decreased Resting Energy Equilibrium (REE)

   C. Infection increases demand for and utilization of antioxidant vitamins and minerals

   D. Breastfeeding with appropriate use of anti-retroviral drugs for mother and baby is the best option for overall well-being and survival of HIV exposed children

   E. A high-fat meal decreases the bioavailability of the Tenofovir, but the same lowers absorption of Amprenavir.

15.3.6.4 Tools, Equipment, Supplies and Materials

- Food exchange list
- Reference manual
- Drug diet interaction reference
- Calculator
- Stationery (Pen, Paper, referral notes, File)
- WHO guidelines
- MOH guidelines
- Ministry of Education

- Skills lab
    - Use of LCDs, video clips, charts and other teaching aids
    - Invitation of competent expertise
    - Computers with internet
- Library and resource centre

15.3.6.5 References

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15.3.7 Learning Outcome 6: Demonstrate understanding in nutritional management of childhood disorders

15.3.7.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe childhood disorders as per resource materials, policies and guidelines	• Use terminologies related to childhood disorders • Consider the nutritional implications of childhood disorders • Plan a diet for childhood disorders Apply guidelines provided for childhood disorders

15.3.7.2 Information Sheet

1. Phenylketonuria (PKU)

- It is an autosomal recessive inherited disorder of amino acid metabolism that affects the body's utilization of protein.
- It is marked by the inability to process the amino acid phenylalanine, causing mental retardation & is caused by the absence of the enzyme phenylalanine hydroxylase
- Children with PKU have a deficiency of the liver enzyme phenylalanine hydroxylase that normally breaks down the essential amino acid phenylalanine into tyrosine.
- As a result, phenylalanine accumulates in the blood, causing a musty body and urine odor, irritability, vomiting, hyperactivity, seizures and eczema like rash.

Diet therapy in PKU

- Diet low in phenylalanine to keep plasma phenylalanine levels between 2 and 6 mg/dl
- The diet must meet the child's need for optimal growth
- High-protein foods (meats and dairy products) are avoided and aspartame are avoided because they contain large amounts of phenylalanine.
- Elemental foods (with phenylalanine removed) can be used.
- The low-phenylalanine diet should be maintained for life
- The low phenylalanine diet is especially good for adolescent females and women prior to conception and during pregnancy to prevent congenital anomalies (low birth weight, mental retardation, microcephaly) in the fetus.

2. Galactosemia

- It is a disorder of carbohydrate metabolism that has an autosomal recessive inheritance pattern
- It results from a deficiency of the liver enzyme galactose-1-phosphate uridyltransferase (GALT), one of the three enzymes needed to convert glucose into galactose.
- The lack of enzyme leads to accumulation of galactose metabolites in the eyes, liver, kidney, and brain, rapidly damaging the organs and causing lifethreatening problems.

Diet therapy in galactosemia

- Infants with galactosemia are placed on a lactose- or galactose-free formula e.g. soybean or meta-based formula
- A galactose-free diet (no milk or cheese products, including foods with dry milk products) is prescribed when the infant is ready to for solid foods.
- In spite of this diet, complications (learning disabilities, speech defects, ovarian failure, and neurologic syndromes) develop in many children)

3. Maple Syrup Urine Disease (MSUD)

- It is a disorder of amino acid metabolism that has an autosomal recessive inheritance pattern.
- In MSUD, three essential amino acids (leucine, isoleucine, and valine) cannot be broken down because of absent or defective enzymes branched chain alpha-ketocid dehydrogenase. This results in in alpha ketoacidosis.
- All three amino acids are essential to form normal structure such as the hair, skin, and muscle.
- Leucine has the potential to accumulate in the brain and cause cerebral edema, progressive neurologic impairment, and death.
- Within 3 to 7 days of life, the new born develops symptoms of poor appetite, lethargy, vomiting, variable muscle tone, irritability, seizures, high pitched cry and a sweet smell.

Diet therapy in MSUD

- Foods rich in amino acids, calories, vitamins, minerals and other nutrients are prescribed.
- These special medical foods have the three amino acids removed.
- The child needs special low-protein foods that are adequate for growth with enough calories to support twice the child's basal metabolic rate.

4. ALLERGY

- It is a hypersensitivity response of the immune system to common substances such as food and pollen.
- Allergens are substances that are foreign to the body and can cause an allergic reaction.
- Allergies can occur to any individual at any time and can be overgrown as with time as well.
- A person has a greater risk of developing an allergic condition if there is a family history of allergy, especially in their parents or siblings, but the environment also plays a role.

Food allergy

- It is an extreme immune response to food protein
- To protect us from illness & disease our immune systems are continuously trying to lessen the damage presented by substances called antigens. Antigens are part of proteins that our bodies recognize as dangerous and take steps to neutralize.
- Antigens can be found almost anywhere there is protein in foods or microorganisms like bacteria.

  There are two types of food allergies;

  - Immediate
  - Delayed allergic reaction

They are different from other adverse reactions to food like toxin-mediated reactions, pharmacological reactions and food intolerance.

The most common allergic component in food is protein. This occurs especially when protein is identified as harmful by body's immune system. Furthermore, some proteins or fragments of proteins are resistant to digestion and those that are not broken down by the digestive system are tagged by the immunoglobulinE (igE). The immune system is fooled by these tag foods to think that protein is the invader. On thinking that that the body is under attack, the immune system sends white blood cells to attack hence triggering an allergic reaction.

The resulting reaction can vary from mild to severe. The resulting allergic reactions are respiratory, gastrointestinal and dermatitis distress. Other reactions such as anaphylactic shock can be life threatening and they need immediate medical attention.

Anaphylactic shock is a life-threatening reaction, following exposure to a trigger. It is characterized by impaired breathing, a drastic drop in blood pressure and can be fatal.

Common food that cause allergic reactions include:

- o Shellfish
- o Eggs
- o Milk

- o Soy
- o Peanuts
- o Fish
- o Wheat

Signs and Symptoms of food allergies include:

- o Vomiting
- o Stomach upsets
- o Hives
- o Shortness of breath and wheezing
- o Pale or blue coloring of skin
- o Repetitive cough
- o Shock
- o Tight throat
- o Trouble swallowing
- o Swelling of the tongue which affects the ability to talk or breathe
- o Weak pulse
- o Dizziness

Management of Food Allergies

- o Foods that cause allergic reaction should be avoided
- o Read food labels to know ingredients of packed foods
- o Infants should be introduced to trigger-foods one at a time to take note of adverse reactions
- o Consume a varied diet to complete dietary needs. In some extreme, supplementation may be necessary.

15.3.7.3 Self-Assessment

1. Discuss diet therapy in phenylketonuria
2. List the common foods that cause allergic reactions
3. List the signs and symptoms of food allergies
4. __________ is an autosomal recessive inherited disorder inability to process the amino acid phenylalanine.

   A. Galactosemia B. Lactose intolerance

   C. Phenylketonuria D. Marple Syrup Disease

5. The following amino acids cannot be tolerated by persons suffering from MSUD except:
   A. Leucine B. Phenylalanine
   C. Isoleucine D. Valine
6. Indicate whether the following statements are TRUE or FALSE
   A. Allergies only affect infants and young children
   B. A person has a greater risk of developing an allergic condition if there is a family history of allergy
   C. Allergies can be fatal
   D. Some allergies can be overgrown with time

15.3.7.4 Tools, Equipment, Supplies and Materials

- Food exchange list
- Reference manual
- Drug diet interaction reference
- Calculator
- Stationery (Pen, Paper, referral notes, File)
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

15.3.7.5 References

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CHAPTER 16:

PROVIDE DIET THERAPY 2

16.1 Introduction of the Unit of Learning / Unit of Competency

This unit addresses the unit of competency: provide diet therapy in diseases states involving CVDs; Atherosclerosis, stroke, hypertension, myocardial infarction, angina pectoris, and deep vein thrombosis. Renal disorders; glomerulonephritis, nephrotic syndrome, kidney stones AKD, CKD, kidney failure. Liver and gallbladder disorders; jaundice, liver encephalopathy, hepatitis, alcoholic liver disease, liver cirrhosis, gallbladder disease, disease of the pancreas. Metabolic disorders; diabetes mellitus, hyperthyroidism, hypothyroidism, hyperkalaemia, ketoacidosis. Mental and mood disorders; schizophrenia, bipolar, depression anxiety disorders, posttraumatic stress (PTSD) disorders and degenerative disorders.

16.2 Performance Standard

By the end of this unit of learning/competency, the trainee should be able to provide nutritional management of cardiovascular disorders in accordance with policies and guidelines and resource materials; provide nutritional management of renal disorders in line with resource materials, and policies and guidelines; provide nutritional management of metabolic disorders as per resource materials and policies and guidelines; provide nutritional management of mental and mood disorders in line with guidelines and policies and material resources; and provide nutritional management of degenerative disorders based on client's diagnosis, resource materials, and policies & guidelines.

16.3 Learning Outcomes

16.3.1 Learning Outcomes

1. Identify terminologies in diet therapy II
2. Demonstrate understanding in nutrition management of CVDs disorders
3. Demonstrate understanding in nutrition management of the renal disorders
4. Demonstrate understanding in nutritional management of liver and gallbladder disorders
5. Demonstrate understanding in nutritional management of metabolic disorders
6. Demonstrate understanding in nutritional management of mental and mood disorders
7. Demonstrate understanding in nutritional management of degenerative disorders

16.3.2 Learning Outcome 1: Identify terminologies in diet therapy II

16.3.2.2 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under diet therapy II	• Use terminologies related to Diet Therapy 2
2. Illustrate the relationship between nutrition and disease and the roles of nutrition in disease management	• Consider the relationship between nutrition and disease • Consider how disease affects nutrition
3. Identify and describe the objectives of diet therapy II	• Formulate objectives of diet therapy

16.3.2.2 Information Sheet

Definitions

Diet Therapy: Practical application of nutrition in promotion of health and prevention of diseases

Malnutrition: A physiological state that results from inadequate, excess or imbalanced intake of nutrients.

Disease: A condition that impairs normal function of body or its parts , whch is manifested by signs and symptoms

Therapeutic diets: It is a diet that is modified from a normal diet to meet the requirements of the ill/ sick individual.

Normal diet: It consists of any and all foods eaten by the person in health. It satisfies the nutritional needs of most patients and serves as the basis for planning modified diets.

Diet modification: It refers to the action of adjusting a normal diet to change its consistency/ texture, flavor and nutrient contents.

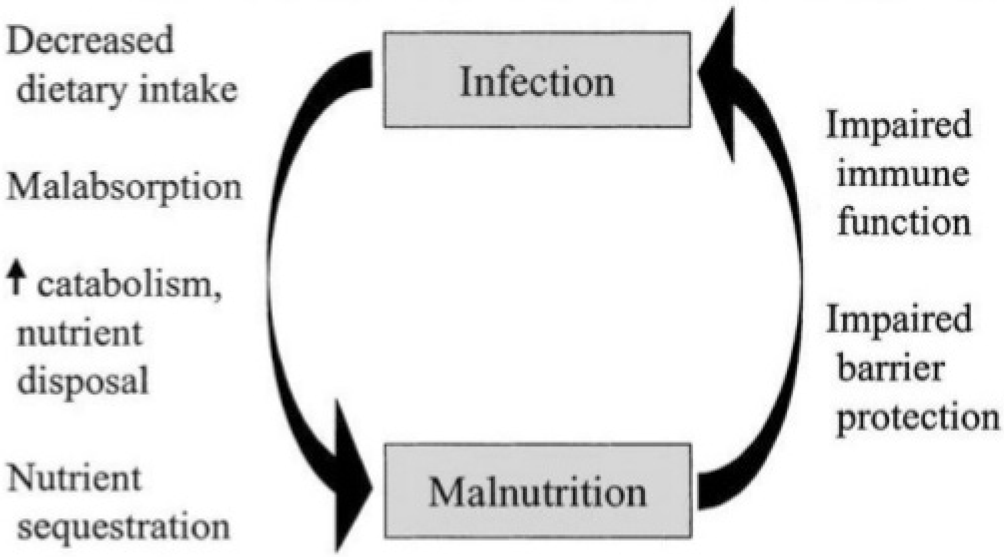
Relationship between Nutrition and Disease

Food provides required raw materials for normal cellular activity. Nutrient deficiency impairs this activity and results to disease. Deficiency may be as a result of inadequate nutrient intake, malabsorption, increased requirement or increased excretion/nutrient loss.

Nutrients have nourishment and pharmacologic function and so they are directly involved with disease prevention. Examples:

- Zinc, Vitamin A, Vitamin B6 and folate support immune function
- Vitamin C, Vitamin E, selenium and carotenoids are antioxidants
- Iron, Vitamin A, zinc and Vitamin Care involved in tissue synthesis.

Relationship between malnutrition and infection



Relationship Between Malnutrition and Disease

The Goals of Nutrition in Disease Prevention

1. To optimize cellular activity and tissue/organ function:
   a) Provide sufficient amounts to satisfy daily demands of adequacy, balance and variety in food choices
   b) Maintain adequate reserves for intermittent increased demand through habitual diet and dietary patterns
2. To reduce the metabolic burden imposed on cardiac, pulmonary, renal, hepatic, musculoskeletal systems by environmental factors
   a) Minimize workload of organ systems by reducing stress on organs involved in transport, metabolism and elimination of nutrients and metabolic waste.
   b) Eliminate compensatory responses required to maintain normal function
3. To support cellular defenses that protects tissue integrity
   a) Maintain immune system competence
   b) Promote efficiency of detoxification systems by controlling levels of reactive chemical intermediates
4. Prevent oxidative damage that is involved in pathogenesis of most chronic diseases and reduction of efficiency of immune cells.

Role of Nutrition in Disease Management

Nutrition plays a key role in maintaining health and wellbeing. Adequate nutrition is needed in every step of the lifespan. Food is needed as a source of energy and various nutrients that support all body functions. Failure to meet nutrient and energy needs leads to nutrient deficiency disorders and increases susceptibility to disease.

Adequate nutrition is also needed in disease management. Disease affects nutrition in that it:

Ways Disease May Affect Nutrition:

- Affects food intake
- Affects digestion and absorption
- Affects nutrient utilization
- May increase nutrient excretion
- May affect nutrient storage
- Can increase nutrient and energy requirements
- Drug-nutrient interactio

Nutrients may also affect the disease progression in that food intake may affect drug absorption and utilization.

It is therefore imperative to plan a patient's diet with consideration of how the disease and nutrition interact. Nutrition should complement medical care to help enhance the recovery process.

16.3.2.3 Self-Assessment

1. Explain the goal of nutrition in disease prevention
2. Outline ways in which a disease may affect nutrition
3. Diet Therapy is:
    A. A condition that impairs normal function of body or its parts , whch is manifested by signs and symptoms
    B. A physiological state that results from inadequate, excess or imbalanced intake of nutrients.
    C. Practical application of nutrition in promotion of health and prevention of diseases
    D. The action of adjusting a normal diet to change its consistency/texture, flavor and nutrient contents.

4. A therapeutic diet is**:**
   A. A diet containing all nutrients in adequate amounts
   B. A diet that is modified from a normal diet to meet the requirements of the ill/ sick individual.
   C. Food prepared in hospital
   D. A diet rich in energy and proteins
5. The following nutrients are antioxidants except:
   A. Vitamin C
   B. Vitamin E
   C. Selenium
   D. Iron
6. Failure to meet nutrient and energy needs leads to nutrient :
   A. Weight gain
   B. Deficiency disorders and increases susceptibility to disease
   C. Growth and development
   D. Disease prevention

16.3.2.4 Tools, Equipment, Supplies and Materials

- Stationery
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

16.3.2.5 References

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16.3.3 Learning Outcome 2: Demonstrate understanding in nutrition management of CVDs disorders

16.3.3.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under CVDs disorders described	• Use terminologies under CVDs
2. Identify CVDs and discuss their pathophysiology	• Apply knowledge of common CVDs • Determine the nutritional factors associated with cardiovascular diseases • Consider the pathophysiology of CVDs
3. Identify and describe nutritional management of CVDs	• Determine the nutritional requirements in CVDs • Plan diet for persons suffering from CVDs • Consider nutrient interaction with drugs used in the management of common CVDs

16.3.3.2 Information Sheet

Definitions

Cardiovascular disease: a class of diseases that affect the heart and blood vessels (arteries and veins). In the majority of cases, this is due to the progressive effects of atherosclerosis in the arteries.

Common examples of cardiovascular disease include:

- Coronary artery disease
- Stroke
- Congestive heart failure
- Hypertension
- Myocardial Infarction.

General risk factors for cardiovascular diseases

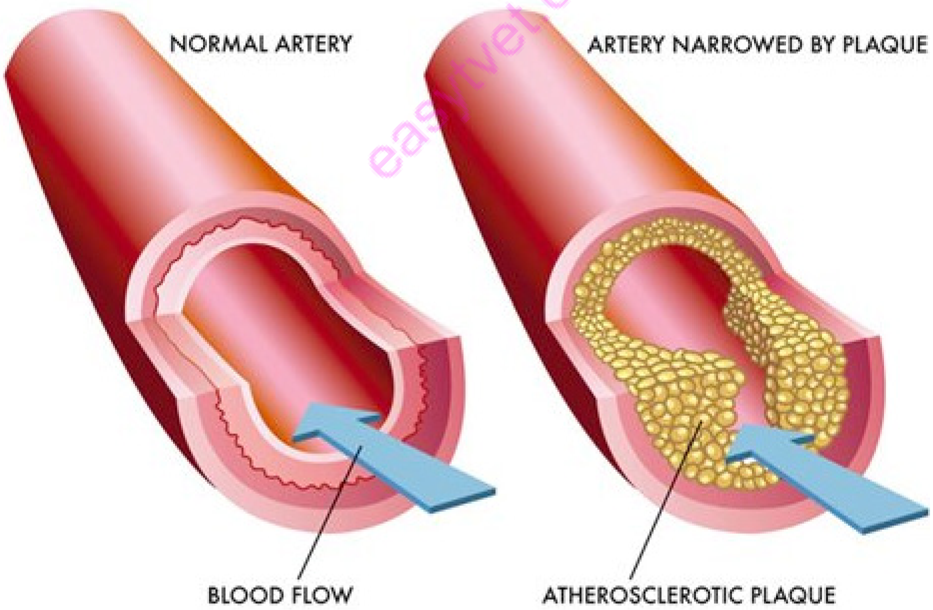
1. Non modifiable factors:
    - Age
    - Gender
    - Genetic factors
    - Race.

2. **Modifiable Risk Factors:**
   - High salt (sodium chloride) intake
   - High blood cholesterol
   - Too much fat, saturated fatty acid, Trans -unsaturated fatty acids
   - High levels of low density lipoprotein (LDL) cholesterol
   - Smoking cigarettes
   - Alcohol
   - Obesity
   - Reduced physical activity
   - Stress

Common Cardiovascular Diseases

1. ATHEROSCLEROSIS

This is a generative process that begins with the accumulation of soft fatty streaks along the inner arterial walls especially at the branch points. These streaks gradually enlarge and become hardened with minerals forming plaques.



Atherosclerosis

Risk Factors

- High calorie intake
- High saturated fat and cholesterol intake
- Increased serum LDL (harmful cholesterol) levels above 5mmol/liter

- Sedentary lifestyles
- Hypertension
- Diabetes.
- Stress
- Obesity

Implications

- Obstruction of normal blood flow
- Tissue damage
- Increased blood pressure

Aims of management

- To normalize blood lipids
- Control the modifiable risk factors and prevent complications.

Nutritional Management

- Reduce total fat intake(15-20%) -LDL–(saturated fat to 7% and dietary cholesterol 200mg/day)
- Reduce body weight for the overweight clients to the ideal body weight
- Avoid smoking and alcohol
- Physical activity is recommended.

2. MYOCARDIAL INFARCTION

This is sudden tissue death caused by interruption of blood flow in vessels that feed the heart muscle, also called heart attack/cardiac arrest. Risk factors include hypertension and arteriosclerosis. Other contributors include abnormal blood clotting, spasms of the coronary artery, rheumatic heart disease, infections of the membranes covering the heart and electrical disturbances that alter the hearty rate.

Implications

- Strained cardiac function

Aims of nutritional management

- To reduce the work load of the heart
- To relieve pain and stabilize the heart rhythm
- To treat infections and the underlying causes
- To regulate electrolyte balance

Nutritional Management

- When the patient is in shock, withhold food intake-nil per oral until shock resolves
- When shock resolves provide between 1000-1200 kcal that progresses from low sodium soft foods of moderate temperature in frequent and small feeding.
- After recovery adjust the diet to meet the individual needs and to deal with the underlying conditions such as hyper lipidemia, hypertension, and obesity
- Avoid caffeine as it stimulates metabolic rate and increase the workload of the heart
- A healthy heart requires minimal consumption of saturated fats and cholesterol, reduced use of salt and sugar, avoiding use of tobacco and too much coffee and regular exercise.

3. CONGESTIVE HEART FAILURE

This is a syndrome in which the heart can no longer adequately pump blood through the circulatory system. Risk factors include; uncontrolled atherosclerosis and hypertension.

Implications

- Pulmonary oedema
- Reduced blood flow to all organs
- Fluid retention hence stagnation of fluids in all organs
- Enlarged heart and rapid heart beat
- Malnutrition due to high energy needs

Aim of Management

- To reduce the workload of the heart
- To provide adequate nutrients
- To reduce weight for the overweight

Nutritional Management

- Restrict sodium, caffeine and fat intake
- Encourage gradual weight loss where necessary
- Use of liquid formula of high nutrient density as oral supplement or enteral or tube feeding to prevent or reverse malnutrition is recommended. In some cases total parenteral nutrition may be required
- Selection of enteral or parenteral formulas should be done carefully to ensure that energy ,fluid, sodium intake will not overload the body
- Adjust dietary fiber to avoid constipation but avoid amounts and types that produce gas and abdominal distention
- For overweight patient counsel on weight reduction
- Restrict cholesterol intake to 300 mg /day

- Reduce intake of saturated fats
- Encourage intake of unsaturated fats (oils)
- Increase intake of dietary fiber to control glucose/fat absorption
- Reduce alcohol intake and encourage the patient to avoid smoking to prevent development of atherosclerosis

4. HYPERTENSION

Hypertension is a cardiovascular disorder characterised by persistently elevated diastolic blood pressure (BP) of above 95mmHg. Uncontrolled hypertension can affect various body organs and can lead to impaired vision, kidney failure, stroke, paralysis, heart attack and brain damage. Risk factors include; diet, race, stress, age, diabetes, obesity, smoking, atherosclerosis and heredity among others.

Implications

- Strained cardiac and vascular function
- Cellular electrolyte imbalance
- Aneurysms (balloon out and busting of the arteries)
- Arterial lining injuries which accelerates the plaque formation.

Aims of nutritional management

- To control blood pressure within the normal ranges
- To achieve a gradual weight loss in overweight and obese individuals and maintain their weight slightly below the normal
- To reduce sodium intake based on severity
- To maintain adequate nutrition
- Regulate fat intake.

Nutritional management

- Provide low calorie diet if the patient is overweight until ideal body weight is achieved
- Reduce fat intake. Encourage intake of unsaturated fats (oils). The poly unsaturated and monounsaturated fatty acids lower BP, the level of triglycerides and LDL cholesterol and consequently lead to increase in HDL cholesterol that carries cholesterol in the blood back to the liver for recycling or disposal. Fats should be 20% of total kilo calorie
- Avoid alcohol intake
- Restrict sodium intake. To achieve this, encourage a selection of food low in sodium. Besides, reduce the amount of salt added to food, avoid using spices containing sodium and processed food.
- Abstain from stimulants such as spirits and caffeine
- Avoid from cigarette smoking that may result in atherosclerosis

- It might be necessary to restrict fluid intake in some cases
- Encourage those leading a sedentary lifestyle to engage in physical activity.

5. STROKE/TRANSIENT ISCHEMIC ATTACK

This is reduction in blood flow to the brain that causes temporal symptoms which depend on which part of the brain is affected.

Risk factors

- Atherosclerosis
- Hypertension or a combination of the two

Implications

- Light headedness
- Paralysis
- Numbness
- Visual disturbances
- Staggering
- Dysphasia (inability to coordinate swallowing appropriately).

Aim of management

- To treat the underlying risk factors

Management

- Restricted energy intake, total fat and sodium
- Tube feeding may be indicated initially until the client is safely able to chew and swallow
- Some patients may need assisted feeding

16.3.3.3 Self-Assessment

1. Outline the risk factors for atherosclerosis
2. Discuss the nutritional management of hypertension
3. Discuss the aim of nutritional management of congestive heart failure
4. Which of the following factors is not a risk factor associated with Atherosclerosis?
   A. Hypertension
   B. Obesity
   C. Low calorie intake
   D. Stress

5. Which of the following is a non-modifiable factor for cardiovascular diseases?
   A. Genetic factor
   B. High blood cholesterol
   C. Smoking
   D. Physical inactivity
6. The following statements are true about the nutritional management of congestive heart failure except:
   A. For overweight patient counsel on weight reduction
   B. Restrict cholesterol intake to 300 mg /day
   C. Reduce intake of saturated fats
   D. Sodium restriction is not necessary
7. Which of the following statement is true about hypertension?
   A. It only affects overweight people
   B. It is a reduction in blood flow to the brain
   C. It results to cellular electrolyte imbalance
   D. Patients with hypertension should be encouraged to reduce sodium intake
8. Which one of the following is an objective of nutritional management for myocardial infarction:
   A. To increase sodium intake
   B. To reduce the work load of the heart
   C. To stabilize blood pressure
   D. To maintain normal blood glucose

16.3.3.4 Tools, Equipment, Supplies and Materials

- Stationery
- Clinical guidelines
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise

- Computers with internet
- Library and resource centre

16.3.3.5 References

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16.3.4 Learning Outcome 3: Demonstrate understanding in nutrition management of the renal disorders

16.3.4.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under renal disorders	• Use terminologies in renal disorders
2. Identify renal disorders and discuss their pathophysiology	• Determine how renal disorders affect nutrition
3. Identify and describe nutritional management of renal disorders	• Determine the nutritional requirements for renal disorders • Plan diet for persons suffering from renal diseases • Consider nutrient-drug interactions in the management of renal disorders

16.3.4.2 Information Sheet

Functions of Kidney

- Excretes dissolved unwanted substances, filtered out of the blood as urine.
- Filtration: a filter through which all dissolved substances pass & those to be retained are selectively re-absorbed.
- Maintenance of fluid, electrolyte and acid base balance
- Helps to regulate the blood pressure through excretion of sodium.
- Produces erythropoietin (hormone) which stimulates the maturation of red blood cells in the bone marrow.
- Converting vitamin D to its most active form calcitriol.

Causes of Kidney Diseases

1) **Inflammation and degeneration:** the membranes and small blood vessel in the nephrons may get inflamed for due to infections and thus lead to glomerulonephritis.
2) **Chemical damage:** Environmental agents such as pesticides, solvents etc. may cause kidney damage.
3) **Infections and obstructions**
4) **Other diseases that damage the kidney function**: any disorder in circulation which results in degeneration of small renal arteries disturbs the normal nephron function e.g. poorly controlled hypertension, uncontrolled type 2 diabetes.

1. GLOMERULONEPHRITIS

This is inflammation of the glomeruli. The inflammatory process affects the glomeruli which is a trough of blood capillaries in the head of the nephron. It is most common in its acute form in children between the age 4-10years and young adults under the age of 30years.

Causes

The most common cause is streptococci infection. In the past, acute glomerulonephritis commonly frequently followed infection with:

i) Beta-haemolytic streptococci in children

ii) Tonsillitis in young adults with respiratory tract infection or pneumonia.

Symptoms

Typical symptoms are:

- Hematuria
- Proteinuria.
- As much as 50% or more reduced renal blood flow and glomerular filtrate rate ,
- Urine volume falls to between 500-1000ml per day and sodium excretion is greatly reduced.
- Because the patient may continue to ingest the normal quantities of sodium and water, edema develops and blood pressure rises leading to complains of malaise, headache, swelling of the face and hands.
- Urea and creatinine concentration in the plasma rises in proportion to the fall in glomerular filtration rate (GFR).
- Patient is generally anorexic; nausea and vomiting occur which contributes to feeding problems.
- If the disease progresses to renal insufficiency, oliguria and anuria occur which is signal for the development of acute renal failure
- Mild acidosis and hyperkalemia are usually present

Objectives of Dietary Management

- To spare the diseased kidney
- To prevent uremia
- To prevent edema
- To maintain adequate nutrition

Dietary Recommendations

Energy: Requirement is the same as in good health. In the absence of fever, previous malnutrition, with bed rest, allowances can be reduced.

Proteins: Restriction of protein is only needed when the BUN is elevated and oliguria is present.

Diet should provide about 0.5g/kg of ideal body weight. When protein is restricted in quantity, it is important to provide these reduced quantities in the form of protein of high biological value for the efficient utilization.

Carbohydrates: In order to provide enough energy, carbohydrate needs to be given freely.

Fats: There is no need to restrict fat in the diet. Include emulsified and easily digestible fat in the diet. It reduces the bulk of the diet, provides non-protein kcal for energy needs and makes the diet palatable

Sodium: Restrict sodium in the diet in the presence of oliguria, edema and hypertension. Restriction of sodium depends on the extent or degree of the symptoms.

Potassium: The renal clearance of potassium is impaired when severe oliguria is a complication. It may lead to potassium intoxication and even require dialysis (hyperkalemia can result in cardiac arrest). Foods that are good sources of potassium should be avoided; it can lead to potassium intoxication especially if oliguria is present.

Water: Water and other fluids need to be restricted according to the ability of the kidney to excrete urine. When oliguria is present, restriction of fluid intake is imposed. The volume of fluid to be given is calculated from the volume of urine passed in the previous 24 hours plus estimated insensible water loss, usually 500ml daily.

2. NEPHROTIC SYNDROME/ NEPHROSIS

Nephrosis is a kidney disorder that causes the body to excrete too much protein in the urine. It is caused by a variety of diseases that all lead to decreased kidney ability to prevent leakage of macromolecules, particularly proteins, into the filtrate. Normally, only a small amount of proteins is filtrated through glomerular and these are completely reabsorbed in the tubules. Proteinuria develops when the leakage of protein from the glomerular exceed the reabsorption capacity of the renal tubules.

Causes:

It may be caused by progressive glomerulonephritis. Besides, it may be in association with several factors that include:

- Diabetes
- Drug reaction
- Exposure to heavy metals
- Reaction to toxic venom.

Symptoms

- It is characterized by heavy proteinuria, hypoalbuminemia and edema. Massive edema leads to ascites. Edema is due to excessive loss of protein in the urine; about 4-10g/day or more.
- Plasma protein is reduced greatly and the albumin fraction responsible for the maintaining the fluid balance between tissue fluids and circulating fluid is decreased

Objectives:

- Correct and control protein deficiency
- Correct and prevent edema.
- To maintain adequate nutrition
- To avoid unnecessary harm to the kidney.

Dietary Modification

Energy

Sufficient energy must be provided to ensure efficient use of protein for tissue synthesis. High daily intake of 50-60 kcal/kg body weight is essential.

Protein

Replacement of the prolonged protein loss is a most immediate and fundamental need. Plasma albumin levels may have been reduced to 20% or less of its normal value, a major cause of the development of nephritic ascites and edema. A high protein intake is associated with a positive nitrogen balance to replenish the depleted stores and enhance hepatic synthesis of albumin. High protein intake of 90-120g for adults and 2-3g/kg of body weight for children is recommended. Besides, intake of protein foods of high biological value such as milk and its products, eggs, meat etc. should be encouraged.

Unfortunately, these foods are also moderately rich source of sodium, and so their intake cannot indiscriminately increase.

Carbohydrates

Sufficient non- protein calories need to be provided for sufficient utilization of protein and for body protein synthesis. A high carbohydrate intake is recommended for protein sparing action.

Fats

Restriction is not necessary unless there are comorbidities that demand so.

Sodium

Sodium intake in the diet needs to be reduced to combat edema. Diuretics are also used to prevent further fluid accumulation for patients in whom the renal tubes are responsive to diuretics. For these patients, extreme degree of salt restriction is not required and they may be given about 1g of sodium per day.

Potassium

Potassium restriction is not necessary for these patients because oliguria and anuria are not present.

Calcium

In some patients with prolonged proteinuria, deficiency of calcium and potassium may occur resulting in bone rarefaction and hypokalemia. Both these defects are corrected by high protein diet with added calcium and potassium.

3. ACUTE RENAL FAILURE (ARF)

It is the sudden stop of renal function as a result of metabolic injury to the normal kidney.

The functioning of the kidney can be completely restored as long as the patient is kept alive during the period when the excretory and homeostasis functions are impaired.

ARF is often a life threatening illness with high mortality rates.

Causes of ARF

- Loss of blood due to any cause including; complications in pregnancy, trauma or gastrointestinal bleeding
- Loss of plasma due to tissue destruction as seen in burns and crush injuries
- Loss of fluid from the gut as seen in severe vomiting, diarrhea etc.
- Excess loss of fluid from the skin as seen in excessive sweating.
- Nephrotoxins: e.g drugs such as paracetamol, industrial chemicals and poisonous mushrooms.
- General anesthetics and surgery: reduces renal blood flow especially in pts with low blood volume.
- Infections especially septicemia caused by E-coli which results in reduced renal blood flow.

NOTE

In most of the conditions, prolonged hypotension with systolic blood pressure less than 90 for one hour or more is a common causative feature.

Whenever there is excessive loss of blood, plasma or fluid, resulting in peripheral circulation failure, the kidney becomes susceptible to ischemic damage.

Phases of ARF

- Initial /Onset phase
- Oliguric/Anuric Phase
- Diuretic phase
- Recovery Phase

Four phases of AKI

This chart describes the features and durations of the four phases of acute kidney injury (AKI).

Phase	Features	Duration
Onset phase	• Common triggering events: significant blood loss, burns, fluid loss, diabetes insipidus • Renal blood flow 25% of normal • Tissue oxygenation 25% of normal • Urine output below 0.5 mL/kg/hour	Hours to days
Oliguric (anuric) phase	• Urine output below 400 mL/day, possibly as low as 100 mL/day • Increases in blood urea nitrogen (BUN) and creatinine levels • Electrolyte disturbances, acidosis, and fluid overload (from kidney's inability to excrete water)	8 to 14 days or longer, depending on nature of AKI and dialysis initiation
Diuretic phase	• Occurs when cause of AKI is corrected • Renal tubule scarring and edema • Increased glomerular filtration rate (GFR) • Daily urine output above 400 mL • Possible electrolyte depletion from excretion of more water and osmotic effects of high BUN	7 to 14 days
Recovery phase	• Decreased edema • Normalization of fluid and electrolyte balance • Return of GFR to 70% or 80% of normal	Several months to 1 year

Phases of Acute Renal Failure

Treatment

The objectives of the initial nutrition therapy are to support overall medical management.

This includes:-

- Re-establishing fluid and electrolyte balance
- Maintenance of adequate nutritional status
- Providing an optimal environment for wound healing
- Preventing infection

Dietary management of the oliguric phase

Fluid intake

The fluid allowance is usually regulated in accordance with the urinary output and any additional losses from vomiting or diarrhea.

Its intake is usually restricted to a basic allowance of 500ml/day for an average adult with additions made for losses via other routes

Electrolyte

- Provided only to replace losses.
- Potassium allowance is individualized in accordance with serum levels.
- Since serum potassium levels are usually elevated due to massive tissue destruction, potassium administration should not be done.
- Sodium allowance is based on its concentration in serum and urine
- Restriction of sodium to 500-1000mg daily is usually necessary during the oliguric phase.

Protein

- During the oliguric and anuric phase, protein metabolism should be reduced to a minimum.
- Initially during the acute phase no protein should be given to the patient.
- As the condition improves only 20g protein daily should be given which is the minimum amount required to compensate for endogenous losses.
- The protein should be of high biological value

Energy

- Non protein sources of energy such as carbohydrate should be included
- A daily intake of 100-200g or more of sugar has a marked protein sparing effect.
- Additional energy may be obtained from fat also.

Dietary management of diuretic phase

This stage indicates a return of renal functions to normal.

Dietary treatment is still very important although the problems are reversed.

- Pt is passing a large volume of urine and so is at risk of excessive loss of water, sodium, potassium and calcium, bicarbonate, phosphate and magnesium.
- Proteins should continue to be restricted until blood urea nitrogen and serum creatinine levels return to normal.

- A normal diet with free fluid intake is prescribed and may even need to be supplemented with electrolytes.
- The fluid and electrolyte status of the patient needs to be monitored by daily weighing and blood and urine analysis.

4. CHRONIC RENAL FAILURE

Also called Chronic Kidney Disease (CKD)

Causes a progressive reduction in renal function that results in a reduced ability to control body water volume, acid-base balance, hormonal regulation, and electrolyte concentrations.

Causes

- Arises from any disease processes that compromises the renal blood perfusion
- Renal diseases; e.g. chronic glomerulonephritis, chronic urinary obstruction
- Systemic diseases, such as diabetes mellitus hypertension; infections;
- Medications or Environmental/ toxic agents- e.g. lead, mercury .

Pathophysiology

- There is decline of renal function as GFR falls.
- The serum levels of urea nitrogen & creatinine increases.
- Uremia develops and adversely affects every system in the body
- When GFR is less than 10– 20mls/min, the effect of uremic toxins on the body becomes evident.
- The greater the build up of waste products, the more severe the symptoms.

Stages of Chronic Renal Failure

Stage 1: Reduced renal reserve

Characterized by a 40% to 75% loss of nephron function.

There are No symptoms because the remaining nephrons are able to carry out the normal functions of the kidney.

Stage 2: Renal insufficiency

- Occurs when 75% to 90% of nephron function is lost.
- Increase in Serum creatinine and BUN
- Kidney loses its ability to concentrate urine

Stage 3: End-Stage Renal Disease (ESRD)

- The final stage of chronic renal failure,
- Occurs when there is less than 10% nephron function remaining.
- All of the normal regulatory, excretory, and hormonal functions of the kidney are severely impaired
- ESRD is evidenced by elevated creatinine and blood urea nitrogen levels as well as electrolyte imbalances.
- At this point, dialysis is indicated
- Many of the symptoms of uremia are reversible with dialysis

NOTE

The severity of the signs and symptoms depends on:-

- The degree of renal impairment
- Other underlying conditions
- The patient's age.

Signs & Symptoms

Cardiovascular manifestations

- Hypertension
- Heart failure and pulmonary edema (due to fluid overload)
- Pericarditis (due to irritation of the pericardial lining by uremic toxins)
- Pitting edema
- Hyperkalemia

Dermatologic symptoms

- Severe itching (pruritus) is common
- Thin, brittle nails; as nitrogen waste products build up
- Uremic frost, the deposit of urea crystals on the skin (uncommon today because of early and aggressive treatment of ESRD with dialysis)

Neurologic symptoms

- Weakness and fatigue
- Inability to concentrate;
- Tremors
- Restlessness
- Confusion
- Disorientation
- Seizures
- Behavior changes

Hematologic symptoms

- Anemia (diseased kidneys do not make enough erythropoietin)

Renal symptoms

- Anuria (output < 50 mL/day)

Psychological symptoms

- Depression
- Anxiety

Gastrointestinal symptoms

- Ammonia odor in breath
- Mouth ulcerations and bleeding,
- Nausea and vomiting
- Bleeding from gastrointestinal tract
- Metallic taste
- Anorexia
- Constipation or diarrhea

Musculoskeletal symptoms

- Muscle cramps
- Loss of muscle strength
- Renal osteodystrophy (alteration of bone morphology when kidneys fail to maintain proper levels of calcium and phosphorus in the blood)

Management

The goal of management is to maintain kidney function and homeostasis for as long as possible

Management is accomplished primarily with:

- Medication
- Dialysis
- Diet therapy
- Transplantation

Dialysis

Process of artificial removal of uremic waste products & excess water in the body.

Used to treat patients with:

- Edema
- Hypercalcemia
- Uremia &
- Hyperkalemia
- Hypertension
- Not responding to other treatments

Principles of dialysis

Diffusion

Toxins and wastes in the blood are removed by diffusion from an area of higher concentration in the blood to an area of lower concentration in the dialysate

Osmosis

Movement of a solvent such as water across a semi permeable membrane from areas of less solute to areas of high concentration of solute.

Ultrafiltration

- Movement of a fluid across a semi permeable membrane from a high pressure area to a low pressure area.
- It is more efficient in removal of water than osmosis.

Types of Dialysis

- Hemodialysis
- Peritoneal Dialysis
- Hemodialysis

Hemodialysis

A dialysis machine and a special filter called an artificial kidney, or a dialyzer, are used to clean the blood.

To get pt's blood into the dialyzer, the doctor needs to make an access, or entrance, into the blood vessels, done with minor surgery, usually to the arm.

The dialyzer, or filter, has two parts, one for pt's blood and one for a washing fluid called dialysate. A thin membrane separates these two parts.

Blood cells, protein and other important things remain in the blood because they are too big to pass through the membrane. Smaller waste products in the blood, such as urea, creatinine, potassium and extra fluid pass through the membrane and are washed away.

Complications of hemodialysis:

- Disturbance of lipid metabolism
- Hypertriglyceridemia
- Gastric ulcers & other GI problems - resulting from the physiologic stress of chronic illness & medication.
- Disturbed calcium metabolism –leads to bone pain & fractures (renal osteodystrophy).
- Sleep disturbance

- Painful muscle cramping due to rapid fluid shift from the extravascular space.
- Hypotension:-if too much fluid is eliminated
- Blood loss:-if blood lines separate or dialysis needles dislodge.
- Dialysis Disequilibrium Syndrome (rare):- due to rapid fluid shift from the cerebral fluid; characterized by headache, nausea, vomiting, restlessness, decreased level of consciousness & seizures.
- Arrhythmias (heart beats with an irregular or abnormal rhythm):-due to electrolyte & pH change.

Peritoneal dialysis (PD)

PD is performed by surgically placing a special, soft, catheter into the lower abdomen.

Dialysate is instilled into the peritoneal cavity and is left in for a designated period of time (dwell time) which will be determined by the nephrologist

The dialysate fluid absorbs the waste products and toxins through the peritoneum which acts as the semipermiable membrane

The fluid is then drained from the abdomen, measured, and discarded.

Indicated for patients who are unable or unwilling to undergo hemodialysis or kidney transplant

In peritoneal dialysis, there is no machine.

Instead of an artificial filter, the lining of the abdomen, the peritoneum is used as a natural filter.

The peritoneum has a lot of small vessels in it.

With peritoneal dialysis, it takes 36 – 48 hours to achieve what hemodialysis accomplishes in 6 –8 hours.

Peritoneal dialysis uses the principle of diffusion and osmosis

Types of peritoneal dialysis:

a) **Continuous Ambulatory Peritoneal Dialysis (CAPD):**

The peritoneum is filled with dialysate, which remains there for a prescribed dwell time, then the fluid is drained. Gravity moves the fluid through the catheter and into, and out of the abdomen.

Pt needs 3-5 exchanges during the day and one with a longer dwell time while asleep

Pt. can do the exchanges at home, work or any clean place.

Procedure allows the pt. reasonable freedom and control of daily activities while the dialysate dwells in their abdomen.

b) **Continuous Cyclic Peritoneal Dialysis (CCPD):**

Also known as Automated Peritoneal Dialysis (APD).

Method uses a machine (automated cycler) that performs multiple exchanges at night while pt. is asleep.

The cycler automatically fills the abdomen with dialysate, allows it to dwell there and then drains it to a sterile bag that emptied in the morning.

P.t must remain attached to the machine for 10 to 12 hours at night.P.t isn't connected to the machine during the day.

They might have a lower risk of peritonitis because they connect and disconnect to the dialysis equipment less frequently than with CAPD.

Nutrition concerns in peritoneal dialysis

- Patients who receive peritoneal dialysis may develop hypokalemia, since commercially available solutions do not contain potassium.
- Potassium can be liberalized in the diet or supplemented orally if needed.
- The peritoneal dialysate can provide a substantial amount of energy from glucose to the patient when hypertonic solutions are needed for increased fluid removal.
- Diabetic patients may have a greater risk for hyperglycemia, and all patients can develop hypertriglyceridemia.
- The nutritional intake of patients who receive peritoneal dialysis may be affected by bloating, abdominal fullness, and loss of appetite due to the indwelling dialysate .
- The protein needs of patients who receive peritoneal dialysis are increased, and it is important to encourage a high-protein diet to minimize the risks of malnutrition and infection.
- Some patients may require protein or protein-energy supplementation to meet their daily estimated protein needs of 1.2 to 1.3 g/kg.

5. TRANSPLANTATION

- A surgical procedure performed to replace a diseased kidney with a healthy kidney.
- It involves the surgical attachment of a functioning kidney, or graft, from a donor to a patient with end-stage renal disease (ESRD).

Sources of kidney

- Deceased-donor kidneys
- Living transplant /Live donor kidneys.

Goals for Dietary Management of CKD

- To minimize uremic toxicity
- To prevent wasting and malnutrition

Nutrition Management of CKD

Energy

The energy requirements of CKD patients who do not receive dialysis are similar to the requirements of healthy individuals and are influenced by age, sex, and physical activity level

When prescribing energy requirements for persons with CKD, the primary goals should be to provide an adequate amount of total energy to maintain or achieve a reasonable body weight and positive nitrogen balance.

Hemodialysis:

For patients 60 years and older with stage 3 disease who receive dialysis, an energy intake of 30 to 35 kcal/kg body weight. For younger patients, energy needs should be calculated at a minimum of 35 kcal/kg bd wt.

Peritoneal dialysis:

- In peritoneal dialysis, glucose is absorbed from the dialysate. Therefore, the dietary energy intake may need to be decreased to prevent excess weight gain and obesity
- Energy absorbed from the dialysate should be subtracted from the daily energy intake from the diet.

Protein

Protein intake is based on the patient's creatinine clearance, estimated GFR, and urinary protein losses.

Hemodialysis:

- For patients who receive hemodialysis three times per week : at least 1.2 g/kg bd wt/ day.
- A patient loses 10 to 13 g of amino acids and small peptides during a single hemodialysis treatment.
- Approximately 30% to 40% of the amino acids lost during hemodialysis are essential. Therefore, high–biological value protein should provide at least 50% of the total protein in the diet

Peritoneal dialysis:

- The protein recommendations is 1.2 to 1.3 g/kg of bd wt.
- Protein requirements may be even higher, depending on the patient's stress level or metabolic needs.

- When used for long-term management of CKD, peritoneal dialysis is associated with progressive wasting and malnutrition

Kidney transplant:

For adult kidney transplant recipients who have recovered from surgery and have an adequately functioning allograft, a daily protein intake of 0.8 to 1.0 g/kg of body weight is recommended.

Consider the medical status of each patient, addressing individual issues as needed.

Adequate but not excessive protein intake supports allograft survival and minimizes the impact on comorbid conditions.

Sodium and Fluid

Hemodialysis:

- The daily sodium allowance is 2 g/day with adjustments based on urine output.
- The more urine that the patient produces, the more sodium the patient may eliminate via the urine.
- If the patient is anuric, 1,000 to 1,500 mL/day of fluid is recommended.

Peritoneal dialysis:

The sodium intake for most patients should be 2 g/day.

The suggested fluid intake 2,000 mL/day

Potassium

Hemodialysis:

- A potassium intake of 40 mg/kg of standard body weight is recommended.
- Removes potassium; therefore, monitoring potassium levels and ensuring adequate intake is important .
- Adjustments in potassium intake (either from the diet or from the dialysate bath) can be made to achieve target potassium levels

Peritoneal dialysis:

- Patients who receive peritoneal dialysis may not need potassium restrictions; however, an assessment should be based on the patient's laboratory values.
- Peritoneal dialysis can increase the risk for hypokalemia, since most commercially available solutions do not contain potassium.
- Oral supplementation and/or dietary intake can be adjusted to compensate for low potassium levels. A target intake of 3 to 4 g/day of potassium is suggested.

16.3.4.3 *Self-Assessment*

1. Outline the causes of kidney diseases
2. Explain the objective of nutritional management in nephrotic syndrome
3. Discuss the phases of acute renal failure
4. Explain the stages of chronic renal failure
5. Outline the nutrition concerns in peritoneal dialysis
6. Uremia is:

   A. Reduced urine output

   B. Accumulation of urea in blood

   C. Fluid retention due to kidney failure

   D. Sudden failure of the kidneys due to injury
7. Which one the following statements is true about the diuretic phase of acute renal failure:

   A. Patient passes very little volume of urine

   B. BUN is usually high

   C. A normal diet with free fluid intake is prescribed and may even need to be supplemented with electrolytes.

   D. Creatinine level is abnormally high
8. Which one of the following is not a function of the kidney:

   A. Maintenance of fluid, electrolyte and acid base balance; carry out selective filtration.

   B. Helps to regulate the blood pressure through excretion of sodium.

   C. Produces erythropoietin (hormone) which stimulates the maturation of red blood cells in the bone marrow.

   D. Produces bile
9. Which of the following is a cardiovascular implication of chronic renal failure:

   A. Severe itching (pruritus) is common

   B. Thin, brittle nails; as nitrogen waste products build up

   C. Hypertension

   D. Confusion
10. The following statements are true about nutritional management in peritoneal dialysis except:

    A. Patients may develop hypokalemia

    B. Potassium intake should be restricted

C. The peritoneal dialysate can provide a substantial amount of energy from glucose to the patient when hypertonic solutions are needed for increased fluid removal.

D. Diabetic patients may have a greater risk for hyperglycemia, and all patients can develop hypertriglyceridemia.

16.3.4.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

16.3.4.5 References

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16.3.5 Learning Outcome 4: Demonstrate understanding in nutritional management of liver and gallbladder disorders

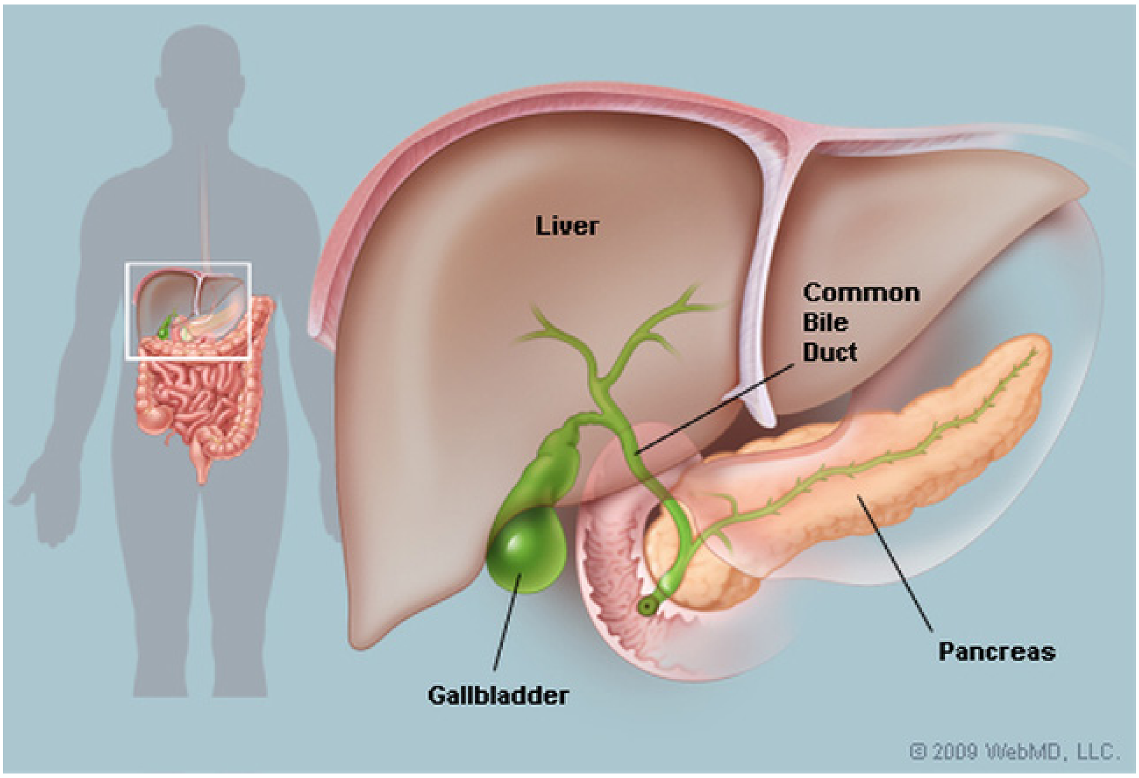
16.3.5.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under liver and gallbladder disorders	• Use terminologies in diseases of the liver and gall bladder
2. Identify liver and gallbladder disorders and discuss their pathophysiology	• Consider how liver and gall bladder diseases affect nutrition
3. Identify and describe Nutritional management of liver and gallbladder disorders	• Plan diet for patients suffering from liver and gall bladder disorders • Determine nutritional requirements of patients suffering from liver and gall bladder disorders • Consider drug-nutrient interactions in management of diseases of the liver and the gall bladder • Apply guidelines in the management of diseases of the liver and the gall bladder

16.3.5.2 Information Sheet

Definitions

- **Atrophy** :the degeneration of hepatic cells
- **Fatty infiltration**: deposition of fat droplets in the hepatic cells.
- **Fibrosis**: formation of an abnormal amount of fibrous tissue as the result of inflammation, irritation, or healing; where the functioning hepatic cells are completely replaced by connective tissue cells.
- **Necrosis:** death of the hepatic cells.



The liver and gall bladder

Functions of the liver

- Fat metabolism.
- Vitamin and minerals storage.
- Bile formation
- Bilirubin excretion.
- Metabolism of glucose and regulation of blood glucose concentration. (Glycogenesis & Glycogenolysis)
- Converts metabolically generated ammonia into urea.
- Plays an important role in protein metabolism. Synthesizes almost all of the plasma protein e.g albumin, globulins e.t.c
- Activation of enzymes

1. HEPATITIS

An infectious disease characterized by inflammation and degeneration of liver cells.

Types of Hepatitis

Type	Virus	Mode of Transmission
Hepatitis A	hepatitis A virus (HAV).	Consuming food or water contaminated by feces from a person infected with hepatitis A.
Hepatitis B	Hepatitis B virus (HBV)	Contact with infectious body fluids, such as blood, vaginal secretions, or semen, containing the hepatitis B virus (HBV)
Hepatitis C	Hepatitis C (HCV)	Direct contact with infected body fluids, typically through injection drug use and sexual contact
Hepatitis D	Hepatitis D (HDV)	Direct contact with infected blood. A rare form of hepatitis that only occurs in conjunction with hepatitis B infection.; Can't multiply without the presence of hepatitis B.
Hepatitis E	Hepatitis E (HEV)	Waterborne disease. Mainly found in areas with poor sanitation and typically results from ingesting fecal matter that contaminates the water supply.

Symptoms of Hepatitis

Initially, non-specific symptoms occur :

- Anorexia,
- Nausea,
- Diarrhea,
- Abdominal discomfort
- Fatigue,
- Vomiting,
- Fever

Followed by :

- Jaundice
- Enlargement and tenderness of the liver.
- Patients may note that their urine darkens and their stools lighten in color.

Dietary Management

Objectives of dietary therapy are:

- To relieve symptoms
- To aid in the regeneration of liver tissue
- To prevent further liver damage.

Recommended Dietary Modifications

Energy

- A high energy intake to promote weight gain & ensure maximum protein utilization.
- Initially pt may not be able to eat such a large amounts of food due to anorexia and only 1500-2000 Kcal may be acceptable.
- Gradually, the energy intake may be increased to 20-30% more than the normal intake.
- If p.t is advised to have bed rest, the recommended intake of energy under normal conditions will suffice

Protein

Intake needs to be increased to:

- Overcome the negative nitrogen balance,
- Promote regeneration of the liver cells
- To prevent fatty infiltration of the liver.

However, the damaged liver may not be able to tolerate the high protein load because the conversion of ammonia to urea gets affected and there exist a danger of impending hepatic coma.

Therefore depending on the extent of liver damage; there is a need to adjust the protein intake accordingly.

In mild to moderate cases:1.5 to 2g/kg/bwt

On the other hand in acute cases with extensive liver damage, the protein intake may have to be decreased even below normal.

It is important to ensure protein of high biological value to ensure their maximum utilization, preferably supplemented with proteins of vegetable origin.

Carbohydrates

A high cbh diet is recommended to:

- Provide the bulk of energy,
- To build up glycogen stores in the liver
- For their protein sparing action.

A daily intake of 300 to 400 grams of cbh is recommended.

Fats

Decrease fat intake though not severely; digestion and absorption of fat is affected because of impaired bile secretion.

- Inclusion of moderate amounts of fat in the diet not only increases palatability of food but also promotes recovery.
- Tolerance of fat may vary from person to person.
- Mild to moderate cases: 40 to 50 grams total fat/day
- Severe cases accompanied by liver damage: restricted to 20-30grams per day.

Vitamins

The availability of fat soluble vitamins like vitamin A tends to be low due to the decreased intake and impaired fat absorption.

- For Vit.A, ensure inclusion of carotene rich foods like deep yellow and orange vegetables and fruits in the diet.
- Prothrombin time is invariably increased; may be corrected by giving vitamin K.
- B Vits: Needs are increased due to increased energy metabolism
- Higher amounts of vitamin C are needed for tissue healing.

Minerals

Diet should provide all minerals, particularly iron in adequate amounts in view of the increased tissue catabolism.

2. LIVER CIRRHOSIS

It is a chronic disease of the liver in which fibrous connective tissue replaces the functioning hepatic cells.

It characterized by destruction of liver cells, distortion of normal lobules with growth of fibrous tissues and nodular regeneration of cell following fatty degeneration.

The cirrhotic liver is contracted and has lost most of its functions.

Causes

- **Chronic alcoholism:** Alcohol & its metabolic products disturb liver metabolism and damage liver cells directly.
- **Chronic alcoholism and malnutrition:** Chronic alcoholics have a long standing inadequate food intake leading to malnutrition and necrosis of liver cells and subsequently cirrhosis.
- **Gross dietary inadequacy, especially of protein**. When there is a nutritional deficiency, the liver is more vulnerable to injury from various toxic agents.
- **Various infective and toxic agents:** As seen in infectious hepatitis, destruction of liver cells. This may lead to fibrotic changes in the liver and finally cirrhosis.
- Obstructions in the bile duct.

- Idiopathic cirrhosis: Liver cirrhosis from undetermined causes is also sometimes observed.

Symptoms

Onset of the disease is gradual with initial symptoms of GI disturbances such as:

- Nausea
- Vomiting
- Anorexia
- Distension and epigastric pain.
- Jaundice appears, with increasing weakness, ascites, and tendencies of gastrointestinal bleeding, and iron deficiency anaemia.
- Steatorrhea is a common symptom too
- Impaired portal circulation with increasing venous pressure may lead to esophageal varices (enlarged veins) with danger of rupture and haemorrhage.
- Blood clotting mechanisms are impaired: factors such as prothrombin and fibrinogen are not adequately produced by the damaged liver.
- Negative nitrogen balance also seen. (Due to general tissue catabolism)

Treatment

- No treatment will cure cirrhosis or repair scarring in the liver that has already occurred.
- Treatment can sometimes prevent or delay further liver damage.
- Treatment involves lifestyle changes, medication, and regular doctor visits.
- Surgery may be used to treat complications from cirrhosis.

The basis of treatment is adequate rest along with dietary modification.

Dietary Management

The objectives of nutritional therapy are:

- To promote regeneration of liver cells
- To correct nutritional deficiencies if any

Energy

Energy requirements are increased to correct malnutrition and to promote regeneration of liver cells.

However since patient is on bed rest, their actual energy expenditure is reduced.

Normal recommended energy intake should be enough to meet the extra needs.

Protein

In the absence of impending coma, the protein intake should continue in the level suggested for hepatitis; is 1.0 to 1.5 grams per Kg actual body weight.

- Help to overcome malnutrition,
- Regenerate liver cells
- Replenish plasma proteins

If signs of impending coma appear, the protein intake is decreased to 0.3g/kg body weight depending on the individual tolerance

Inclusion of large amounts of animal protein may lead to hepatic encephalopathy. Use plant proteins too.

Carbohydrates

As in infective hepatitis, a high carbohydrate diet is recommended to provide energy and to protect the liver cells from further damage.

A daily intake of 300g of carbohydrate is advised.

Fats

Restrict fat: Many cirrhotic p.t suffer from malabsorption of fat due to impaired bile secretion.

Amount will vary depending on the individual's tolerance.

Inclusion of moderate amount of fat in the diet increases palatability of the diet and promotes recovery.

Emulsified fats and those containing medium chain triglycerides are better tolerated.

Vitamins

The availability of fat soluble vitamins like vitamin A is affected due to the decreased intake and impaired absorption of fat.

Supplements of some vitamins may have to be provided to replenish liver stores and repair tissue damage.

Minerals

Presence of ascites and oedema necessitates the restriction of sodium in the diet.

Supplementation is recommended when diagnosis of a specific deficiency may be more costly and would delay the provision of micronutrients

Supplementation with zinc may improve food intake for pt. with dysgeusia.

3. HEPATIC ENCEPHALOPATHY/HEPATIC COMA

A condition characterized by degenerative changes in the brain and neurological symptoms.

Generally attributed to the fact that the failing liver can no longer inactivate or detoxify certain substances or metabolize others.

Causes

Four main theories have been suggested as the causative factors:

- **The Ammonia Theory**

An important theory which attributes the pathological changes to elevated blood levels of ammonia.

Based on the cirrhotic changes in the liver which diminish portal circulation

Ammonia is not converted to urea for excretion, accumulates in the blood and subsequently affects the brain

- **The synergistic theory**

Suggests that the encephalopathy is due to synergistic effect of ammonia and other substances like short chain fatty acids.

However, the measurements of such effects are difficult and have not been substantiated.

- **The Amino Acid Neurotransmitter theory**

Suggests that the failing liver induces an amino acid imbalance, with an accumulation of animal source amino acids in the central nervous system.

These amino acids are neurotransmitter precursors and their imbalance leads to coma. This theory has lately developed much support.

- **The GABA theory**

This theory is being investigated.

Gamma aminobutyric acid (GABA) is an inhibitory neurotransmitter which has been found to be increased in the plasma of patients with hepatic coma.

One of the reasons suggested for this increase is decreased removal of circulating GABA by the liver

Symptoms

- Changes in consciousness, behavior and neurological status.
- Apathy, mental confusion, drowsiness, leading to coma.
- Speech may be slurred and monotonous with blank facial expression.
- Motor change involving flapping tremors in arms and legs. This is due to sustained contraction in a group of muscles
- The breath may have fecal odour

- Urine output decreases with advancement in coma. If the condition is not checked, it may even prove fatal.

Dietary management

Objectives of dietary treatment include:

- Reducing protein intake
- Minimizing tissue catabolism.

Modification in the diet

Energy

Adequate energy intake contributes to healing and building up glycogen stores in the liver.

About 1500-2000kcal mainly from carbohydrate is sufficient to prevent tissue breakdown.

Protein

Should be restricted according to the patient's condition.

15 to 20g of protein daily may be given initially and gradually increased according to tolerance.

Fats

Fat intake is lowered and small amounts may be included as tolerated.

Emulsified and medium chain triglycerides are better tolerated.

Vitamins

Parenteral administration of vitamin K, B complex and C may be done incase of deficiencies.

Minerals

Sodium restriction may be advised if ascites is observed in the patient.

Close attention is given to other mineral deficiencies like iron.

Fluid intake

It is closely monitored according to the output.

4. LIVER TRANPLANT

Used to treat life threatening end stage liver disease for which no other form of treatment is available.

The transplantation involves total removal of diseased liver and its replacement with a healthy liver in the same anatomic location.

A major surgery transferring a liver from the donor with healthy organs but who is brain dead is done.

The success of the liver transplant depends on the successful immunosuppression to reduce the incidence of rejection of the transplanted organ

- Liver transplant is not a routine procedure and may be accompanied by complications related to:
  - lengthy surgical procedure immunosuppressive therapy infections
  - technical difficulties encountered in reconstructing the blood vessels and biliary tract.

Nutrition Therapy

Goals for nutrition therapy are:

To correct malnutrition particularly:

- Muscle wasting
- Electrolyte imbalance
- Abnormal blood glucose and lipids.

Pre-plantation diet

- Recommend an intake of 30-35kcal/kg of energy.
- 1.0-1.5g/kg of protein is given as tolerated.
- Vitamins and minerals are given depending with the RDA.
- Adjust sodium and fluid as appropriate.

Post-plantation Diet

- TPN may be necessary if oral and enteral feeding cannot be initiated within 5 days after surgery.
- Feeding by mouth begins when post-operative ileus resolves (a disruption of the normal propulsive ability of the gastrointestinal tract following abdominal surgery)
- Reduce TPN as enteral nutrition is increased.
- 30% of the total calories should be provided as fats, 50-60% as carbohydrates.
- Give protein at 1.5-1.75g/kg body weight.

DISEASES OF THE GALL BLADDER

The gall bladder concentrates bile formed in the liver and stores it until needed for digestion of fat.

The entrance of fat in the duodenum stimulates the secretion of the hormone cholecystokinin by the intestinal mucosa. The hormone reaches the gall bladder via the blood and causes it to contract releasing bile. Interference with the flow of bile impairs fat digestion.

1. CHOLECYSTITIS

This involves the inflammation of the gall bladder usually due to infection. Such an infection affects the normal function of the gall bladder

Causes

- Infection
- High dietary fat intake over a long period of time can predispose to gallstone formation.

Symptoms

- Nausea and vomiting
- Sensitivity to fatty foods
- Flatulence
- Chills and fever
- Colicky pain

Treatment

Treatment may involve surgical removal of the gall bladder- cholecystectomy.

Surgery may have to be withheld till acute infection subsides.

Till then, patient is kept in bed and suitable analgesics and antibiotics are administered.

Dietary treatment

Main aim of dietary treatment is to reduce discomfort by providing a diet restricted in fat.

In acute cases, it is advisable to keep the gall bladder at rest and minimize contraction thus fat is excluded from the diet.

2. CHOLELITHIASIS

Formation of stones (hard, pebble-like deposits) in the gall bladder.

Stones are made up of cholesterol, bile acids, calcium and other inorganic salts and bilirubin.

Associated with:

- Obesity

- Use of oral contraceptives
- Hypercholesterolemia
- Cholecystitis.

Signs & Symptoms

- Most patients have no symptoms
- Discovered during routine medical procedures such as x-ray, abdominal surgery etc.
- Cramping pain in the center to the right upper abdomen when a large stone blocks either the cystic duct or common bile duct
- Fever
- Jaundice
- Nausea & vomiting

Treatment

Treatment involves a hospital stay to control the inflammation in the gall bladder.

Doctor may recommend surgery to remove the gallbladder,(cholecystectomy) since gallstones frequently recur.

Once the gallbladder is removed, bile flows directly from the liver into the small intestine, rather than being stored in the gallbladder.

Nutrition therapy

Unless fat induces symptoms, a low fat diet is not necessary.

In acute gallstone attack, use a low fat diet to decrease gall bladder contraction and lessen the pain.

If the gall bladder is sluggish, a moderate fat intake is desirable to stimulate its contraction and prevent stagnation of bile.

CASE STUDY 1:

56 year old Mrs. M is admitted at Outspan Hospital after undergoing laparoscopic cholecystectomy, following prolonged cholelithiasis. She is 153M tall, 92 kg. She is also anaemic and has poor appetite. Answer the following questions to explain her nutritional management

- What is laparoscopic cholecystectomy
- What are the risk factors in the development of cholelithiasis
- Discuss the dietary management of Mrs. M, citing specific nutrient requirements.

CASE STUDY 2:

Mr.Q is suffering from liver cirrhosis. He is a recovering alcohol addict, currently in a rehabilitation centre. You have been asked to provide nutritional management for Mr. Q 's condition. Upon assessment, you find; he is 163 M tall, 43 kg. His lab results show that he has low Hb, elevated AST & ALT levels and steatorrhea,

- Explain the lab results
- Formulate a nutrition diagnosis statement
- Discuss the nutritional management of Mr. Q's condition, citing specific nutrient requirement.

16.3.5.3 Self-Assessment

1. Identify the types of hepatitis
2. Outline the symptoms of hepatic encephalopathy
3. Distinguish between cholecystitis and cholelithiasis
4. Outline the causes of gall stones
5. Explain the causes of liver cirrhosis
6. Which one of the following is a function of the liver:

   A. Synthesis of Vitamin D B. Storage of Vitamin C

   C. Production of bile D. Production of insulin
7. Which of the following is an implication of protein deficiency in liver cirrhosis?

   A. Fluid retention B. Gastrointestinal bleeding

   C. Anorexia D. Nausea and vomiting
8. Which one of the following is not true about the gall bladder:

   A. It temporarily stores bile

   B. It is not an essential organ

   C. High dietary fat intake over a long period of time can predispose to gallstone formation

   D. We cannot live without the gall bladder
9. Which one of the following is an objective of the nutritional management of hepatitis?

   A. To correct electrolyte imbalance

   B. To increase fat intake

   C. To prevent further liver damage.

   D. To promote negative nitrogen balance

10. The _______ theory of hepatic encephalopathy attributes the condition to elevated blood levels of ammonia.

A. GABA

B. Ammonia

C. Synergistic

D. Amino Acid- Neurotransmitter

16.3.5.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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16.3.6 Learning Outcome 5: Demonstrate understanding in nutritional management of metabolic disorders

16.3.6.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under metabolic disorders	• Use terminologies under metabolic disorders
2. Identify metabolic disorders and discuss their pathophysiology	• Consider how common metabolic disorders affect nutrition
3. Identify and describe nutritional management of metabolic disorders	• Consider the nutritional implications of metabolic disorders • Plan diet for metabolic disorders • Consider drug-nutrient interaction in the management of metabolic disorders • Apply guidelines for the management of metabolic disorders

16.3.6.2 Information Sheet

Metabolic Disorders

These physiological disorders either result from altered metabolism or affect metabolism. These includes; diabetes mellitus, gout, hyper/hypothyroidism.

1. DIABETES MELLITUS

Diabetes mellitus is a chronic metabolic disorder that occurs when the pancreas does not produce enough insulin or when the body cannot effectively utilize the insulin it produces. It is characterized by decreased ability or complete inability of the tissue to utilize carbohydrates accompanied by a change in metabolism of fats, protein, water and electrolytes. This results in elevated blood sugar (hyperglycemia) which over time leads to multiple organ damage. It is associated with acute complications such as ketoacidosis and hypoglycemia, as well as long-term complications affecting the eyes, kidneys, feet, nerves, brain, heart and blood vessels.

There are three types of Diabetes mellitus.

- Type I: Results from the body's failure to produce insulin
- Type II: Results from Insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with relative insulin deficiency

- Gestational Diabetes: Pregnant women who have never had diabetes before but who have high blood sugar (glucose) levels during pregnancy are said to have gestational diabetes. Gestational diabetes affects about 4% of all pregnant women worldwide. It may precede development of type 2 (or rarely type 1)

Risk factors for diabetes mellitus

These include: heredity, age, sex, obesity, dietary factors, physical inactivity and infections

Common symptoms include:

- Increased thirst (polydipsia)
- Increased urination (polyuria)
- Increased hunger (polyphagia)
- Weight loss in Type 1 diabetes
- Over weight/Obesity in type 2 diabetes
- Sugar in the urine (glycosuria)
- Elevated blood sugar or glucose (hyperglycemia)
- Skin irritation or infection
- Weakness/general loss of strength

Management Plan

The aim of management in diabetes is to control blood sugar and prevent development of disease complications.

Objectives

- Attain and maintain blood glucose levels as close to normal as possible
- Prevent hypo- and hyperglycaemia
- Attain optimum blood lipids and blood pressure control and so reduce the risk of macro vascular disease
- To promote physical, social and psychological well being
- To prevent, delay or minimize the onset of chronic degenerative complications e.g. hypertension and renal diseases
- To achieve and maintain optimal metabolic and physiologic outcomes
- To provide relief from symptoms

Components of management plan

- Medical therapy
- Medical nutrition therapy
- Exercise and physical activity

Medical Therapy

Medical therapy includes clinical diagnosis, drug prescription and administration. Insulin administration is important in the nutrition therapy. Insulin doses need to be adjusted to balance with nutritionally adequate food and physical activity. The quantity of food at each meal should be consistent and at regular times every day and harmonized with drug intake.

The table below shows types of insulin, onset peak and duration of action and the consequences resulting when the drugs administration and diet intake is not harmonized in reference to drug action.

Type of insulin	Onset of action	Peak of action	Duration of action	Common pitfalls
Insulin lispro (Humalog)	5 to 15 minutes	1 to 2 hours	4 to 5 hours	Hypoglycemia occurs if the lag time is too long or the patient exercises within one hour of administration; with high-fat meals, the dose should be adjusted downward.
Regular insulin (Humulin R)	30 to 60 minutes	2 to 4 hours	6 to 8 hours	Lag time is not used appropriately; the insulin should be given 20 to 30 minutes before the patient eats.
NPH insulin (Humulin N)	1 to 3 hours	5 to 7 hours	13 to 18 hours	In many patients, breakfast injection does not last until the evening meal; administration with the evening meal does not meet insulin needs on awakening.
Lente insulin (Humulin L)	1 to 3 hours	4 to 8 hours	13 to 20 hours	Zinc suspension binds with regular insulin, which loses its effect if it is left in the syringe for more than a few minutes.
Ultralente insulin (Humulin U)	2 to 4 hours	8 to 14 hours	20 to 24 hours	Same as for lente insulin; in addition, peak of action is erratic in some patients.

Medical Nutrition Therapy

Medical nutrition therapy is an integral component of diabetes management. It has both short and long term benefits for diabetes outcomes. Dietary modification is one of the cornerstones of diabetes management, and is based on the principle of healthy eating in the context of social, cultural and psychological influences of food choices. Dietary modification and increasing levels of physical activity should be the first step in the management of diabetes mellitus that have to be maintained. The nutrition care process should be followed when managing diabetic patients.

Diabetes nutrition therapy aims to enable people with diabetes to make appropriate changes to their lifestyle in order to reduce the risks of both micro- and macro vascular complications and control blood sugar. Nutritional therapy should be individualized to accommodate age, nutritional needs, religion, culture, preferences and lifestyle. Nutrition therapy involves modifying both diet and patterns of physical activity.

Positive outcomes of the therapy include:

- Improved metabolic control
- Decreased risk of micro- and macro vascular complications
- Quality of life and life expectancy similar to that of the general population

Aims of the Nutrition Therapy

Diet therapy aims at tailoring the diet care plan in accordance with the prevailing clinical situation. Diet therapy is not only concerned with the prevention and management of micro and macro vascular complications but also chronic complications of diabetes.

The objectives of nutrition therapy are to:

- Attain and maintain blood glucose levels as close to normal as possible
- Prevent hypo- and hyperglycaemia
- Attain optimum blood lipids and blood pressure control and reduce the risk of macro vascular disease
- Assess energy intake to achieve optimum body weight (this can mean taking action to either increase or decrease body weight).
- Promote physical, social and psychological well being
- Prevent, delay or minimize the onset of chronic degenerative complications e.g. hypertension and renal diseases
- Achieve and maintain optimal metabolic and physiologic outcomes
- Provide relief from symptoms

Individualize meal plan according to a person's lifestyle and based on usual dietary intake

Essential considerations in planning the diet

- Determine energy requirements

  Calculate the energy requirement for each diabetic patient individually

  Type 1: base the energy requirement on needs for normal growth and development, physical activity and maintenance of desirable body weight

  Type 2: majority is overweight and obese therefore energy requirement is meant for weight loss

  Distribute energy in terms of carbohydrates, proteins and fats

- **Protein** allowance is essentially as that for normal individuals and should not exceed 1gm/kg. Protein should provide 15-20% of total energy in the diet.
- Energy from carbohydrates should contribute 45% to 60% of total calories. An amount of less than 100gms carbohydrates per day is not advisable as it leads to ketosis, on the other hand more than 300g per day may overburden the metabolic capacity. The

distribution and amount of carbohydrates between meals is extremely important to synchronize with the action of insulin and drugs.

- **Fats** should provide < 30% of energy

  A lower fat intake of up to 20% or less of the daily energy in case of obese adult diabetics

- Determine the type of carbohydrates and type of preparations

Give more of carbohydrate as complex starches e.g. whole grain cereals, roots and stem tubers, whole grain bread, rather than simple sugars because they breakdown more slowly to release glucose.

In case of hypoglycaemia provide some glucose

Nutritional Education and Counseling

It is important to educate all diabetic patients on the disease and its' management i.e.

- Causes, signs and symptoms
- Basic information about nutrition
- Nutrient requirements
- Healthy eating guidelines
- How to make healthy food choices
- Relationship between diabetes and diet
- Drug-nutrient interactions
- Acute and chronic complications and their management
- Encouraging self monitoring of blood glucose at home (SMBG) or at the nearest facility
- Self management training using food pyramid, plate model, signal system
- Administration of insulin
- Healthy lifestyle- i.e. importance of exercise and maintenance of ideal body weight
- Preparing structured meal plan using menus, food exchange lists, counting calories, counting carbohydrates, glycemic index
- How to deal with special situations-eating out, travelling, exercise, sickness, lifestyle
- Individual counselling
- Discuss the outcome of assessment with the diabetic client/patient
- Explain how the diagnosis has been arrived at
- Involve the patient in the formulation of the diet
- Discuss other factors that may affect the disease e.g. stress
- Fill in knowledge gap identified in the assessment

Exercise and Physical Activity

Exercise and physical activity is an important component in diabetes management. All patients should have individualized exercise and physical activity plan. This helps to:

- Improve insulin resistance and lipid profile
- Lower blood pressure
- Reduce mortality in Type I diabetes and can reduce HbA1c by 0.7% in Type II diabetes
- Protect against the development of Type II diabetes
- Maintain appropriate body weight

NB: It is recommended that every patient should have at least 30 minutes of exercise per day.

Diabetes Complications

a) Hypoglycemia

This is a metabolic disorder caused by a drop in the blood glucose level to below the normal minimum essential for normal (80mg/100ml) brain functioning.

Causes

- Uncontrolled diabetes
- Strenuous physical activity
- Inadequate food intake
- Excessive insulin administration
- Skipped meals and delayed meals
- Severe vomiting or diarrhea

Symptoms

Weakness, hunger, nervousness, dizziness, sweating, palpitation, disorientation, slurred speech, headache, shakiness

Advanced hypoglycemia symptoms are related to neuroglycopenia and include headaches, confusion and lack of coordination, blurred vision, anger, seizures and coma.

Aim of management

Increase the glucose level to normal.

Management

In acute state administer one sweet or one tea spoon of sugar to raise the blood glucose followed by a meal

For long term management advise the client to adhere to the diet recommendations as stipulated

b) Hyperglycemia

This is a condition that is characterized by elevated blood glucose.

Causes

Include insufficient insulin, ineffective insulin and untreated diabetes.

Symptoms and implications

Drawing of water from tissues into the blood leading to severe dehydration

Glycosuria (when blood glucose exceeds 180mg/100ml), polydepsia, polyuria, blurred vision, weight loss, fatigue, acetone breath, labored breathing.

Management

- Adjust dosage of regular insulin
- Enhance physical activity
- Reduce amount of CHO
- Space meals based on insulin activity time span

c) Metabolic Acidosis

This disorder results from a lowered blood and extracellular fluid PH of < 7.4

Risk factors/causes

Heavily meat based diet; uncontrolled diabetes; renal failure and prolonged fasting.

Implications

Acetone breath; dehydration; severe acidosis can result to fatal coma.

Aim of management

To control acidosis by increasing the blood PH

Management

- Treat underlying cause
- Withhold acidic foods especially meat
- Use of plant based foods that are alkaline in nature .e.g. potatoes is recommend
- Take safe drinking water based on tolerance.

2. GOUT

A disorder of purine metabolism in which abnormal levels of uric acid accumulate in the blood and result to deposition of uric acid at the joints. It is a manifestation of inflammation and sharp joint pain because of crystallized deposits of uric acid.

Main **Risk factors/causes**

- Excessive intake of red meat and fish which result to elevated uric acid in the blood
- Excessive intake of alcohol, as it blocks the elimination of uric acid from the body
- Excessive consumption of stimulant beverages as caffeine if part of the chemical family of purine. It transforms into uric acid in the body
- Hormonal factor
- Obesity.

Symptoms/ implications

Inflammation and pain of the joints especially the meta tarsal pharyngeal (the base of big toe)

- A risk factor to chronic arthritis
- Aim of nutritional management
- Prevent excessive accumulation of uric acid

Management

- Use of low purine diet by restricting consumption red meat, fish, alcohol, stimulants, and high protein foods to avoid exogenous addition of purines to the existing high uric acid load is recommended
- Encourage consumption of alkalizing foods e.g. lemons, tomatoes, green beans, fruits milk and milk products
- Intake of fluids about 3lts/day to enhance excretion of uric acid based on assessment is recommended
- Moderate protein intake (0.8g/kg/day)
- Maintain adequate CHO intake to prevent ketosis
- Limit fat intake
- Avoid large and heavy meals late in the evening
- Encourage consumption of whole grains.

3. HYPERTHYROIDISM

This is condition due to overactive thyroid gland. This may be initiated by hormonal imbalances **or tumors.**

Causes

- Hormonal imbalances
- Tumors

Symptoms and implications

- Increased metabolic rate
- Excessive production of the thyroid hormones
- Increased energy expenditure and weight loss
- Nervous excitation due to excessive hormone product
- Tachycardia (high heart rate)
- Increased perspiration and heat sensitivity

Aims of management

- To prevent/control weight loss-through provision of high calorie diet.
- Reduce workload

Management

- Treat the underlying cause
- Use of high calorie diet to meet the extra energy needs is recommended
- Refer to high calorie diet

4. HYPOTHYROIDISM

This is state resulting from reduced activity of the thyroid gland. The gland does not produce sufficient levels of thyroxine hormone.

Causes

Inadequate iodine intake and selenium deficiency

Symptoms/implications

- Enlargement of thyroid gland as the cells enlarge to trap as much iodine as possible
- Sluggishness and weight gain
- In pregnancy it can result to impaired fetal development

Aim of management

To control iodine deficiency

Management

- Recommend iodine rich foods e.g. sea foods or iodine fortified foods
- Recommend suitable exercise program

16.3.6.3 *Self-Assessment*

1. Outline the causes of hypoglycemia
2. Explain the common symptoms of diabetes
3. Discuss the nutritional management of diabetes
4. List the causes of gout
5. Explain the signs and symptoms of hyperthyroidism
6. Hypoglycemia is:
   A. Abnormally high blood glucose
   B. Low blood glucose
   C. The amount of glucose in a carbohydrate food
   D. Blood glucose level after a meal
7. Which one of the following is not true about diabetes:
   A. All obese people develop diabetes
   B. Diabetic people cannot participate in sports
   C. Type 2 diabetes results from insulin resistance
   D. Diabetics can consume more simple carbohydrates than complex carbohydrates
8. The following are risk factors of gout except:
   A. Excessive intake of red meat and fish
   B. Excessive intake of alcohol
   C. Excessive consumption of stimulant beverages as caffeine
   D. Weight loss
9. The following are symptoms of hyperthyroidism except:
   A. Increased metabolic rate
   B. Decreased energy expenditure and weight loss
   C. Tachycardia
   D. Increased perspiration and heat sensitivity
10. The aim of nutritional management in diabetes is:
    A. To control blood pressure
    B. To increase bmi
    C. To control blood sugar and prevent development of disease complications
    D. To reduce physical activity.

16.3.6.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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16.3.7 Learning Outcome 6: Demonstrate understanding in nutritional management of mental and mood disorders

16.3.7.1 Learning Activities

Learning activities	Special instructions
1. Identify and describe terminologies under mental and mood disorders	• Use terminologies under mood disorders
2. Identify mental and mood disorders and discuss their pathophysiology	• Consider how mental and mood disorders affect nutrition
3. Identify and describe nutritional management of mental and mood	• Determine the nutritional requirements in metabolic disorders • Plan diet for mental and mood disorders • Apply guidelines provided for the management of mental and mood disorders

16.3.7.2 Information Sheet

Definition

Mental health; Refers to emotional, psychological and social well-being of an individual.

Mental health conditions can cause individuals disability and even cause death through suicides. Medical care for mental conditions only provides partial benefit. Nutrition intervention supports medical treatment by enhancing function of the nervous system and dealing with nutritional problems caused –by the mental conditions.

Diet therapy also helps in management of the side effects of medication, such as poor appetite.

Interventions provided by Registered Dietitians to individuals with mental health conditions and their care providers can lead to reduced nutrition-related side effects of psychiatric medications, improved cognition, better self-management of concurrent and comorbid conditions, and improved overall occupational, social, and psychological functioning.

1. AUTISM SPECTRUM DISORDERS

Autism spectrum disorders (ASD) are pervasive developmental disorders with the onset usually before 3 years of age. Individuals with ASDs usually have communication, social, and behavioural characteristics in common, with individual differences in levels of functioning

ASD may impact appetite, with increased needs being common.

Nutritional Implications and Recommendations:

The diets of children with ASD may lack dairy, fibre, calcium, iron, and vitamins D and E.

Some may respond to increased intake of omega-3 fats, especially docosahexaenoic acid (DHA), ranging from 1 g to 3 g per day.

Glutenfree, casein-free diets are often advocated for ASD, but the current evidence is limited.

Autistic person exhibit some difficult feeding behaviours may affect food intake. Examples:

- Limited diet
- Dysfunctional feeding behaviour
- Sensory sensitivities.

2. ATTENTION DEFICIT HYPERACTIVITY DISORDER

Attention deficit/hyperactivity disorder (ADHD) includes inattention (e.g., distractibility), hyperactivity, and/or impulsivity (e.g., fidgeting, excessive running, interrupting others). This condition can affect children and adults — up to 60% of those with ADHD are adults. There is a high overlap of ADHD with other conditions, including dyslexia (reading problems), dyspraxia (motor skill problems), and autism spectrum disorders. A challenge of working with people with ADHD is that they may have impaired ability to retain and use new information after counselling. Individuals with ADHD tend to have deficiencies of polyunsaturated fatty acids, zinc, magnesium, and iron. Serum ferritin and zinc levels may be low; supplementation of iron and zinc helps symptoms if there is deficiency

- If the child is food sensitive, an additive-free diet (no food colours or preservatives) may improve symptoms but needs to be supervised by a Registered Dietitian to ensure adequacy.
- Though sugar is thought to cause hyperactivity, research suggests removal of this ingredient from the diet will not improve symptoms.
- The individual with ADHD should be checked for celiac disease and, if present, a gluten-free diet can improve behaviour.
- The ketogenic diet has been suggested for ADHD, but the available evidence is only based on animal experiments.
- Supplementation with magnesium and iron therapies may help reduce ADHD severity.
- Some studies show lower levels of docosahexaenoic acid (DHA) and arachidonic acid (ARA) in children with hyperactivity.
- For the person who is hyperactive during meals, behavioural management programs may be effective.
- Children with ADHD are often prescribed stimulants (e.g., methylphenidate or Ritalin) to improve the ability to concentrate. These medications have been shown to reduce growth in children . Height and weight should be monitored (measured at least twice a year) and dietary advice that focuses on consumption of adequate calories from a healthy balanced diet provided. Altering the times and dosages of stimulant medication and taking breaks from their use (e.g., during summer holidays) may help reduce effects on growth

3. BIPOLAR AND RELATED DISORDERS

Bipolar disorders include a history of manic, mixed, or hypomanic episodes, usually with concurrent or previous history of one or more major depressive episodes. Mania is an abnormally elated mental state, typically characterized by feelings of euphoria, lack of inhibitions, racing thoughts, and diminished need for sleep, talkativeness, risk taking, and irritability. In extreme cases, mania can induce hallucinations and other psychotic symptoms. Bipolar disorders may be classified as bipolar I, bipolar II, or cyclothymia, depending on the severity of symptoms.

Nutritional concerns and recommendations

- The cyclical nature of bipolar disorder presents unique challenges for nutritional care. During mania, large amounts of sugar, caffeine, and food may be consumed or there may be periods of not eating. If the individual is in a controlled environment, measures can be put into place to ensure healthy foods are available in order to prevent weight gain from overeating.
- With mood instability, contact with health care providers may be infrequent, leading to increased risk of developing a chronic condition.
- Depressive episodes can lead to increased risk of cardiovascular disease through the effects of a sedentary lifestyle.
- Compared with those without a mental health condition, people with bipolar disorder are more likely to report poor exercise habits and suboptimal eating behaviours such as having fewer than two daily meals and having difficulty obtaining or cooking food.
- Antipsychotic medications are often prescribed as treatment for this condition, which contributes to weight gain and metabolic disturbance as detailed in the previous section on the schizophrenia spectrum and other psychotic disorders.
- Celiac disease, which is associated with increased prevalence of depressive and disruptive behaviours, should be tested for.
- If the individual is taking lithium, caffeine-containing drinks such as tea and coffee should be minimized as they can reduce lithium levels.
- Selenium, folic acid (folate), omega-3 fatty acids, and tryptophan have all been implicated in keeping moods stable. A diet rich in these nutrients should be tried before considering supplements.
- Supplementation with 1 g to 3 g of omega-3 fatty acids daily may help with depressive episodes.
- If folate supplementation is warranted, it may mask a deficiency of vitamin B12; therefore, supplementation with vitamin B12 should also occur.

4. DEPRESSIVE DISORDERS

Within the group of depressive disorders are chronic depressive (dysthymia), disruptive mood dysregulation, major depressive, and premenstrual dysphoric disorders.

Depression is manifested by a combination of symptoms that interfere with the ability to work, study, sleep, eat, and enjoy pleasurable activities.

Disabling episodes of depression commonly occur several times in a lifetime.

Dysthymia involves longterm (two years or longer) less severe symptoms that keep one from functioning normally or from feeling good. Some forms of depressive disorder exhibit slightly different characteristics or they may develop under unique circumstances and include psychotic

depression (depression accompanied by psychosis), postpartum depression *(*new mother develops a major depressive episode within one month of delivery), and seasonal affective disorder (onset of depression occurs during the winter months when there is less

natural sunlight).

Almost all chronic health conditions are associated with major depression, particularly those characterized by inflammation and pain.

- Depression often leads to weight changes as appetite may increase or decrease. For some, overeating or comfort eating may occur and lead to weight gain. The tendency in this population to carry excess weight may be exacerbated by a preference for higher-calorie liquids and/or convenience foods as well as a sedentary lifestyle.
- Other individuals with depressive disorders may undereat due to feelings such as not being worthy enough to eat, lacking motivation or energy to prepare foods, or somatic delusions of not being able to eat. Reduced food intake leads to nutrient inadequacies and weight loss.
- Tube-feedings may be needed for those who refuse food. Total parenteral nutrition (TPN) is usually not recommended as the TPN line may be used to inflict sepsis or other harm (e.g., suicide attempt).
- A well balanced diet with protein/calorie supplementation as needed and structuring eating for mood stability throughout the day may help.
- Poor food hygiene presents food safety risks so advice may be given to care providers to assist the person with keeping food safe.
- Because celiac disease is associated with an increased prevalence of depressive disorders, it is recommended that testing be done to rule it out.
- Depressive disorders may coexist with an eating disorder, thereby requiring behavioural interventions to normalize eating.

16.3.7.3 Self-Assessment

1. Explain how depressions affects nutrition
2. Explain three difficult feeding behaviour common in autistic children
3. Outline the nutrition concerns in bipolar disorder

4. Which of the following statements is not true about Attention Deficit Hyperactivity Disorder:
   A. Children with sensitivities should consume food free of additives
   B. Removal of sugar from the diet improves symptoms
   C. For patients with celiac disease, a gluten-free diet is recommended
   D. Supplementation with magnesium and iron therapies may help reduce ADHD severity.
5. _______is an abnormally elated mental state, characterized by feelings of euphoria, lack inhibitions, racing thoughts, and insomnia, talkativeness, risk taking, and of irritability.
   A. ADHD
   B. Autism
   C. Mania
   D. Bipolar disorder
6. The following nutrients help in mood stabilization in bipolar disorder except:
   A. Selenium
   B. Folic acid
   C. Omega-3 fatty acids
   D. Methionine
7. _______ refers to emotional, psychological and social well-being of an individual.
   A. ADHD
   B. Bipolar disorder
   C. Mental health
   D. Psychiatry
8. The following conditions affect the health and nutrition of autistic individuals except:
   A. Limited diet
   B. Dysfunctional feeding behaviour
   C. Gluten-free diet
   D. Sensory sensitivities

16.3.7.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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16.3.8 Learning Outcome 7: Demonstrate understanding in nutritional management of degenerative disorders

16.3.8.1 Learning Activities

Learning Activities	Special instructions
1. Identify and describe terminologies under degenerative disorders	• Use terminologies under degenerative disorders
2. Identify degenerative disorders and describe their pathophysiology	• Consider how degenerative disorders affect nutrition
3. Identify and describe nutritional management of degenerative disorders	• Determine the nutritional requirements in degenerative disorders • Plan diet for degenerative disorders • Apply guidelines provided for the management of degenerative disorders

16.3.8.2 Information Sheet

1. Amyotrophic Lateral Sclerosis (ALS)

Amyotrophic lateral sclerosis (ALS) is the most common of the MNDs, defined by the progressive degeneration of upper and lower motor neurons, and causes atrophy, fasciculation, weakness and spasticity .

The natural course of ALS can be defined as death from respiratory failure. The prevalence rate of ALS currently is 2.7-7.4 per 100,000 inhabitants; the incidence is 1.9 per 100,000 inhabitants.

The aetiology of ALS is not fully clarified; however, excitotoxicity from glutamate neurotransmitter, changes in immunity, deficiency of neurotrophic factors, physical traumas, persistent viral infections and even environmental factors has been suggested as possible causes of the disease.

During the course of ALS, nutritional status (NS) declines, and is often inadequately treated in clinical practice, Although various studies confirm the correlation between decrease in body weight and body mass index as negative predictors of survival.

Some factors are inherent to the amendments to the NS and the reduction of food intake in patients with it, such as: loss of appetite, dysphagia, dyspnea, depression and hyper-metabolism. Hyper-metabolism origin and development in ALS have not been thoroughly elucidated; 50% of these patients, however, present in hypermetabolic state causing the increased nutritional needs make the nutritional treatment even more complex.

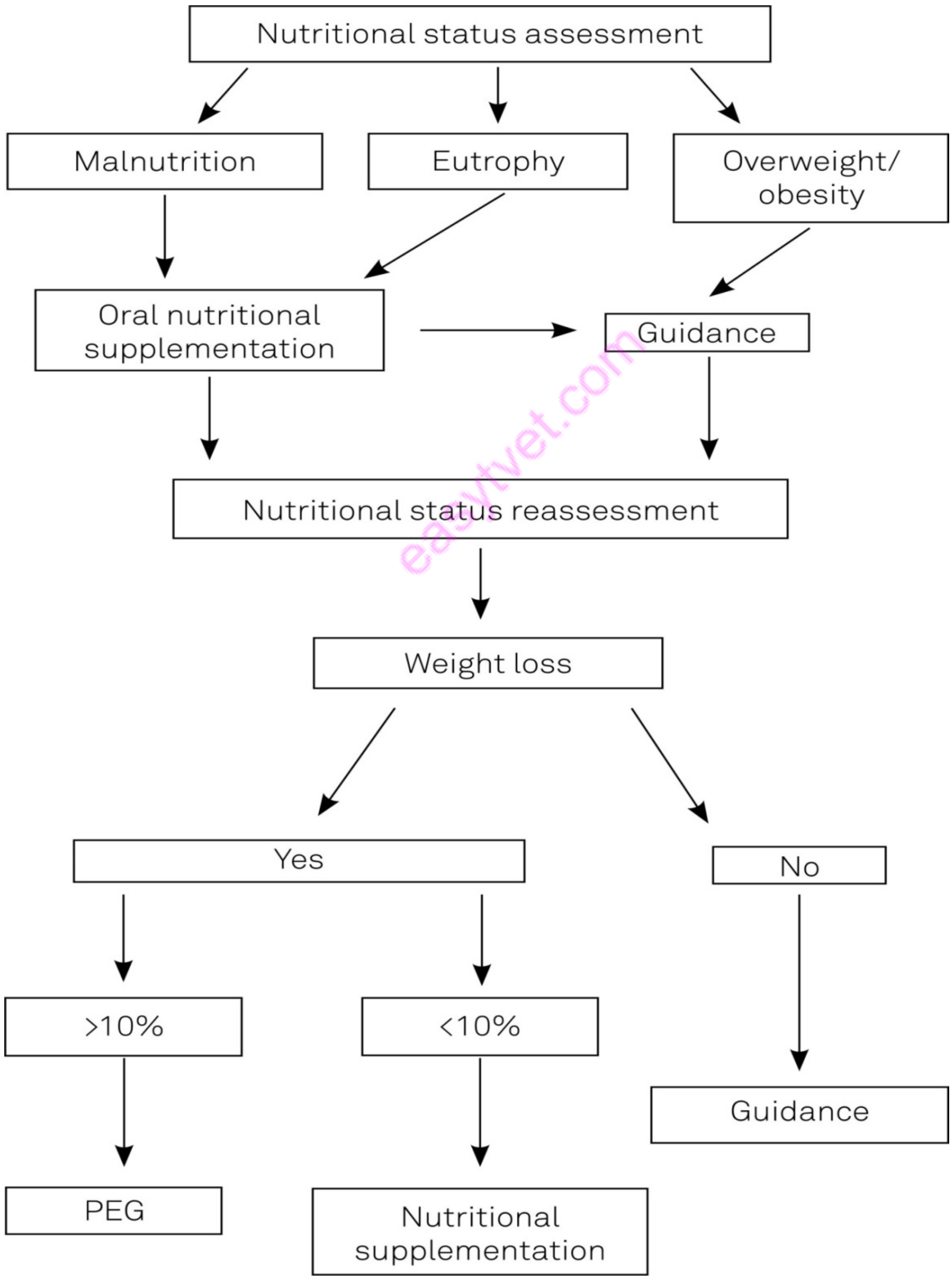
The disease affects bulbar muscles of patients first, from 25% to 30%, resulting in progressive dysphagia and leading to decrease in food and hydric intake. The need for modifying diet consistency contributes to reduction of high-value food-protein energy. In analysis of food intake, found that only one of sixteen patients studied presented appropriate recommendations for front intake energy.

Malnutrition, common with progression of disease, muscle strength and breathing capacity due to weakening as well as increase the relative risk of death .

Meet the energy requirements of macro and micronutrients, adjust degree of dysphagia brought and indicate enteral nutritional therapy at right time have been the subject. Within this context, this present review aims to present nutritional treatment strategies for the maintenance of NS of ALS patients.

Nutrition intervention

The identification of nutritional status through diagnostic methods leads to the formulation of a plan to deal with each situation individually.



Nutritional treatment protocol

Dietary Recommendation

Nutritional therapy applied to ALS aims to supply the nutritional needs for all stages of disease progression, minimise protein catabolism, ensure oral feeding and indicate early nutritional support.

Energy needs

Estimate energy requirements used with the current weight while considering factors such as activity and injury.

Protein

The calculation of protein requirements is based on the recommendations of the Brazilian Society of Food and Nutrition , being offered 1.0 g–1.2 g protein/kg in current weight/day. Food intake, source of high biological value protein, should be highlighted, comprising roughly 70% in total protein intake per day.

Carbohydrates

The diet is oriented normoglycidic (50-60% of total energy intake) and modified to hypoglycemic, specifically for patients with abnormal oxygen saturation. For these cases, the energy supply must be maintained at the expense of lipids, with high-fat diets (>35% of total energy intake).

Lipids

It is recommended ingesting 25-35% of total energy intake, considering ≤7% saturated fatty acids, ≤10% polyunsaturated fatty acids and ≤20% monounsaturated fatty acids

Fibres

The fibre intake gradually restricts itself in the course of the disease, worsening dysphagia. Cooking food is necessary for a suitable consistency limitation, ensuring that its consumption is not excluded from diet.

Adding cereal flour to porridge, orange juice with papaya and dried pitted prunes, liquefied food, boiled and mashed vegetables and legumes cooked well are preparations easy to swallow and help intestinal transit.

When adequate intake of fibres becomes impossible, supplemental fibre with module containing industrialized mix of soluble and insoluble fibres is necessary.

According to the age and sex of the individual, 25-38 g of dietary fibre intake per day is **recommended.**

Water

At times, when dysphagia signals occur, liquid must be thickened to reduce the aspiration risk and offer the proper water requirement to patients. The use of industrialised thickeners grants a more suitable consistency to liquid, however, excessive consumption can worsen constipation. Gelatin, with or without flavour, can also be used as a means to modify food consistency.

Food with high liquid content, e.g. fruit and vegetable puree, fruit juice and smoothies assist in hydration and reaching the estimated water requirement of 30-40 mL/kg/day

Micronutrients

The micronutrient prescription follows the recommendations of dietary intake recommended according to age and sex of patients.

2. PARKINSON'S DISEASE

It's a degenerative disorder of the central nervous system.

It's the second most common neural degenerative disorder and the most common movement disorder.

It's characterized by progressive loss of muscle control which leads to trembling of the limbs and head at rest, stiffness, slowness and impaired balance.

As symptoms worsen it may become difficult to take and complete simple tasks.

The progression of Parkinson's disease and degree of impairment vary from individual to individual and many people with Parkinson's leave long productive life whereas others become disabled much more quickly.

Premature death is usually due to complications such as falling related injuries or pneumonia

Causes

The neurotransmitter dopamine acts as a messenger between two brain areas to control movement. They are :

- Substantia nigra
- Corpus stratium

Most of the movement related symptoms of Parkinson's diseases are caused by lack of dopamine due to the loss of dopamine producing cells in the substantia nigra.

When the amount of dopamine is too low communication between the substantia nigra and the corpus stratium becomes defectivesand movement becomes impaired.

The greater loss of dopamine the worst the movement related symptoms.

Risk Factors

- Age –is the largest risk factor for the development and progression of prisons disease and most people who develop Parkinson disease are older than 60 years of age
- Sex or gender –men are affected about 1.5 -2 times more often than women
- Genetics- a small number of individuals are at a n increased risk because of a family history of the disorder
- Head trauma illness or exposure to environmental toxins such as pesticides and herbicides maybe at a risk.

Symptoms

- The primary symptoms of Parkinson's disease are all related to voluntary and involuntary motor function and usually starts on one side of the body
- Symptoms are usually mild at first and they will progress overtime
- Tremors –trembling in fingers, arms, feet ,legs ,jaw or head they most often occur while the individual is resting they may worsen when an individual is exited, tired or stressed
- Rigidity-stiffness of the limbs which may increase during movement and they may produce muscle aches and pain loss of fine movement may lead to crammed handwriting and may make eating difficult
- Bradykinesia –it's the slowness of voluntary movement bradykinesa together with stiffness affects the facial muscles and therefore resulting to an expressionless appearance
- Postural instability-impaired or lost reflex can make it difficult to adjust posture to maintain balance
- Other symptoms: anxiety confusion constipation depression difficulty in swallowing diminished sense of smell male erectile dysfunction urinary frequency slowed quieter speech and excessive salivation.

Medical Treatment

- There is currently no treatment to cure Parkinson's disease.
- Several therapies are available to delay the onset of motor symptoms and to decrease the motor symptoms.
- All this therapies are designed to increase dopamine movement in the brain
- Either by replacing dopamine or prolonging the effect of dopamine inhibiting its symptoms.
- The main drug levodopa or combination with carbidopa.

Nutrition Therapy

Parkinson's disease shows mild to moderate nutritional depletion with weight loss less of subcutaneous fat varying degrees of swallowing difficult.

Dysphagia becomes a significant feeding programme in the final stages of the disease while rigidity is the permanent feature.

The nutritionist should focus on the dysphagia difficult in self feeding and the nutrients drug interactions.

- If patient is taking levodopa.a high level of protein interferes with this drug.
- Restrict protein to 0.8g/kg/day
- Patients responding poorly to levodopa may benefit from the intake of low protein meals for breakfast and lunch, followed by an evening meal that provides the balance of 0.8g/kg/day allowance for protein.

- Give proteins of high biologic value, modifying the consistency according to the chewing and swallowing abilities of the patient.
- Serve the protein rich foods mainly in the evening meal.
- This may reduce tremors and allow some normal functioning during the day.
- However, consumption of a larger protein meal in the evening can result in suboptimal levodopa effect and increased rigidity.
- Tyrosine (a precursor of dopamine) maybe beneficial.
- Limit the intake of pyridoxine to less that 5mg/day to make levodopa move effective.
- Avoid constipation and encourage the intake of fluids.
- Promote independence with self feeding. Get the patient in the best possible for feeding and use adaptive feeding devices such as cups with double handles and timed dishes.
- Serve small frequent meals and use semisolid foods rather than fluids if swallowing is a problem.

3. ALZHEIMER'S DISEASE

It's a form of dementia characterized by a group of symptoms that include loss of memory thinking and reasoning power disorientation confusion and sometimes speech disturbances.

The exact causes of Alzheimer disease depends on its characterized symptoms.

A victim gradually looses memory and reasoning, the ability to communicate, physical capabilities and eventually life itself.

Nerve cells in the brain die and the communication between the cells breaks down

Other symptoms include early depression found in 30% of the patient's mild anemia repetition of words and sounds

NB: Early onset is usually mild and middle and then there is late onset.

This disease progresses to death due to infection or malnutrition.

Food intake is affected and weight loss is common and the following are typical feeding problem seen during the three stage of the disease.

Stages of Alzheimer's Disease

Stage 1: difficult in shopping and cooking unusual food choices decreased appetite changes in taste and smell and forgetting to eat.

Stage 2- : loosing ability to use utensils eating with hands holding food in the mouth forgetting to swallow and failing to chew food before swallowing.

Stage 3-: no recognition of food refusing to eat or opening the mouth and dysphagia.

Causes

- Genetics
- Cardiovascular disease i.e. high blood pressure and diabetes maybe related to the development of Alzheimer's disease

Medical Treatment

Medical treatment involves providing care to clients and support to their families.

Drugs are use to improve or at least slow the loss of short term memory and cognition but they do not treat the disease.

Other drugs maybe used to control depression anxiety and behavior problems.

Nutrition Therapy

- Feeding must be individualized and one should be able to recognize and assess feeding problems associated at each stage of the disease
- Encourage and promote as much independence in eating by selecting appropriate food consistency providing adequate time t eat using the appropriate feeding equipment and technique and by providing the proper dining environment
- Give small frequent meals of nutrient dense foods
- Supplemental vitamins and minerals maybe necessary monitor body weight and guard against dehydration and aspiration of food
- Delay tube feeding unless absolutely necessary

16.3.8.3 Self-Assessment

1. Discuss the dietary management of Parkinson's disease.
2. Discuss the stages of Alzeihmer's disease.
3. _____is a progressive loss of muscle control which leads to trembling of the limbs and head at rest, stiffness, slowness and impaired balance.

   A. Alzheimer's Disease

   B. Parkinson's Disease

   C. ALS

   D. Dysphagia
4. Nutritional care in ALS aims to do the following except:

   A. To supply the nutritional needs for all stages of disease progression

   B. Minimise protein catabolism

   C. Ensure oral feeding

   D. Reduction of high-value food-protein energy.

5. Which of the following is a risk factor for Parkinson's Disease?
   A. Gluten-free diet
   B. Head trauma
   C. Obesity
   D. High fat diet
6. _____ is a form of dementia characterized by a group of symptoms that include loss of memory thinking and reasoning power disorientation confusion and sometimes speech disturbances
   A. Depression
   B. ADHD
   C. Alzeihmers
   D. Parkinson's Disease
7. Which of the following is true about the nutritional management of Parkinson's disease:
   A. Tyrosine improves symptoms
   B. Intake of pyridoxine should be increased
   C. Protein foods should not be taken in the evening as they increase tremors
   D. High level of protein enhances drug utilization

16.3.8.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH guidelines
- Ministry of Education
- Skills lab
- Use of LCDs, video clips, charts and other teaching aids
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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CHAPTER 17:

PERFORM DIETETICS OPERATIONS

17.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to manage nutrition and dietetic services. It includes: diet modifications, enteral and parenteral nutrition, surgery, trauma and burns management, and palliative and hospice care and drug nutrient interactions.

17.2 Performance Standard

By the end of this unit of learning/competency, the trainee should demonstrate ability to design normal hospital diet which meets nutritional requirements for different clients as per workplace procedures and resource materials; carry out diet modification in line with resource materials and workplace procedures, determine routes of administration and monitoring of enteral feeding as per resource materials, client's condition and policies and guidelines; recommend, calculate nutrient requirements in and monitor parenteral feeding in line with resource materials, policies and guidelines; provide nutritional management in surgery, trauma and burn as per SOPs, resource materials, policies and guidelines; provide palliative and hospice care based on resource materials, policies and guidelines; offer nutritional support and advise clients on drug-nutrient interactions in line with resource materials, policies and guidelines.

17.3 Learning Outcomes

17.3.1 List of the Learning Outcomes

i) Identify terminologies in dietetics
ii) Demonstrate understanding of modified diets in the management of non-communicable and communicable diseases
iii) Demonstrate understanding in the management of malnutrition and micronutrient deficiencies of public health concerns
iv) Demonstrate understanding in enteral nutrition
v) Demonstrate understanding in parenteral nutrition
vi) Demonstrate understanding in nutritional management of surgery, trauma, and burn
vii) Demonstrate understanding of palliative and hospice care
viii) Demonstrate understanding in nutrient drug interactions

17.3.2 Learning Outcome 1: Identify terminologies in dietetics

17.3.2.1 Learning Activities

Learning activity	Special instructions
i) Demonstrate ability to describe terminologies in dietetics	
ii) Describe normal and modified diets	➢ Differentiate between normal hospital diets and modified diets ➢ Apply the knowledge of therapeutic/ modified diets in nutrition care

17.3.2.2 Information Sheet

Terminologies under dietetics

- **Dietetics:** It is the interpretation and communication of the science of nutrition; it helps people make informed and practical choices about food and lifestyle in both health and disease
- **Nutritional care:** It is the application of the art and science of nutrition in helping people select or obtain food from the primary purpose of nourishing their bodies in health or disease throughout their lifecycle
- **Therapeutic diets:** It is a diet that is modified from a normal diet to meet the requirements of the ill/ sick individual.
- **Normal diet:** it consists of any and all foods eaten by the person in health. It satisfies the nutritional needs of most patients and serves as the basis for planning modified diets.
- **Diet modification:** It refers to the action of adjusting a normal diet to change its consistency/texture, flavor and nutrient contents.
- **Food allergy:** refers an adverse immune response to a food protein.

Description of normal and modified diets

Normal and therapeutic diets are planned to maintain or restore good nutrition in the patient. In manual diets or hospitals, the normal diet may be designed as;

1. **Regular diet**- This diet is designed to provide adequate nutrition for promotion of optimal health. This diet is used when there are no required diet modifications or restrictions. It is the foundation of all other diets. Individual requirements for specific nutrients may vary based on age, sex, height, weight, activity level, and different physiological states.

Characteristics: foods from the basic food groups are included with the addition of other foods to provide essential nutrients

Food guide for the regular diet

Food groups	Major nutrients	Servings	One serving equivalent
Cereals and starchy foods	Carbohydrates *Thiamine, Iron, Niacin (Refined cereals are poor sources of thiamine- vit. B1)	6-11	1 slice of bread ½ cup cooked cereal, pasta or rice ¾ to 1 cup potatoes, green bananas 1 pancake (5 inches diameter x ¼ inches thick 3 biscuits/crackers (1½ inches cube
Milk and milk products	Calcium, Riboflavin (vit. B2), protein, fat	2-4	1 cup fresh milk, fermented milk or yoghurt 45g cheese ¾ cup dairy ice cream
Meat or substitutes	Protein, niacin, iron, thiamine	2-3	60-90 g cooked fish, meat, chicken, eggs 1-1½ cups of dried beans or peas 4 tbsp peanut butter
Fruits and vegetables	Vitamin A Vitamin C Vitamin K	2 good sources of vitamin C 2 good sources of vitamin A	1 piece whole fruit ½ cup cooked vegetables ½ cup fruit or juice 1 cup green leafy vegetables/ chopped raw vegetables
Fats and sugars	Vitamins A, D, E, K, Fat, Carbohydrates	As needed to meet energy needs. Fat- 25%-35% of total calories	Vegetable oil, margarine, butter, cream, salad dressings, mayonnaise, sweets, sugar, honey
Water		6-8 glasses	250ml

2. House diet
3. Normal/full diet

In morbidity, nutritional homeostasis is altered. This creates special nutritional needs necessitating nutritional modification. Modified diets are normal diet qualitatively or quantitatively altered as per patients'/clients' special needs and in line with the general principles of meal planning.

Principles of diet modification

The six principles of diet modification are;

1. **Adequacy**: An adequate diet provides the human body with energy and nutrients for optimal growth, maintenance and repair of tissue, cells and organs. Water, carbohydrates, fats, proteins, vitamins and some minerals comprise the six nutrient classes relied upon for performance of essential functions and activities. These nutrients must be replaced through diet to keep the body working efficiently. An adequate diet includes foods containing proper amounts of these nutrients to prevent deficiencies, anemia, headaches, fatigue and general weakness.

2. **Balance:** A balanced diet includes foods containing sufficient amounts of each class of nutrients. For example, while milk is a good source of calcium and fish provides necessary iron and protein, the two are not enough alone. Other essential vitamins, carbohydrates and fats are found in whole grains, vegetables and fruits. The U.S. Department of Agriculture provides a great blueprint for a balanced diet with its five food groups -- grains, proteins, vegetables, fruit and dairy. Consuming the proper amount of servings from each category ensures a well-proportioned diet.

3. **Calorie control:** Once you know what to eat, the next factor is how much. It is possible to eat healthy foods and still overindulge. Therefore, a reasonable calorie allowance must be established. The amount of energy the body receives from incoming food needs to match the amount of energy needed for the body to sustain its biological and physiological activities. In other words, input needs to match output. An imbalance leads to weight loss or gain.

4. **Density**: Eating well without overeating is often challenging. One must select foods that pack the most nutrients into the least amount of calories. For example, 1 ounce of cheese and 1 cup of fat-free milk contain the same amount of calcium. While both foods are adequate sources of calcium, the milk is more calcium-dense than the cheese because you get the same amount of calcium with one-half the calories and no fat. In another example, calorie allowance is not a useful tool by number alone. Although a bowl of grapes and a can of soda contain roughly the same number of calories, the grapes contain far more nutrients than the cola. Designing a nutritionally sound diet requires proper “budgeting” of calories and nutrients so that you eat less while supporting good health.

5. **Moderation**: **Socrates once said «Everything in moderation; nothing in excess.» Though over 2,500 years old, this adage still holds true. Those who place severe restrictions on what they can or cannot eat often find it difficult to stick to a pattern of sensible eating. Depriving yourself of foods rich in fat and sugar is not necessary. When eaten on occasion, these treats are not detrimental to your health and often provide enough enjoyment to keep one motivated to continue healthy eating practices.**

6. **Variety**: It’s possible for a diet to have all the aforementioned characteristics, but still lack variety. While some people are creatures of habit and don’t mind eating the same meals every day, most of us crave a wide array of choices and tastes. Good nutrition does not have to be boring. The USDA’s food groups allow you to receive the proper nutrients while having a great selection of foods to pick and choose from. After all, variety is the spice of life.

Food allergies or food intolerances

Sometimes people become sick from eating a particular food, because they cannot properly process or digest the food, or because they have a true allergic (immune) reaction to the food. Food allergies and food intolerance are sometimes confused with each other, but they are quite different in terms of their origin, symptoms and treatment.

Food allergies

To protect us from illness & disease our immune systems are continuously trying to lessen the damage presented by substances called **antigens**. Antigens are part of proteins that our bodies recognize as dangerous and takes steps to neutralize. Antigens can be found almost anywhere there is protein in foods or microorganisms like bacteria.

There are two types of food allergies;

- Immediate
- Delayed allergic reaction

They are distinct from other adverse responses to food such as food intolerance, pharmacological reactions and toxin-mediated reactions. The protein in food is the most common allergic component. This occurs when the body's immune system mistakenly identifies a protein as harmful. Some proteins or fragments of proteins are resistant to digestion and those that are not broken down in the digestive process are tagged by the immunoglobulinE(igE).

When the body identifies a food as harmful, the immune system sends white blood cells to attack, it does so by producing antibodies directed against that food. The next time the food is consumed, the body mounts an immune response with the release of histamine and other chemicals that trigger allergic symptoms.

Food allergy symptoms can include:

- Skin rash
- Hives
- Swelling of the tongue and throat
- Itchy skin
- Chest pain
- Breathing problems including asthma
- Vomiting or diarrhea
- Abdominal pain and cramping

Severe allergic reactions may result in a drop in blood pressure, loss of consciousness, or even death.

The main allergic responses include; dermatitis, gastrointestinal and respiratory distress. Other responses can be life-threatening like anaphylactic responses and they need immediate medical attention.

Foods that cause allergy include peanuts, milk (mostly in children), eggs, tree nuts (like walnuts and pecans), soy, wheat, fish (mostly in adults), and shellfish (mostly in adults).

Treatment of food allergies

Immunotherapy; avoidance, in which the allergic person avoids all forms of contact with the food to which they are allergic.

Food intolerance

Food intolerance is a digestive system response rather than an immune system response. It occurs when something in food irritates a person's digestive system or when a person is unable to properly digest, or break down, the food. A common type of food intolerance is lactose intolerance. Persons with lactose intolerance lack an enzyme (called lactase) needed to digest the milk sugar (called lactose).

They can develop gas, bloating, and abdominal pain when they consume milk products. If an individual thinks they may have either food allergy or food intolerance, keep a diary of the foods eaten and any symptoms experienced. A food diary can help the doctor establish the correct diagnosis.

Common symptoms of food intolerance include:

- Nausea
- Stomach pain
- Gas, cramps or bloating
- Vomiting
- Heartburn
- Diarrhoea
- Headaches
- Irritability or nervousness

17.3.2.3 Self-Assessment

1. Define the following terms;

A. Dietetics

B. Diet modification

C. Therapeutic diets

2. The sickness which people experience after eating a particular food because they cannot digest food is called_____________

A. Food allergy B. Autoimmune reaction

C. Food intolerance D. Bloating

3. One serving of cereals for regular diet is equivalent to all of the following except;

   A. 1 pancake B. 1 cup cooked rice

   C. 1 slice of bread D. 3 biscuits

4. A______________ can help the doctor establish the correct cause of food allergy or food intolerance

   A. Diet history B. Food diary

   C. Direct observation D. 24-hour recall

5. Differentiate between food intolerance and food allergy
6. Explain how food allergies are treated
7. Giving a relevant example, identify the symptoms of food intolerance

17.3.2.4 Tools, Equipment, Supplies and Materials

- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Stationery
- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

17.3.2.5 References

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17.3.3 Learning Outcome 2: Demonstrate understanding of modified diets in the management of non-communicable and communicable diseases

17.3.3.1 Learning Activities

Learning activity	Special instructions
i) Describe diet modifications in the management of non-communicable disorders.	• Recommend a therapeutic diet for patients with different non-communicable diseases • Calculate the nutritional requirements of different patients suffering non communicable diseases
ii) Describe diet modification in the management of communicable disorders	• Recommend a therapeutic diet for patients with different communicable diseases • Calculate the nutritional requirements of different patients suffering communicable diseases
iii) Produce modified diets	• Prepare therapeutic diet for patients with different diseases • Determine the frequency and quantity of food to be given per feed. • Monitor patient's response to the diet and document in the patient's file

17.3.3.2 Information Sheet

Therapeutic diet: A meal plan that controls the intake of certain foods or nutrients.

Hyperlipidemia: Elevated plasma lipids

Hyperlipoproteinemia: Elevated plasma lipoproteins.

Therapeutic diets

A therapeutic diet is part of the treatment of a medical condition and are normally prescribed by a nutritionist or a physician. A therapeutic diet is usually a modification of a regular diet. It is modified or tailored to meet the nutrition needs of a particular person.

Therapeutic diets are modified for:

- Nutrients
- Texture

Purpose of therapeutic diets

Many health conditions are caused in part by what you eat. As such treating or preventing these conditions may involve a change in diet or a special diet, often called therapeutic diet. With therapeutic diet you add or limit certain foods to improve a specific health condition

Significance of therapeutic diet

Therapeutic diets are special diets designated for people with certain medical conditions. A therapeutic diet is used to help a medical condition from a nutritional perspective. Changes in diet can help or even relieve some medical conditions.

Conditions for therapeutic diets

Some of the conditions that can benefit from a therapeutic diet include;

- Cardiovascular diseases such as coronary artery disease, hypertension, and heart attack and stroke
- Diabetes can also benefit from a therapeutic diet
- People with gastrointestinal diseases such as crohns disease, ulcerative colitis and celiac disease
- People with food allergies can also benefit from therapeutic diets.

Importance of therapeutic diets

Therapeutic diets are very important in the practice of nutrition and dietetics for the following reasons;

- To maintain nutritional status
- To restore nutritional status
- To correct nutritional status
- To decrease weight for weight control
- To provide extra calories for weight gain
- To balance amount of carbohydrates, fats and protein for control of diabetes
- To provide a greater amount of nutrient such as protein
- To decrease amount of a nutrient such as sodium
- To exclude foods due to allergies or food intolerance
- To provide texture modifications due to problems with chewing and or swallowing.

Factors to consider when modifying a diet include;

- Disease symptoms
- Severity of the symptom or disease (condition of the patient)

- Nutritional status of the patients
- Metabolic changes involved
- Physiological state

Therapeutic modification of normal diet:

A. **MODIFICATION IN CONSISTENCY**

1. Clear liquid diet

Purpose

This is a diet modified to provide oral fluids to prevent dehydration and relieve thirst, small amounts of electrolytes and calories in a form that requires minimal digestion and stimulation of the gastrointestinal tract. It is indicated for short term use (24hrs to 48hrs as indicated in table X. Nutritionally depleted patients should receive additional nutritional support through use of nutritionally complete minimal residue supplements or parenteral nutrition.

Indication and characteristics for clear liquid diet

Diet	Indications	Characteristics of the diet
• E.g. Black tea, broth, strained fruit/ vegetable juices etc.	• Pre- and Post-operation, • As a transition from intravenous feeding to a full liquid diet, • When other liquids and solid foods are not tolerated, • During bowel preparation prior to diagnostic visualization or surgery • In the initial recovery phase after abdominal surgery	• Composed of water and carbohydrates. • Clear liquid at room temperature • Leaves minimal amount of residue in the Gastrointestinal (GI) tract. • Provides approximately 400-500kcals, 5-10g proteins, 100-120g CHO and no fat. • Should be of low concentration • Milk and milk drinks are omitted • Improve energy level by addition of sugar • Are nutritionally inadequate in all nutrients.

Food guide for clear liquid diets

Foods	Allowed	Avoid
Milk	None	All
Eggs	None	All
Fruit juice	Clear fruit juices such as apple, grape or strained fruit juices such as oranges, lemonade, grape fruit, tangerine, pineapple	All other fruits with pulp

Soups	Clear broth, bouillon (fat free)	All others
Beverages	Carbonated and non-carbonated beverages, coffee, tea, decaffeinated coffee	All others
Miscellaneous	Sugar, syrup, plain or flavored gelatin, iodized salt	All others

Calorie content of selected clear liquids

Food item	Measure	Weight in gm	Energy in Kcals
Orange juice (fresh)	1 cup	240 gm	110
Lemon juice	1 tbsp	15 gm	4
Lime juice	1 tbsp	15 gm	4
Cocacola	240 ml	240 gm	110
Ginger ale	240 ml	240 gm	85
Pepsi cola	240 ml	240 gm	110
Gelatin	½ cup	-	71
Sugar	2tsp	11 gm	40
Honey	1 tbsp	21 gm	65

Nutrition adequacy

This diet is nutritionally inadequate in calories, protein and all nutrients. It should not be used for more than four days

2. Full Liquid diet

Purpose

The full liquid diet is designed to provide nourishment in liquid form and facilitate digestion and optimal utilization of nutrients in acutely ill patients who are unable to chew or swallow certain foods. The diet is often used as a transition between the clear liquid diet and a soft regular diet. Patients with hypercholesterolemia full liquid diet to be modified to have low fat by substituting high saturated fats with low fat dairy products and polyunsaturated fats and oils. Increasing protein and caloric value of full liquid diet becomes necessary when the diet is used for a period extending over 2-3 weeks. The Table below provides indications for and characteristics of full liquid diet.

Indications and characteristics of full liquid diet

Diet	Indications	Characteristics of the diet
• Soft desserts from milk and eggs, • Pureed and strained soups, ice creams, milk or yoghurt, etc.	• For post-operative patients • For acutely ill patients or those with oesophageal/GIT disorders and cannot tolerate solid foods • Following surgery of the face-neck area or dental or jaw wiring	• Foods should be liquid at room temperature • Free from condiments and spices • Provides between 1500-2000kcal/day • Large percentage is milk based foods; lactose intolerant individuals need special consideration. • The diet may be inadequate in micronutrients and fibre

Food guide for full liquid diet

Food group	Allowed	Avoid
Milk and milk products (3 or more servings)	Milk, milk drinks, plain yoghurt, fermented milks	Any not tolerated
Meat and substitutes (2-3 servings daily)	Blended strained meat added to broth or cream soup, strained legumes, eggs in milk drinks, eggs in custard egg	All others Raw eggs or unpasteurized eggs if not tolerated
Cereals and starch foods (4 or more servings)	Gruel made from refined cooked cereal, strained or pureed with potatoes added to soup	All others
Fruits/vegetables 2 or more servings of fruit juice daily including 1 serving of citrus juice 2 or more servings of vegetable daily	All fruit juices are tolerated All blended strained vegetables in soup, all vegetable juices	None All others
Soups	Broth, bouillon (fat free) and strained cream soups made from foods allowed	All others
Fats	Butter, margarine, vegetable oils, cream in cream soups	All others
Sweets/deserts	Honey, syrup, sugar, custard, gelatin, plain ice-cream, fruit juices	All others

Beverages	Coffee, tea, cocoa, decaffeinated coffee, carbonated and non-carbonated beverages, high protein, high calorie fluid supplements	None
Miscellaneous	Salt (iodized), flavourings, herbs, spices as tolerated	All others

Milk based foods constitute a large percentage of the full liquid diet. Therefore, lactose intolerance is sometimes observed in certain individuals e.g. after surgery involving the GI tract, cases of protein energy malnutrition etc. Lactose hydrolysed milks or lactose free products may be used for such cases.

The full liquid diet can be modified to be low in fat for individuals with hypercholesterolemia by substituting low fat dairy products and polyunsaturated fats and oils for those high in saturated fats. Further adjustments may be necessary to meet the needs of patients with diabetes, renal diseases and other diseases.

Nutritional adequacy

This diet may be inadequate in iron, niacin, folic acid, ascorbic acid, vitamin A, dietary fibre, proteins and calories. They therefore may require supplementation in long term use

3. Thick liquid diet

This diet is moderately low in cellulose and connective tissue to facilitate easy digestion. Tender foods are used to prepare the diet. Most raw fruits and vegetables, coarse breads, cereals, tough meats and nuts are eliminated. Fried and highly seasoned foods are omitted.

Purpose of the diet

The blended liquid diet is designed to provide adequate calories, protein and fluid for the patients who are unable to chew, swallow or digest solid foods. The diet prescription should be individualized to meet medical condition and tolerance. Patients with wired jaws may use a syringe, spoon, or straw to facilitate passage of liquid through openings in the teeth, depending on the physician's recommendation. Frequent feedings (six to eight feeds per day) facilitate ingestion of adequate calories and proteins. Depending on individual choice and tolerance, the diet can be used to provide adequate nutrients. Some patients experience palatability problems or may have difficulty consuming adequate volume of liquids, they may be unable to meet nutrient and fluid needs. In such situations supplementation may be necessary. Blended foods should be used immediately but can be refrigerated up to 48hrs or frozen immediately after blending to prevent growth of harmful bacteria. The following Table provides indications for and characteristics of thick liquid diet.

Indications and characteristics of thick liquid diet

Diet	Indications	Characteristics of the diet
	• After oral surgery or plastic surgery of the face or neck area with chewing or swallowing dysfunctions • For acutely ill patients and those with oral, esophageal or stomach disorders who are unable to tolerate solid foods due to stricture or anatomical irregularities • Those progressing from full liquid to a general diet. • Patients who are too weak to tolerate a general diet. • Those whose dentition is too poor to handle foods in a general diet. • Those for whom a light diet has been indicated e.g. post operative	• Fluids and food blended to a liquid form • Viscosity ranges from the thickness of fruit juice to that of cream soup • All liquids can be used to blend foods. However, nutrient dense liquids with similar or little flavor are preferable. Use of broth, gravy, vegetable juices, cream soups, cheese and tomato sauces, milk and fruit juices is recommended • Multivitamin and mineral supplementation is recommended

4. Complete Blenderized /Soft Or Light Diet

This diet is designed to provide nutrients for patients unable to physiologically tolerate a general diet in which mechanical ease in eating, digestion or both are desired. The diet should be individualized based on the type of illness or surgery and the patient's appetite, chewing and swallowing ability and food tolerance. The table below shows indication for and characteristics of soft diet.

Indication and characteristics of soft diet

Diet	Indications	Characteristics of the diet
• Fruit juices or cooked fruits, • Well-cooked cereals, strained if necessary; • Fresh spinach • Amaranth (*Terere*); • Pumpkin leaves; • Managu • Strained peas; • Potatoes, baked, boiled, or mashed. • Fats: butter, thin cream.	• Post-operative patients • Patients with mild gastro intestinal problems • Non-surgical patients whose dentition is too weak or whose dentition is inadequate to handle a general diet • For transition from thick liquid to a general diet	• Moderately low in cellulose and connective tissues • Tender foods • Fluids and solid foods may be lightly seasoned • Food texture ranges from smooth and creamy to moderately crispy • Most raw fruits and vegetables, course breads and cereals gas producing foods and tough meats are eliminated

• Milk: plain, in scrambled egg, in cream soups, in simple desserts. • Eggs: soft-cooked, omelettes, custards. Simple desserts; custards, ice cream, gelatine desserts, • Cooked fruits or cereal puddings		• Fried and highly seasoned foods, strong smelling foods should be omitted

Patients who are unable to chew or swallow hard or course food need a light diet.

Food guide for light diet

Food group	Foods recommended	Foods excluded
Milk and milk products	All milk and milk products	Those not tolerated
Vegetables	All vegetable juices, cooked vegetables as tolerated, lettuce in small amounts, salads made from allowed foods	Raw vegetables, dried peas and beans, corn, gas-forming vegetables such as broccoli, Brussels sprouts, cabbages, onions, cauliflower, cucumber, green pepper and turnips.
Fruits 2 or more servings/day One vitamin C rich source	All fruit juices, cooked or canned fruit. Avocado, banana, pawpaw, grape fruit and orange sections without membrane	Fresh or dried berries and figs
Breads and cereals 4 or more servings per day Other starch foods	Whole grain flour products or enriched breads and cereals Potatoes, rice, spaghetti, macaroni, other pastas and other starches as tolerated.	Coarse cereals such as bran, seeds in or on breads and crackers ,bread or bread products with nuts or dried fruits potato chips fried potatoes wild rice

Meat or substitutes 180 gm or more per day (3 servings per day)	All lean, tender meats, poultry, fish and shell fish, eggs, milk, cheeses, smooth peanut butter, soybean and other meat substitutes	Highly seasoned or smoked meats, poultry, fish, luncheon, meats, frankfurters, sausages, strong flavoured cheeses, and chunky peanut butter
Fats	All fats and oils, butter or fortified margarine, mild salad dressings such as mayonnaise, vinegar and oil	Highly seasoned salad dressings
Soups		Those not tolerated
Sweets and desserts		All sweets and desserts containing nuts,coconut,or fruits not allowed,fried pastries such as doughnuts

B. MODIFICATION IN FIBRE CONTENT;

Fiber is the portion of carbohydrates not capable of being digested by enzymes in the human digestive tract, thus contributing to increased fecal output. There are two types of fiber; soluble and insoluble fiber. Diseases affecting digestive system generally require modification in fiber content. This can be high or low fiber diet.

1. High fiber diet

This diet contains large amounts of fiber that cannot be digested. Fiber increases the frequency and volume of stools while decreasing transit time through the gastro-intestinal tract. This promotes frequent bowel movement and results in softer stools. The recommended fiber intake for women aged 50 years and below is 21-25g/day and for men aged 50 years and below is 30-38g/day. Men over 50 years should consume at least 30g/day while women above 50 years should consume 21g/day.

Purpose

The diet is designed to prevent constipation and slow development of hemorrhoids, reduce colonic pressure and prevent segmentation. The diet also reduces serum cholesterol levels by decreasing absorption of lipids, reduces transit time and can be used to control- glucose absorption for diabetic patients and overweight clients. Dietary fiber reduces the risk of cancer of the colon and rectum. The table below shows the indications for and characteristics of high fiber diet

Indications and characteristics of high fibre diet

Diet	Indications	Characteristics of the diet
	• Gastro-intestinal disorders • Diverticular disease: high • Cardiovascular disease (hypercholesterolemia): • Cancer prevention: • Diabetes mellitus: • Weight reduction**:**	• High in complex carbohydrates • Has less of refined cereals

It should however be noted that Intake of excessive dietary fiber may bind and interfere with absorption of calcium, copper, iron, magnesium, selenium and zinc. This results in their deficiency. Therefore, excessive intake of dietary fiber is not recommended for children and malnourished adults.

2. Low fibre diet or fibre restricted diet

This diet is composed of foods containing low amounts of fiber which leave relatively little residue for formation of fecal matter. Residue is the dietary elements that are not absorbed and the total post digestive luminal contents present following digestion. The diet excludes certain raw fruits, raw vegetables, whole grains and nuts high in fiber and meats high in connective tissue. The diet is modified to meet the clients caloric, protein, fat as well as vitamins and minerals requirements.

Purpose of the diet

The fiber (low residue) restricted diet is designed to prevent blockage of an inflamed gastrointestinal tract and reduce the frequency and volume of fecal output while prolonging intestinal transit time. The table below shows indications for and characteristics of fiber restricted diet

Indications and characteristics for fibre restricted diet

Diet	Indications	Characteristics of the diet
	• Gastro-intestinal disorders colitis, colostomy • Inflammatory bowel disease, diarrhea, hemorrhoids, etc • Acute phase of diverticulosis • Ulcerative colitis in initial stage • Partial intestinal obstruction • Pre and post-operative periods of the large bowels • convalescents from surgery, trauma or other illnesses before returning to the regular diet • Post - perennial suturing	• Low in complex carbohydrates • Has refined cereals and grains • Legumes, seeds and whole nuts should be omitted

Food guide for fibre restricted diet

Food group	Allowed	Avoid
Milk and milk products	Limit up to 2 cups daily, whole skim evaporated or powdered milk ,chocolate milk and milk drinks	If not tolerated
Meat and meat substitutes Legumes Eggs	Tender lean meats, chicken, fish, liver, cottage cheese Smooth peanut butter Any	Meat with tough connective tissue, corned beef, luncheon meats, spiced or smoke meat or fish, strong cheese, sausage, frankfauters, samosas, mutura (African sausage), omena (sardines), fried meat.
Starchy foods and cereals	White potato, macaroni, spaghetti, white rice, refined cereals, cream of wheat, cream of rice, dry cereals such as rice, refined bread, toasts, rolls, refined crackers, smooth wimbi porridge, refined maize meal porridge	Potato skins, whole grain maize, whole grain rice, wild rice, whole grain breads or cereals containing seeds, nuts or bran, sweet potatoes.
Vegetables	Tender cooked carrots, green beans, egg plants, mushrooms, spinach, tomato juice, vegetable juice	Raw vegetables, other cooked vegetables such as cabbages, unless tolerated, corn, celery, leeks, onions, peppers, stewed tomatoes, French beans.
Fruits	Ripe bananas or citrus sections, strained fruit juices, plums, pears only if peeled, cooked and canned fruits, avocado	All other raw fruits, skinned or canned fruit if not tolerated, cooked prunes
Desserts	Any plain dessert with allowed ingredients; cake pie, ice cream, custard, pudding	All desserts containing: coconut, spices, fruits, nuts or seeds
Sweets	Jelly, syrup, sugar, honey and hard candy, plain creams, jam without seeds and skins	Jams, preserves and marmalades with seeds and skins; sweets with nuts, fruits and coconut
Beverages	Weak coffee, tea, carbonated beverages, decaffeinated coffee, cereal beverages as tolerated.	Any other if not tolerated
Miscellaneous	Salt, mild spices and herbs as tolerated	Pepper, mustard, vinegar, lemon juice, meat sauce and soy sauce unless tolerated

C. MODIFICATION IN ENERGY

1. High energy diet

High energy diet is recommended to provide an energy value above the total energy requirement per day in order to provide for regeneration of glycogen stores and spare protein for tissue regeneration.

Purpose

Energy dense foods are used to avoid complication of bulky diet. For effective metabolism, an extra of 500kcal of the RDA is recommended per day. If there is poor appetite small servings of highly reinforced foods should be given. The diet may be modified in consistency and flavor according to specific needs. Excessive amounts of low calorie foods, fried foods or others which may interfere with appetite are avoided. Indications for and characteristics of the high energy diet is as shown in the table below.

Indications and characteristics of high energy diet

Diet	Indications	Characteristics of the diet
Energy dense foods include butter, sugar, honey and ghee which are added to the normal diet to increase energy content	• Hyperthyroidism • wasting • Typhoid • Malaria • HIV/AIDS • All cases of prolonged degenerative illnesses	• Increased kilocalorie energy 35-40kcal/kg/day in adults

Food guide for high fibre diet

Food group	Foods recommended
Cereals and starches	Whole wheat bread and chapattis, millet and sorghum porridge or ugali, maize, oatmeal, brown rice, wheat germ and whole wheat flour, sesame seeds etc
Meat and meat substitutes	Meat, chicken, fish, eggs, beans, nuts, cowpeas, peas, pigeon-peas etc
Fruits and vegetables	Pineapples, oranges, bananas, passion-fruits, pawpaw fruits with skin: mangoes, peas, plums, guavas, grapes, wild fruits etc Raw vegetables: cauliflower, tomato, lettuce, carrots, onions, cucumber, celery, parsley etc. cooked vegetables: cabbage, spinach, kales, French-beans, cowpeas leaves, locally-available vegetables, broccoli, mushrooms etc
Fats	Butter, cooking fat, margarine, cream, salad-oil, salad dressing etc

Miscellaneous	Soups: vegetable soup, bean soup etc Desserts and sweets: fruit salad and puddings. Others: popcorn, pumpkin seeds etc

2. Calorie restricted diet

These diets are prescribed for weight reduction. The recommended kilocalorie level is 20-25kcal/kg/day. The diet should comprise of complex carbohydrates and should provide 50-60% of the total calories. Fats should provide <30% of the total calorie.

Purpose

To provide adequate nutrition, maintain desirable body weight, maintain normal glucose and lipid levels and to prevent, delay and treat diabetic related complications. The Table below shows the indications for and characteristics of calorie restricted diet

Indications and characteristics of calorie restricted diet

Diet	Indications	Characteristics of the diet
• Vegetables, • Carbohydrates	• Overweight and obesity • Hypertension with excess weight • Hyper lipidemia • Diabetes mellitus with excessive weight • Gout • Gall bladder diseases preceding surgery	• The diet should provide20-25kcal/kg Bodyweight/day • Complex carbohydrates • High in dietary fiber • Proteins should be within the DRI

Food guide for calorie restricted diet

Groups	Nutrients	Tips to reduce calorie intake
Milk and milk products: 2 servings daily 1 serving=240 mls milk or 15 gm cheese or 2 cups cottage cheese	Calcium, protein, phosphorus, riboflavin, vitamin D	Use low fat or skim milk, cheese made from skim milk. Reduce the portion sizes of ice-cream and other milk type desserts

Meat and substitutes 2 servings daily 1 serving=60 to 90gm meat, poutry, fish or 1 egg or ½ cup dried legumes	Protein, calcium, phosphorus, iron, vitamin B1 (Thiamine) vitamin B2 (Riboflavin), Niacin, vitaminB12, vitaminA	Trim fat from meat before cooking, boil, roast or grill meats ,avoid gravies, sauces and fried or boiled meats Use more fish,poultry and less meats .Reduce portion sizes
Cereals and starchy foods 4 servings daily 1 serving = 1 slice bread or ½ roll or ½ cup rice, spaghetti, macaroni, ugali mashed potatoes, matoke (green bananas), 1/2chapati,6 inch diameter	B vitamins, iron	Choose whole grain breads and avoid cereals Boil rice or spaghetti and do not add butter or margarine Use plain bread and pastries
Fruits and vegetables 4 servings daily (1 serving of a good source of vitamin C ,and 1 serving of a good source of vitamin A 2 servings from other fruits and vegetables)	Vitamin C, vitamin A, vitamin E, iron, potassium	Add no butter, margarine or cream in sauces; use broth or other spices for flavouring. Use low calorie dense or vinegar or lemon for salad dressing; fruit for dessert use freshly packed fruits rather than using syrup packed fruits
Others Sugars Fats	Energy Vitamins A, D, E, K and energy	Use fewer fats in form of salad oil as dressing, butter, margarine, ghee and sauces, oils. Avoid sugary foods and drinks

Dietary management in haemodialysis

Purpose

The diet for a patient on Haemodialysis is aimed at:

- Maintaining optimal nutrition to preserve ideal body weight
- Treating abnormal body biochemistry and symptoms of uraemia

The abnormalities in biochemistry and the physical signs vary from person to person and with the type of renal disease present.

Characteristics

This diet is designed to provide sufficient proteins for tissue building and adequate calories for energy and sparing proteins in the body from being broken down.

Approximately 65-75% of the allowed protein should be High Biological Value (HBV).To be best utilized by the body, this HBV protein should be spread throughout the day. Snacks eaten between meals should be high in calories. Fluids, sodium and potassium are restricted, except in special circumstances as indicated in the table on daily dietary recommendations for adult patients on Haemodialysis. Vitamins and minerals require supplementation.

Daily dietary recommendations for adult patients on Haemodialysis

Nutrient	Remarks
Protein; Maintenance 1.0-1.2g/kg between* Repletion 1.3-1.4g/kg between* 65-75% Protein of HBV	• Protein allowance increased to maintain ideal body weight • Protein requirements should be calculated based on body weight • The increased protein allowance aims at maintaining nitrogen equilibrium and replacing the amino acids and protein lost in the dialysate during treatment(6-10gm/kg amino acids per one single Haemodialysis)
Calories; Maintenance 35kcal/kg between Repletion40-50kcal/kg between Reduction 25-30kcal/kg between	• 85% calories supply should be from carbohydrates and fats. These nutrients have a protein – sparing effect • Overweight patients should lose weight, as obesity may interfere with access to the veins
Sodium 2-3g	• Dietary sodium is restricted to help control fluid retention and hypertension • Sodium needs on Haemodialysis are judged by the state of blood pressure and the amount of fluid gained between dialysis • Hypotension due to salt depression will require increased sodium intake
Potassium: 1.5-3g/day No restriction with urine output of 1000ml/day	• Potassium is restricted to prevent hyperkalaemia • Hypokalaemia may lead to cardiac arrest • In case of hypokalaemia, potassium supplementation required
Phosphorus; 1200mg/day	• Dietary phosphates are restricted in the Haemodialysis patient • When phosphate hiders are used they may cause constipation. A stool softener or a diet high in fibre should be prescribed

Calcium 500-1000mg/day	• Supplementation of calcium and vitamin D is necessary since there is reduced intestinal absorption of calcium due to lack of active form of vitamin D
Fluids 24 hours urine output +500mls per day	• The calculated fluid intake would prevent severe urine overloading • Fluid intake should be increased in the event of hot weather or severe and persistent pyrexia(fever, diarrhoea or vomiting)
Vitamin;B1,B2,B6 VitaminB1 Thiamine 1.5mg/day Vitamin B2, Riboflavin 1.8mg/day Niacin 20mg/day VitaminB6, Pyridoxine 5-10mg/day Folic Acid 1mg/day vitaminC100mg/day vitaminB12,Pantothenic acid5mg/day	• Water soluble vitamins are dialyzable • Restriction of potassium containing foods leads to deficiency of water soluble vitamins • These require supplementation
Iron: 10mg men/women 18mg fertile women (child bearing age)	Although the main cause of anemia is deficient production of erythroprotein due to kidney failure; • Iron depletion is common in uremic patients due to bleeding tendency or occult gastrointestinal blood loss • Some blood is also lost with each Haemodialysis treatment and blood tests • Iron supplementation is therefore necessary

Diabetic diet

Purpose

- Provide adequate nutrition
- Maintain desirable body weight
- Maintain normal blood glucose and lipid levels
- Prevent, delay and treat diabetic related complications

Characteristics

This is a normal diet which should be individualized according to the patient's specific needs such as lifestyle, body weight, type of diabetes, food tolerances, medications, nutrition needs etc.

The general guidelines for distribution of calories are as follows;

Carbohydrates

50-60% of the total calories be provided by the carbohydrates with emphasis on complex carbohydrates and foods high in natural and dietary fiber.

There should be an even distribution of carbohydrates throughout the day.

Simple carbohydrates (sugars) are discouraged but could be carefully incorporated in the diet

Proteins

12-15% of the total calories should be provided by proteins or 0.8 gm/kg body weight per day for adults. Higher levels are desirable given the risk of accelerating nephropathy.

Fibre

A daily consumption of 25 gm of diet fibre for each 1000 kcal is recommended.

Fats

≤ 30% of the calories should be provided by fats with emphasis on a reduced saturated fat intake (10%) and increased unsaturated fat intake.

Vitamins and minerals

The diet should supply adequate amount of vitamins and minerals

General information

Adequate control of diabetes depends on various factors e.g.:

- Control of caloric intake to achieve and maintain desirable body weight. The caloric allowance of patients of normal weight should range from 30-35 kcal/kg BW per day; 20-25 Kcal/kg BW/ day for patients with excess weight and 40-45 Kcal/kg BW/day for underweight patients
- Increased intake of dietary fibre to lower post prandial blood glucose level and alter insulin requirements. Dietary fibre also promotes satiety and assist in weight loss among other benefits.
- Meal patterns should be based on individual's lifestyle e,g, physical activities, eating habits, exercise etc
- Meal and snacks should follow a regular time schedule although lifestyles and level of activities may alter meal patterns
- Controlled exercise matched with meals could improve plasma lipids and increase insulin sensitivity. To avoid hypoglycaemia in persons with Insulin dependent diabetes mellitus (IDDM) consumption of foods supplying about 15 gm of carbohydrates is recommended 30 minutes-1 hour before moderate exercise
- The glycemic index used to qualify and compare the two 2 hour glycemic response of individual foods is unreliable. However it may be used as adjunct to the food exchange system in meal planning.
- It is recommended that sodium intake for diabetics may be limited to 6 gm per day and further restriction to 2-3 g per day for diabetic patients with hypertension or renal failure

- Use of alcoholic beverages is not recommended as this may result in hyperglycaemia especially if meals are missed or delayed. Alcohol may also cause unwanted weight gain; however, if alcohol is desired, moderate amounts could be worked into the patient's meal plans and should not exceed two equivalents of alcohol once or twice weekly.

  One equivalent of alcohol is;

  360ml light beer

  120ml wine

It is worthwhile to note that alcohol should not be consumed on an empty stomach.

It should be ingested in combination with a meal.

Meal planning

Diabetic meal patterns are best planned using the food exchange approach has been proved easier for patients to comprehend.

Diabetic diet patterns with total food exchanges.

Food group	Kcal 800	Kcal 1000	Kcal 1200	Kcal 1500	Kcal 1800	Kcal 2000	Kcal 2200	Kcal 2500	Kcal 3000
Milk	1	2	2	2	2	2	2	3	4
Vegetables	2	2	2	2	2	3	3	3	5
Fruits	2	2	3	3	3	4	4	4	6
Starch	3	4	5	7	9	10	12	13	14
Meat	4	4	4	6	7	7	7	8	9
Fat	0	1	2	2	3	4	5	6	8

Nutrient composition of diets in table

Nutrient	Kcal 800	Kcal 1015	Kcal 1201	Kcal 1509	Kcal 1789	Kcal 2003	Kcal 2210	Kcal 2498
Carbohydrates (g)	97	124	154	184	214	249	279	306
Protein (g)	49	60	63	83	96	101	107	125
Fat (g)	24	31	37	49	61	67	74	86

Composition of diabetes exchanges

Exchange	Approximate measure	Weight (g)	Protein (g)	Fat (g)	Carbohydrate (g)	Calories
Milk No fat	1 cup	240	8	Trace	12	90
1% milk	1 cup	240	8	2	12	100
2% milk	1 cup	240	8	5	12	120
Whole milk	1 cup	240	8	8	12	150

Meat or substitute						
Low fat	1 oz	30	7	3	-	55
Medium fat	1 oz	30	7	5	-	75
High fat	1 oz	30	7	8	-	100
Bread or starch	1 slice (other items vary)	25	2	trace	15	70
vegetable	½ cup	100	-	-	5	25
fruit	varies	varies	-	-	15	60
fat	1teaspoon (other item vary)	5	-	5	-	45

Diabetic diet in special conditions

Condition/diet	Special dietary needs	Comments
Pregnancy	Caloric requirements; 1st trimester same as in ordinary situation 2nd-3rd trimester 30-38 kcal/kg 1BW Protein requirement; 20-25% of the total calories or 2gm/kg, BW Obese pregnant diabetics: Sever dicting should be avoided. Restrict energy intake to 1200-1800 kcal daily	Allow 3meals per day and 3 snacks with insulin therapy Without insulin,allow 3 meals and 1-3 snacks per day
Lactation	Nutritional requirements are same as for non-diabetic lactating mother	Monitor blood glucose closely and adjust insulin accordingly to hypoglycaemia
Paediatrics	0-1/2 year old: Calories:115kcal/kg Protein:2.2gm/kg 1/2-1 year old: Calories:105kcal/kg Protein:2gm/kg 1 year old and above: Calories:1000+100kcal(age) or years Protein: 1.8gm/kg	Modify consistency for developmental age. Give adequate calories allow normal growth. 3 meals and at least 2-3 snacks are desirable

Protein restricted	Protein levels of less than 60gm/day with caloric requirements greater than 2000kcal/day necessitate an increased percentage of fat and carbohydrate above the diadetic diet standard	Calories from fat may be increased from 30-35%
Liquid diets	Clear liquids: Minimal calories are provided by this diet Full liquid diet: Calories provided as carbohydrates, protein and fats in percentages similar to that of the standard diet	Diet is nutritionally inadequate. Advance to full liquid diet as quickly as possible
Tube feedings	Tube feeding mixtures should be prepared with the standard nutrient composition for diabetic diet in mind	Closely study the composition of commercial and other tube feeding mixtures
In illness	Encourage frequent intake of nutritious fluids(1-1/2cup per hour)and aim at15gm carbohydrate every half,hour in casily digestible forms such as sweetened liquids or soft foods e.g.porridge with milk,fruit juices,potato purce, soft cereal	Blood sugar often elevated therefore,monitor closely
Hypoglycaemia (insulin shock)	As first aid give: 15gm (60kcal)of rapid acting carbohydrate,e.g 3sweets 1 grass soda 4 teaspoons sugar 3 teaspoons glucose etc. Follow up with some food within 30 minutes after symptoms subside i.e,1bread and 1 protein e.g1bread and 1 glass of milk or 1 cup uji made with milk	Encourage patients to adhere to diet and drug dosage instructions Advise patients to always carry some sweets and sugar to avert symptoms while they are still mild
Restricted fibre	Omit tough meats,raw fruits and raw vegetables,whole grain,seeds,nuts,bran and spicy foods	Use this only during acute stages of inflammatory bowel syndromes because fibre is an important component of the diabetic diet

Nutritional adequacy

D. MODIFICATION IN ONE OR MORE NUTRIENTS

1. Fat restricted diet

The diet is designed to restrict fat intake for patients who experience symptoms of nutrient losses when high fat foods are eaten. A fat restricted diet limits the amount of fat you can consume each day and may be prescribed conditions that make it difficult for the body to digest fat. Provision of fat restricted diet will minimize the unpleasant side effects of fat malabsorption such as diarrhea, gas and cramping. The table below shows indications for and characteristics of fat restricted diet.

Indications and characteristics of fat restricted diet

Diet	Indications	Characteristics of the diet

	• Gall bladder diseases
	• Biliary tract and lymphatic system
	• Hepatic cirrhosis (liver cirrhosis)
	• Pancreatic insufficiency
	• Malabsorption syndromes
	• Intestinal resections
	• Overweight and obesity
	• Cardiovascular diseases (CVDs
	• bloating, diarrhoea, steatorrhea
		• The diet provides overall fat between 25-50g/kg/day
		• This diet is tailored to provide <30% of total calorie and < 10% saturated fat acids. Levels of restriction are as follows:
		    • Mild restriction-25-30% of total calories
		    • Moderate restriction-20-25% of total calories
		    • Severe restriction-15-20% of total calories
		• The base of the diet should be composed of grains, vegetables and fruits
		• Meat fish, poultry and eggs should be limited to 180g per day

Recommended levels of fat restriction in different conditions

Condition	Fat levels per day	Comment
Gallbladder disease	40-60 g or 25% of total calories	Fat restriction is continued until symptoms subside or after surgical intervention. The diet may be used for a short time after surgery until inflammation subsides.
Pancreatitis	40-50 g	With small frequent meals
Pancreatitic insufficiency	50-70 g	
Cirrhosis	30-40 g	
Intestinal malabsorption	Less than 30 g	

Low fat diet is not designed to alter the cholesterol content or the ratio of polyunsaturated to saturated fats

Food list for fat restricted diet

Food groups	Allow	Avoid
Milk and milk products	Skim milk mala/yoghurt made from skim evaporated milk	Whole milk, 2%milk, condensed milk, mala/yoghurt made from whole milk, and beverages made from whole milk.
Meat and substitutes Meat, fish, poultry	Lean meats, fish, chicken without skin	Fried or fatty meats, fish, chicken, bacon, corned beef, luncheon meats, sausage, oil, packed fish peanut butter, mincemeat with greater than 20% fat
Eggs 1=30gm meat	Egg white as desired 1 boiled or poached	Fried egg, egg prepared with milk or cream
Cheese 30gm=30gm meat	Low fat or skim milk cheese Low fat cottage cheese	All others
Legumes 1/2cup=30gm meat	Dried beans or peas, lentils, green grams	Sometimes may not be tolerated
nuts		all
Vegetables 1/2cup=25gm	2 or more servings All kinds raw or cooked,1 good source of vitamin A prepared without fat	Strong flavoured vegetable like cabbage, cucumber, cauliflower, onions, Green pepper, sometimes not tolerated Fried vegetables
Fruits	2 or more servings All kinds raw or cooked,1 good source of vitamin C, such as citrus fruits	Avocado, coconut, sometimes not well tolerated
Cereals and starchy foods 1 or more servings	White or sweet potato, rice, macaroni,uji,etc.prepared without fat	All fried or creamed starchy foods
Fats 3 servings daily 1 serving=1 Teaspoon(5gm)	3 teaspoons only of fat or oil daily	Any in excess of 3 teaspoons
Soups	Fat free broth or vegetable soup, soup made with skim milk	Commercial soups. Soups prepared with cream, or whole milk

miscellaneous	Salt, pepper, spices flavouring, fat free gravy	Gravies, cream, sauces, cocoa, chocolate, popcorn, buttered coconut, excessive amounts of spices and seasonings

Adequacy

It is possible to meet nutrient requirements on this diet, but depending on how long you follow it and how much fat you can digest a supplement may be recommended and provided that the types and amounts of food suggested are included each day. Patients with prolonged stearrhoea or diarrhea may develop vitamin or mineral deficiencies. Vitamin A, D, E and K are fat soluble which means they need fats to be absorbed and this requires advice from the nutritionist/dietitian or doctor. The requirements for iron may not be met in the case of steatorrhea which decrease iron absorption. When fat is severely restricted, protein intake may be limited since most protein foods also contain fat. A fat restricted diet may not meet the patient's energy needs, because many calorie dense foods are omitted. Medium chain triglycerides are useful to increase the energy intake of patients who cannot ingest and absorb sufficient sources of energy.

DIETARY MANAGEMENT OF HYPERLIPOPROTEINEMIA

Plasma lipids consist of cholesterol, cholesterol esters, phospholipids and triglycerides. These plasma lipids circulate as fat-protein complexes called lipoproteins.

Purpose of this diet

These diets are designed to control serum lipids. They are used in amanagement of ;

- Hyperlipdaemia
- Coronary heart disease
- Arteriosclerosis
- Artherosclerosis

Characteristics

The total fat content of this diet may be controlled to provide 35-40% of the total calories. Foods high in cholesterol and saturated fats are restricted or omitted. Fatty meat, fatty meat product, visible animal fat, dairy fat and other saturated fats are excluded. Egg yolk, organ meat and cheese are restricted and may be substituted for each other. The total cholesterol intake is restricted to 300-500 mg per day or less. Limited amount of polyunsaturated fats are essential and need to be incorporated into the diet. These are primarily of vegetable sources such as sunflower, corn and cotton seed oil.

Emphasis is laid on lean meat, fish, skinless poultry, low fat dairy products and polyunsaturated margarines.

There are five major classifications of plasma lipoproteins. Thus:

1. Chylomicrons: They consist of a core of triglycerides coated with phospholipids and proteins.
2. Very Low Density Lipoproteins (VLDL), which contain mainly triglycerides and little proteins.
3. Low Density Lipoproteins (LDL),which contain mainly cholesterol, some triglycerides and proteins
4. High density lipoproteins(HDL), which contain high concentrations of proteins, some cholesterol and low concentrations of triglycerides
5. Intermediate Density Lipoproteins (IDL): these are VLDL remnants.

The total serum cholesterol is used to predict the risk of coronary heart disease for people of all ages. However, the ratio of the total serum cholesterol to HDL and that of LDL to HDL and that of LDL to HDL are more accurate risk measures for people above 55 years old.

Table A illustrates the total serum cholesterol levels associated with different degrees of risk for different age groups. Tables B and C illustrate the degree of risk associated with different ratios of cholesterol, LDL and HDL.

Table A: Total serum cholesterol measurements in Mg/dl

Age	Moderate risk	High risk
2-19 years	>170	>185
20-29 years	>200	>220
30-39 years	>220	>240
>40 years	>240	>260

Table B: Ratios of cholesterol to High Density Lipids (HDL)

Ratio	Level of risk
5.0	High risk
4.5 or more	Cause for concern
3.5	½ Standard risk

Table C: Low Density Lipids to High Density Lipids Ratio in Men over 50-70 years

Ratio	Level of risk
1.0	Half the average risk
3.6	Average risk
6.3	Two times average risk
8.0	Three times average risk

2. Sodium restricted

Sodium is a mineral that naturally occurs in some foods. However it can also added to food in form of salt to help preserve them and add flavor. Limit sodium intake to less than 3000mg per day. RDI should be limited to 2400mg

3000mg (130mEq) -Eliminate or eat sparingly processed foods and beverages such as fast foods, salad dressings, smoked and salted meats. Omit 2000mg (87mEq)-prepared foods high in sodium do not allow salt in preparation of food or table.

1000 (45mEq) eliminate processed foods and prepared foods and beverages high in sodium. Omit many frozen foods and fast foods. Limit milk and milk products to 16oz per day. Do not allow any salt in food preparation or table use. This meal plan used in the inpatient setting for a short term basis

500 (22mEq) omit processed or canned foods high in sodium. Omit vegetables containing high amounts of natural sodium limit milk to 16 oz daily and meat to 5 oz daily and meat products. Use low sodium bread and distilled water for cooking where available.

Allow up to ¼ tsp table salt in cooking or at the table

Purpose

The purpose of a low sodium diet is to aid control of blood pressure (BP) in salt sensitive people and to promote the loss of excessive fluids in edema and assist and manage hypertension. The table below shows the indications for and characteristics of low sodium diet.

Indications and characteristics of low sodium diet

Diet	Indications	Characteristics of the diet
• Unprocessed foods and beverages • Low sodium bread	• Impaired liver functions • Cardiovascular diseases • Severe cardiac failure • Acute and chronic renal diseases	• A diet low in processed foods and beverages • Diet should be low in canned foods, margarine, cheeses, and salad dressings.

Nutritional adequacy

3. Low protein

A low protein diet is temporarily indicated/ prescribed to avoid breakdown of tissue protein which can lead to undesirable levels of nitrogen constituents in the blood. It is essential that the calorie intake from carbohydrates be sufficient to avoid excessive breakdown of tissue protein. Low protein may range from (0.6g-0.8g/kg/day). Indications and characteristics of the diet are as shown in the following Table.

Indications and characteristics of low protein diet

Diet	Indications	Characteristics of the diet
	• Hepatic coma • Acute and chronic renal failure • Liver cirrhosis • Acute and chronic glomerulonephritis	• Low biological value protein can be used during this time. • The amount can be reduced to 20-35gms per day.

4. High protein-high calorie diet

This diet is tailored to provide higher amounts of calorie and protein than usual diet. It is prescribed where tissue regeneration is required. Its purpose is to help heal wounds, maintain or increase weight, promote growth, decrease respiratory complications, resist or fight infections and support the immune system. For a high protein diet, adequate energy from carbohydrates and fats must be supplied.

Purpose

The diet is designed to maintain a positive nitrogen balance, promote normal osmotic pressure, promote body tissue repair, prevent excessive muscle atrophy in chronic disease states and build or repair worn out tissues of severely malnourished individuals. This diet can also be used to meet increased energy and protein demands during illness, during certain periods like pregnancy and lactation. The table below shows indication for and characteristics of the diet.

Indications and characteristics of high protein-high calorie diet

Diet	Indications	Characteristics of the diet
	• Febrile conditions • Cancer • Wounds • Burns • Tissue injuries and trauma • After surgery • Acute and chronic fever e.g. TB, Malaria and Typhoid. • Certain physiological alteration - pregnancy and lactation/infancy	• The diet must provide adequate protein carbohydrates ratio of (2:1). • The diet should provide i.e.35-40kcal/kg body weight/day 1.5-2.0g/kg body weight/day • Consist more of high biological value protein

5. Bland diet

This is a diet modified to avoid irritation of any kind to the alimentary tract. Such diets are chemically, mechanically and thermally modified. In bland diet, strong spices, stimulants and strongly flavored vegetables and fruits that irritates should be avoided. The food should be served at room temperature.

6. Exclusion of certain foods from the diet in allergic conditions, increasing frequency of feeding

In allergic conditions certain specific foods to which the individual is extremely allergic should be excluded from the diet. Some people are allergic to protein foods like milk, eggs, peanut, soya and seafood.

OTHER THERAPEUTIC DIETS

Aldosterone test diet

Aldosterone is the adrenal coltexs hormone that regulates water and electrolyte balance (sodium and potassium). The aldosterone test is performed to aid in the diagnosis of primary and secondary aldosteronism. All dietary sodium and potassium prescriptions are eliminated. The patient should consume a normal dietary intake of sodium (at least 110 milliequivalents) and potassium (50 milliequivalents) during the testing period.

Hydroxyproline test diet

The test diet is required in the determination of hydroxyproline in the urine in which reflects collagen metabolism. Hydroxyproline is an index of bone collagen turn over and metabolic activity of the bone associated with medication, growth hormone and certain disease states e.g(pagets disease, hyperpatathyroidism). This diet is used 24 hours prior to and during the 24 hour urine collection. After the test period, the previous diet is resumed unless ordered otherwise.

Food which are excluded:

Gelatin and gelatin containing foods such as:

- Meat
- Fish
- Ice cream
- Puddings
- Whipped topping
- Salad dressing
- Soft candy

LOW SEROTONIN TEST DIET

5-Hydroxy Indole Acetic Acid)

(5-HIAA)

Serotonin is a derivative of the amino acid tryptophan. This compound is formed predominantly in the argentaffin cells of the gastrointestinal tract. It is excreted in large amounts by patients with metastatic carcinoid syndrome. A metabolite of serotonin (5-HIAA) may be elevated in the urine of patients with carcinoid syndrome.

Therefore, the urinary determinations of 5-HIAA is the most useful means for diagnosis of carcinoid tumors.

Foods with high serotonin content interfere with determination and invalidates results.

The following items may need to be avoided prior to 5-Hydroxy Indole Acetic Acid (5-HIAA) urine collections:

- Tomatoes and tomato products
- Bananas
- Pineapples
- Pears
- Plantain
- Passion fruit
- Apricots
- Chocolate
- Coffee
- Ice cream
- Broad beans
- Red plums
- Avocado
- Peanut oils
- Pawpaw
- Nuts
- Egg plant
- Vanilla
- Tea

FAT FREE TEST DIET

This diet is used prior to gall bladder radiological examination. it provides food with no fat content such as fruit gelatin, skim milk, bread and cereal products , sugar products, coffee and tea . lean meats or cottage cheese may be allowed. Give test diet at the evening meal prior to the examination.

Approximate values

Carbohydrates	60gm
Protein	33gm.
Fat	10gm.
Calories	386Kcal.

Sample menu

- Fat free broth
- Toast
- Coffee or tea
- Sugar, lemon, salt
- Canned fruit plate with cottage cheese
- Plain gelatin
- Skimmed milk

LOW CALCIUM TEST DIET

This test is used chiefly for metabolic studies, as a means of diagnosis, as treatment in conjunction with surgical removal of parathyroid adenoma, or as a medical treatment when operation is delayed or contra-indicated. The low calcium test diet should be ingested for a period of 2 or 3 days before starting to collect urine for analysis.

Approximate values

Carbohydrate	191gm.
Protein	60gm
Fat	75gm
Calcium	120gm
Phosphorus	1795gm
Magnesium	200
Calories	1895 Kcal

FOODS ALLOWED

Meat; beef, lamb, veal or chicken (plainly prepared)

Beverages; coffee or tea made with distilled water

Distilled water for drinking

Fruits; bananas, preaches, apple sauce, water melon, orange juice

Vegetables; corn, peas, cauliflower, beets, asparagus, tomatoes, Brussel sprouts.

Fats; butter, bacon

Miscellaneous; sugar

Note: ***All other foods must be avoided***

2.3.3.3 Self-Assessment

1. Define therapeutic diet
2. Hyperlipidemia is _______________
   A. Elevated lipids in urine
   B. Reduced plasma lipids
   C. Elevated plasma lipoproteins
   D. Elevated plasma lipids

3. The following foods are recommended for use in light diet except
    A. Fresh or dried berries and figs
    B. All vegetable juices
    C. Milk and milk products
    D. Whole grain flour products
4. Intake of excessive dietary fiber may
    A. Bind and interfere with absorption of calcium, copper, iron, magnesium, selenium and zinc
    B. Help relieve diarrhoea
    C. Interfere with appetite
    D. Improve skin texture
5. A diabetic diet should contain proteins amounting to ____________ of total calories
    A. 12-15%
    B. 25-30%
    C. 50-60%
    D. 35-45%
6. Identify the conditions that can benefit from a therapeutic diet
7. Describe the principles of diet modification
8. Describe the purpose, characteristics and indications for the following modified diets;
    A. Bland diet
    B. High calorie high protein diet
    C. Low protein diet
    D. Calcium test diet

17.3.3.3 Tools, Equipment, Supplies and Materials

- Food exchange lists
- Reference manual
- Stationery (Pen, paper, referral notes, file)
- Calculator
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab

- Projectors, video clips, charts and other teaching aids
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

17.3.3.5 References

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17.3.4 Learning Outcome 3: Demonstrate understanding in the management of malnutrition and micronutrient deficiencies of public health concerns

17.3.4.1 Learning Activities

Learning activity	Special instructions
i) Describe management of ***SAM*** and ***MAM***	• Identify the patients who are candidates for SAM and MAM • Determine the admission and discharge criteria • Carry out monitoring of patient on SAM and MAM • Document the process and outcomes in relevant documents
ii) Describe management of overweight and other eating disorders	• Manage eating disorders such as binge eating, anorexia nervosa and bulimia nervosa • Modify diets for weight management
iii) Discuss roles of nutrient supplements and fortified foods in the management of micronutrient deficiencies of public health concerns	• Advice client on nutrient supplements • Prescribe nutrient supplements to specific clients • Monitor nutrient supplements on clients

17.3.4.2 Information Sheet

Definitions

Protein energy malnutrition

Chronic malnutrition: a type of malnutrition which occurs over an extended time period, right from conception, and is determined by a person's degree of stunting i.e. when a child has not reached his/her expected height for a given age

Acute malnutrition: a type of malnutrition that occurs within short period of food shortage (e.g. during emergencies) and is determined by patient's degree of wasting

Obesity: defined as a state of adiposity in which the body fat is above the ideal i.e. when the individual's body weight is 20% more than the normal body weight or when the BMI is more than 30kg/m^2.

Categories of malnutrition

There are two categories of malnutrition;
a. **Acute malnutrition**: categorized into; Moderate Acute Malnutrition (MAM) and Severe Acute Malnutrition (SAM), determined by the patient's degree of wasting.

b. **Chronic malnutrition**: determined by a patient's degree of stunting, i.e. when a child has not reached his or her expected height for a given age.

Protein Energy Malnutrition (PEM)

This refers to the form of malnutrition where there is inadequate protein intake. It is known as protein calorie malnutrition (PCM)

There are 4 main types of PEM;

- Kwashiorkor: protein deficiency
- Marasmus: energy deficiency
- Marasmic kwashiorkor: combination of chronic energy deficiency and chronic or acute protein deficiency
- Failure to thrive(FTT)

PEM in developing countries

The prevalence of PEM is so high in developing countries due to;

- Lack of food and clean water
- Infections
- Poor sanitation
- Social unrest

These could also lead to low birth weight (LBW). Among the developing countries are Asia and Africa

PEM in Africa is related to;

- The high birth rate
- Overused soil, drought and desertification
- Poverty
- Political instability(war & displacement).
- Subsistence farming
- Pests and diseases destroy crops
- Low protein diet

Risk factors for PEM

a) Morbidity factors;

- Malnutrition is strongly associated with morbidity factors.
- Children who have recently suffered/ are suffering from diseases such as malaria, acute respiratory infections (pneumonia, colds, running nose, congested chest etc) are most likely to suffer from PEM.

- HIV/AIDS is also a threat

b) mother's educational level

- Mothers of higher educational levels have low percentage of their children getting PEM due to better finances, in giving adequate food and accessing health services

c) Household size

- A larger household has more mouths to feed
- Research shows that in low socio-economic households there is a risk of PEM for chn <5yrs

Individuals at risk of malnutrition include;

i) Elderly people, especially those who are hospitalized or in long-term institutional care

ii) Individuals who are socially isolated

iii) People on low incomes (poor people)

iv) People with chronic eating disorders, such as bulimia or anorexia nervosa

v) People convalescing after a serious illness or condition.

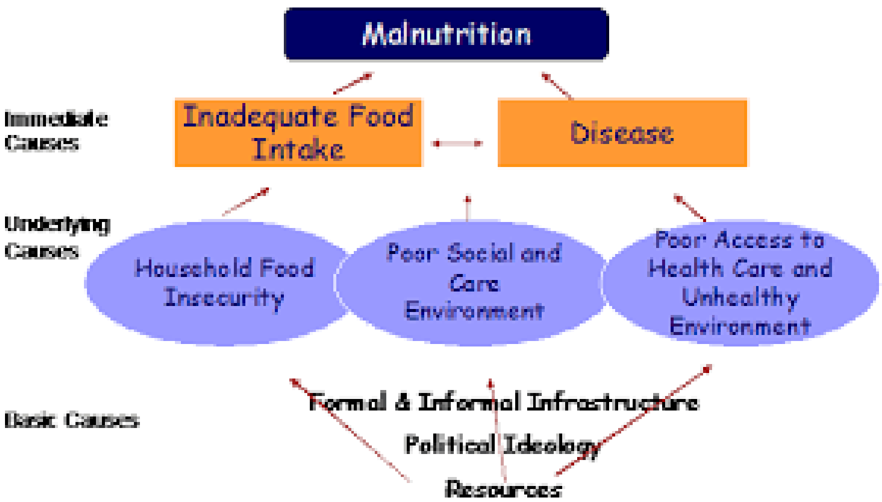
Causes of malnutrition

Based on UNICEF'S conceptual framework, the causes are categorized into three;

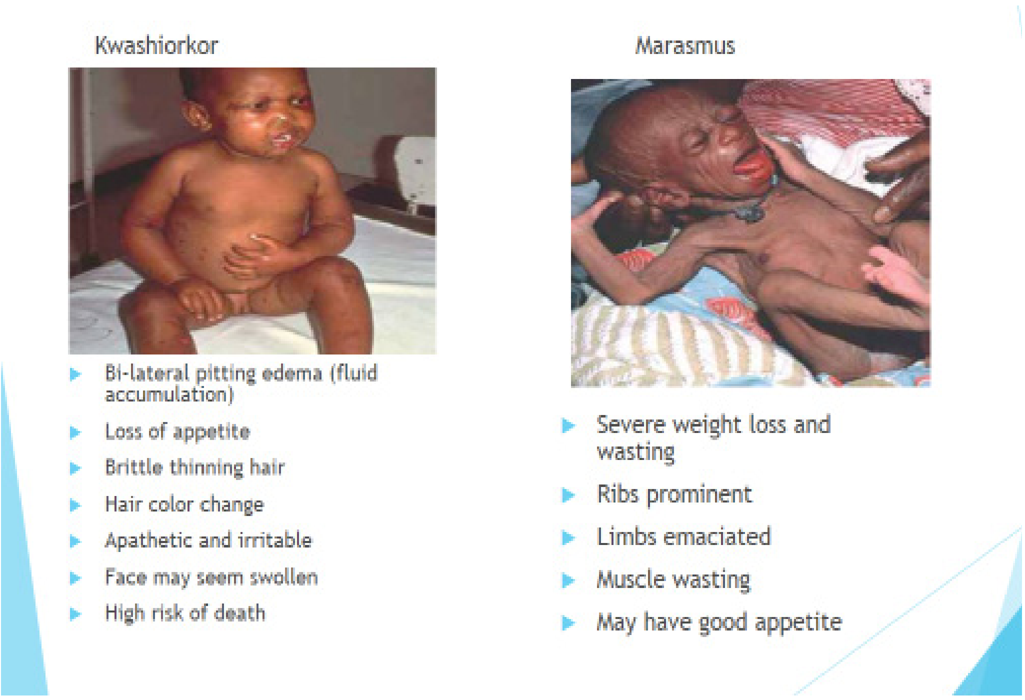
i) Immediate causes

ii) Underlying causes

iii) Basic causes



UNICEF's conceptual framework



Characteristics of Kwashiorkor and Marasmus

PATHOPHYSIOLOGY OF MALNUTRITION

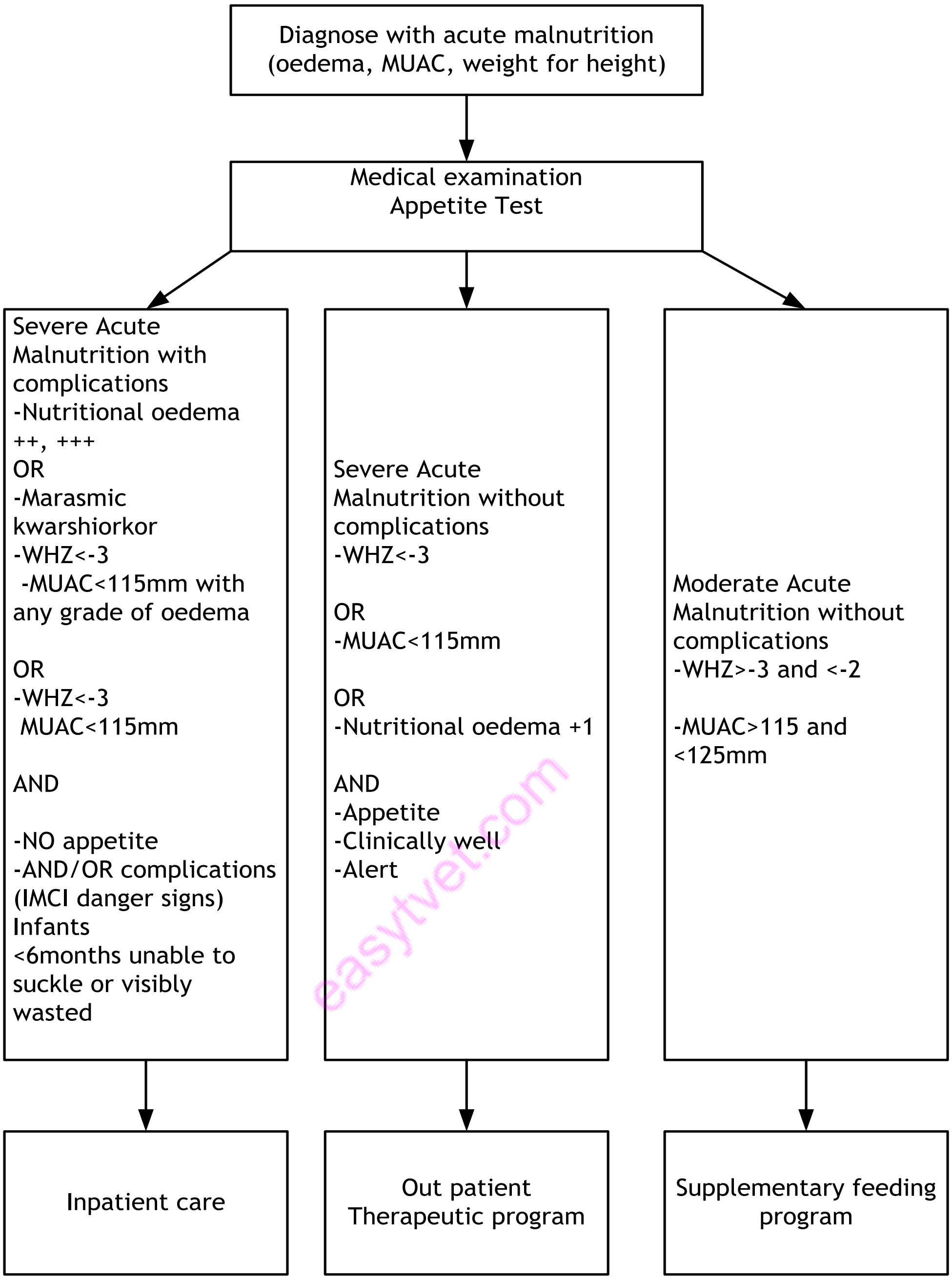
Malnutrition result in profound metabolic, physiological and anatomical changes. All physiological processes are altered due to acute malnutrition and all body organs slow down in order to survive on the limited macro and micronutrient intake a condition refered to as reductive adaptation. These include:

- Reduced metabolic rate
- Impaired protein synthesis and metabolism
- Impaired liver function
- Impaired kidney function
- Impaired immunity
- Impaired electrolyte balance

Diagnosis and Triage

Various categories of acute malnutrition will require different nutrition therapies (management). The following figure provides an algorithm for diagnosis and triage of acute malnutrition.

Algorithm for Diagnosis and Triage of Acute Malnutrition



NUTRITIONAL MANAGEMENT

The aim of nutritional management is:

- To correct nutritional imbalances
- Restoration of patho-physiological function

SAM With Medical Complications

Severely malnourished patients with complications are usually rehabilitated in three phases namely: cautious feeding phase, transition phase and catch up (Rehabilitation) phase. The three phases encompass ten (10) step approaches as outlined below:

Stabilization Phase (Cautious Feeding)

1. Treatment/prevention of hypoglycaemia
2. Treatment/prevention of hypothermia
3. Treatment/prevention of dehydration
4. Correcting electrolyte imbalance
5. Treatment/prevention of infection
6. Correcting micronutrient deficiencies
7. Starting cautious feeding

Transition and Catch up Phase

8. Achieving catch-up growth
9. Providing sensory stimulation and emotional support
10. Preparing for follow-up after recovery

Stabilization Phase (Cautious Feeding)

The aim of this phase is to stabilize the patient both medically and nutritionally. It usually takes 2 to 3 days. In this phase a cautious approach is required because of the child's fragile physiological state and reduced homeostatic capacity. Feeding should be started as soon as possible after admission and should be designed to provide just sufficient energy and protein to maintain basic physiological processes. The essential features of feeding in the stabilization phases are:

- Small, frequent feeds of low osmolarity and low lactose
- Oral or nasogastric (NG) feeds
- 100 Kcal/ kg/day
- 1-1.5 protein/kg/day
- 130 ml/kg/day of feed (100 ml/kg/day if the child has severe edema)
- If the child is breastfed, encourage to continue breastfeeding but give the prescribed amounts of starter formula to make sure the child's needs are met.

The suggested starter formula and feeding schedules (see below) are designed to meet these targets. Milk-based formulas such as starter F-75 containing 75 Kcal/100 ml and 0.9 g protein/100 will be satisfactory for most children. Give from cup; dropper or syringe may be used to feed very weak children. All patients must be kept warm to prevent hypothermia (for infants, kangaroo method is encouraged).

- On admission, if the patient is alert give 5 ml/kg of 10% glucose to prevent hypoglycemia and feed with F-75 at 130 ml/kg/day every 3 hrs
- If patient has generalized edema (grade 3 or +++) give 100ml/kg/day of F-75 every 3 hours
- If the patient is losing consciousness, give 50ml (5 – 10ml/kg) of sugar-water by NG tube immediately. When consciousness is regained, give milk feed frequently
- On admission, if the patient is unconscious, give sugar water by NG tube. Give glucose as a single intravenous injection (5ml/kg of sterile 10% glucose solution)
- If the patient is dehydrated, rehydrate using Resomal at 5ml/kg every 30 minutes while monitoring for two hours. Start feeding after two hours of successful rehydration. Alternate feeds every hour with Resomal up to 10 hours
- If the patient has severe anemia, transfuse for 3 hours with close monitoring. Feeding using F-75 should start 2 hours after transfusion
- Feeding should be encouraged and monitored after every feed, If the patient is not taking sufficient amount (less than 75%), has pneumonia with rapid respiration rate, mouth lesions, cleft palate or other physical deformity or disturbance of consciousness a naso-gastric tube should be used to feed at 130 ml/kg/day
- Vitamin A should be provided as per IMAM guidelines

NB: When feeding on F-75, monitoring is important and especially for night feeds to ensure that the patient has adequate intake. Iron supplementation is contraindicated in this phase and should be delayed until the patient moves to Phase 2.

Transition Phase

The ONLY change in the diet when transferring from Phase 1 to Transition Phase is that F75 is replaced by either F100 or equivalent made-up milk. The number of feeds, the timing, and the volume of the diet remains exactly the same in Transition Phase as in Phase 1 (130ml/kg/day).

The purpose of transition phase is to move the patient to a more energy dense food (F-100) in preparation for rapid weight gain. During this phase minimal weight gain can be expected (6g/kg/day) and lasts for 2 days. Criteria for transition phase include: a patient regaining appetite (No NG tube/finishes all prescribed feed), medically stable and losing edema.

- Give 130ml/kg/day of F-100 five to six feeds a day
- Feed amounts should be strictly controlled and no more should be given
- If the child is breastfeeding, encourage and continue breastfeeding on demand
- Close monitoring on patients adaptation to the feed is important

NB: In case there is increase/development of oedema, loss of appetite, development of medical complication, re-feeding diarrhoea, tense abdominal distension, and signs of fluid overload or rapid increase in liver size transfer immediately to Phase 1.

Rehabilitation Phase (Achieving Catch-Up Growth)

In Phase 2, the main objective is to achieve catch-up growth and resolve micronutrient deficiencies. As the patients are recovering, the frequency of meals and some of the routine surveillance is less frequent as in Phase 1 and Transition Phase. A vigorous approach to feeding is required to achieve very high intakes and rapid weight gain of >10g/kg/day. F-100 is used at 130ml/kg/day and 2.9 g protein/100mls. Modified porridges or modified family foods can also be used provided they have comparable energy and protein concentrations.

Readiness to enter the rehabilitation phase is signaled by a return of appetite i.e. a patient is able to finish all prescribed feed in transition phase usually about one week after admission.

- The volume of milk is increased from 130ml/kg/day to 200ml/kg/day (equivalent to 200kcal/kg/day).
- The frequency is reduced to 5 feeds a day
- If the child remains hungry after completing a feed, more milk can be offered
- Either F100 or RUTF can be given, or a combination of both.

Iron

Iron is given in this phase usually by adding an iron tablet into the milk. Crush an iron tablet and add to 4mls of water and mix well (Iron Solution).

For one sachet of F100 (makes 2.4 litres of F100), add one (1) crushed tablet of ferrous sulphate (200mg) in the 4mls of water (Iron Solution).

- If using locally made-up formulas add iron solution as above to the milk
- If the patient is on RUTF, do not give additional iron as it already contains the necessary iron.

Preparing Patient For Discharge

During this phase the patient should be prepared for eventual discharge. After a clinical team has ascertained that the patient is ready for discharge, specific criteria for discharging clients with appropriate follow up action should be followed as outlined in IMAM guideline.

NB: severely and moderately malnourished patients without medical complications can be managed as outpatient by following specified guidelines outlined in the National guideline on Integrated Management of Acute Malnutrition (IMAM)

Obesity In Adults

Defined as a state of adiposity in which the body fat is above the ideal i.e. when the individual's body weight is 20% more than the normal body weight or when the BMI is more than 30kg/m2. The normal body weight of a person depends on age, sex, height and body frame. Obesity is a chronic disorder of excessive accumulation of fat in the body, whereas overweight refer to the excess amount of body weight in all tissues.

Risk Factors

- Genetics
- Sedentary Lifestyle
- Dietary

Causes

- Energy imbalance between calories consumed and those that are expended
- A shift in diet towards increased intake of energy-dense foods high in fat and sugar but low in vitamins, minerals and other micronutrients
- A trend towards decreased physical activity due the increasingly sedentary nature of many forms of work, changing modes of transport and increasing urbanization

Management Of Obesity

Aim of nutritional management is to:

- Achieve and maintain ideal body weight by bringing about gradual weight loss
- Correct fault food habits

Management

- Control total energy intake based on individual assessment by limiting energy intake from total fat and simple sugars.

NB: A maximum reduction of 1000kcal daily is required to lose about 1kg a week and a reduction of 500kcal daily brings about a weight loss of about half a kg a week. Drastic reduction of calorie intake is however not advisable. Put the client on a weight reduction diet regime of 30-25kcal/kg /day.

- High fiber, restricted fat diets based on individual assessment is recommended
- Offer nutrition education and counseling to the clients with emphasis on weight management, fad diets and other unhealthy practices in weight control
- Recommend suitable exercise program and encourage physical activity for gradual weight loss

17.3.4.3 Self-Assessment

1. Define the following terms;

    A. Malnutrition

    B. Underweight

    C. Obesity

2. State whether the following statements are true or false about management of SAM

   A. On admission, if the patient is unconscious, give sugar water by NG tube

   B. If the patient has severe anemia, administer blood builders

   C. On admission, if the patient is alert give 5 ml/kg of 10% glucose

   D. Avoid giving the patient any vitamin A supplement

3. During the transition phase of management of malnutrition, the patient's diet should be _________

   A. 130 ml/kg/day of F75

   B. 130 ml/kg/day of F100

   C. 200 ml/kg/day of F75

   D. 200 ml/kg/day of F100

4. Which of the following nutrients should be provided as a supplement during management of malnutrition?

   A. Vitamin E

   B. Iodine

   C. Iron

   D. Protein

5. Describe the FOUR factors that influence nutrition.

6. Describe the causes of malnutrition using UNICEF's conceptual framework.

7. Explain the risk factors and clinical signs of malnutrition.

17.3.4.4 Tools, Equipment, Supplies and Materials

- Reference materials
- Clinical guidelines
- IMAM Guidelines
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Stationery

- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

17.3.4.5 References

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17.3.5 Learning Outcome 4: Demonstrate understanding in enteral nutrition

17.3.5.1 Learning Activities

Learning activity	Special instructions
i) Identify and describe terminologies in enteral nutrition	➢ Define the terms used in dietetics; o Enteral nutrition o Refeeding syndrome o Nutrient adequacy o Bolus feeding
ii) Identify and describe tube feeding/enteral nutrition routes	➢ Identify the routes through which enteral feeds can be administered
iii) Identify and describe types of enteral formulas	➢ Formulate specials feeds for enteral nutrition ➢ Administer enteral feeds ➢ Monitor the patient during tube feeding ➢ Record any complications experienced during parenteral feeding ➢ Identify and manage complications of enteral feeding

17.3.5.2 Information Sheet

Definition of terms

Enteral nutrition refers to a way of providing nutrition to the patients who are unable to consume an adequate oral intake but have at least a partially functional GI tract.

Bolus feeding: infusion of up to 500 ml of enteral formula into the stomach over 5 to 20 minutes, usually with a large bore syringe catheter a fine tube that can be threaded into the lumen of a blood vessel for infusion of fluids or withdrawal of blood central parenteral nutrition (CPN) vein, usually the superior vena cava continuous drip infusion enteral formula administration into the gastrointestinal tract via pump, usually over 8 to 24 hours per day

Refeeding syndrome: low serum levels of potassium, magnesium, and phosphorus with severe, potentially lethal outcome that results from the too-rapid infusion of substrates, particularly carbohydrate, into the plasma with the consequent release of insulin and shift of electrolytes into the intracellular space as glucose moves into the cells for oxidation and there is reduction in salt and water excretion

Nutrient adequacy: A result of consumption of sufficient amount of all essential nutrient and energy to meet individual requirements

TYPES OF PATIENT FEEDING

Enteral and Parenteral Nutrition

This refers to the provision of food and nutrients to the patient when the conventional feeding methods are not adequate or cannot meet nutrition needs. These include Enteral and parenteral nutrition. Selection of the mode of feeding is dependent upon several factors.

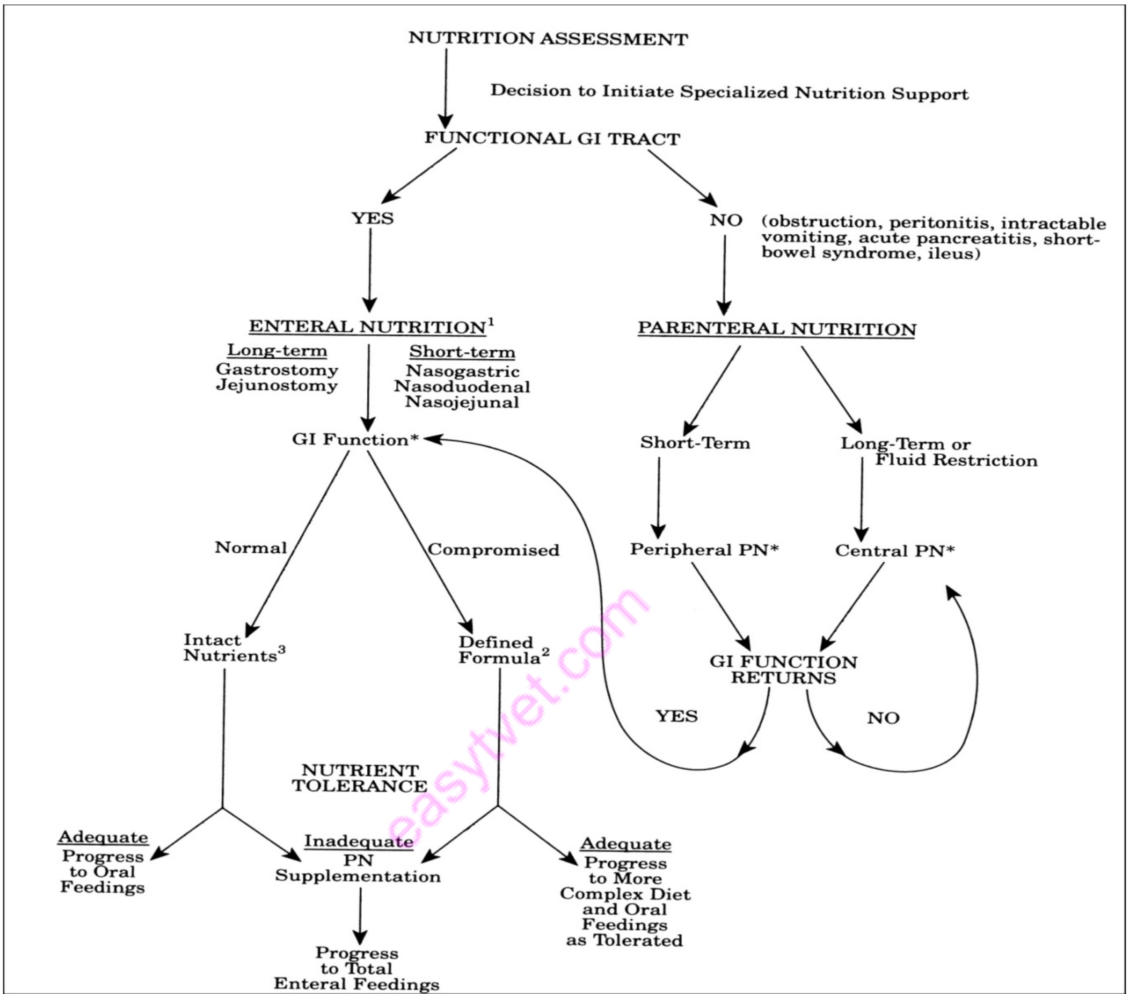

FIGURE 7.1. *Routes to Deliver Nutrition Support in Adults*
Reprinted with permission from A.S.P.E.N. Board of Directors. Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. J Parenter Enteral Nutr. *1993;17(4):1SA.*

Choice of route of nutrition administration Adopted from JPEN 1993; 17 (4): 1SA.

Enteral Nutrition

Enteral nutrition is a way of providing nutrition to the patients who are unable to consume an adequate oral intake but have at least a partially functional GI tract. Enteral nutrition may augment the diet or may be the sole source of nutrition. It is recommended for patients who have problems chewing, swallowing, prolonged lack of appetite, an obstruction, a fistula or altered motility in the upper GIT; are in coma or have very high nutrient needs.

Enteral feeds are

- Standard formula
- Hydrolyzed formula.

Tube Feeding

This is the delivering of food by tube in to the stomach or intestine. It is indicated whenever oral feeding is impossible or not allowed.

Tube feeding routes

The decision regarding the type of feeding route/tube depends on the patient's medical status and the anticipated length of time that the tube feeding will be required.

Mechanically inserted tubes;

- Nasogastric tubes where by a feeding tube is pushed through the nose into the stomach
- Orogastric tubes whereby a feeding tube is pushed through the mouth into the stomach
- Nasoduodenal tubes – the tube is pushed through the nose past the pylorus into the duodenum
- Naso-jejunal tube – the tube is passed during the endoscopy from the nose past the pylorus into the jejunum

Surgically inserted tubes

- Oesophagostomy: A surgical opening is made at the lower neck through which a feeding tube is inserted to the stomach
- Gastrostomy: A surgical opening is made directly into the stomach
- Jejunostomy : A surgical opening is made into the jejunum
- Figure below illustrates different routes of enteral nutrition administration.

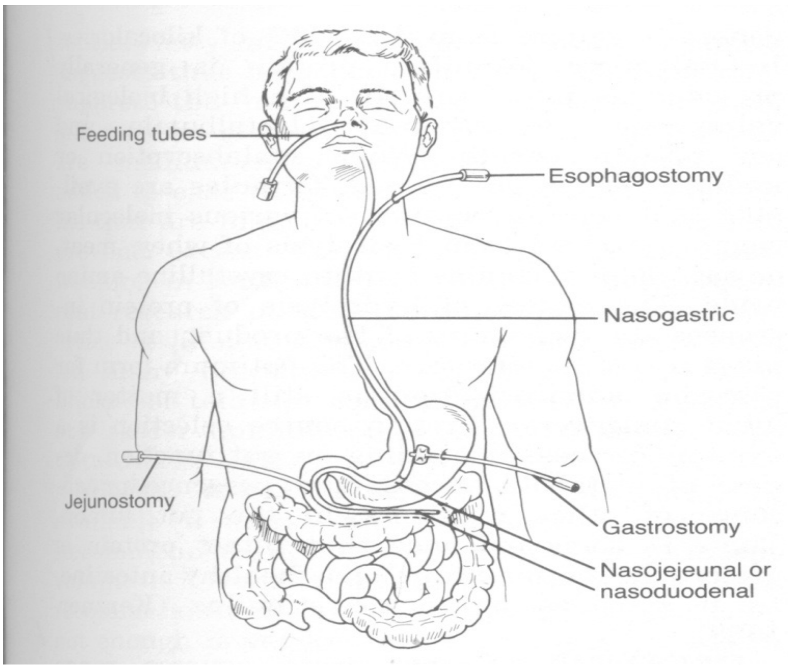

Figure X: Different routes of enteral nutrition administration (Draw if possible)

Advantages of Enteral nutrition

i) There is a stimulation of GI hormones and consequent regulated metabolism and utilization of nutrients.

ii) It ensures adequate nutrient supply to the mucosal wall, and protection against atrophy of intestinal Villi.

iii) It offers physiological protection against ulcers due to its buffering effect from gastric acids.

Disadvantages of enteral formulas

i) GI, metabolic, and mechanical complications—tube migration; increased risk of bacterial contamination; tube obstruction; pneumothorax

ii) Costs more than oral diets (not necessarily)

iii) Less “palatable/normal”: patient/family resistance

iv) Labor-intensive assessment, administration, tube patency and site care, monitoring

Administration of enteral feeds

The administration of enteral feeds should start slowly by giving 1litre in day one and 2 litres in day two as the patient is being closely monitored. The formula should also be stopped slowly (reduce rate by half every 1-2 hours or switch to dextrose IV. For the cyclic mode, give 12 to 18 hours perday.

Methods of administration of enteral feeds

Method	Administration	Remarks
Bolus feeding	Initially – 50ml then increase gradually up to a maximum of 250 to 400ml over approximately 30 minutes, 3 to 4 hourly daily (in 24 hrs)	• Most appropriate when feeding in to the stomach • Check aspirate before each feeding • Feeds may poorly tolerated causing nausea, vomiting, diarrhea, cramping or aspiration
Intermittent slow gravity feeding.	400 – 500ml infused by gravity over approximately 20 -30 minutes to 1 hr. 3 to 4 hourly daily (in 24 hrs)	• Patient retains freedom of movements in between feeds • Improved tolerance of feeds
Continuous	Total volume of feed required is slowly administered; approximately 100ml/hour over 18 – 24hrs	• Most suitable when feeding in to the duodenum or jejunum where elemental diets are most appropriate • May also be suitable for feeding in to the stomach • Method may slow peristalsis • Feeds are better tolerated

Tube feeding instructions

- Tube feeding should be used at room temperatures, cold mixtures can cause diarrhea
- Ensure proper placement of tube and feed at slow constant rate
- Prescribed intervals and volumes of feeding should be adhered to
- Care should be taken to ensure that the tube feeds meet the patient's nutrient requirements
- Prepared mixture should be well covered, properly labeled including time of preparation and stored in a refrigerator for up to 24 hours
- In the absence of refrigeration, quantities lasting only six to twelve hours should be prepared
- All feeding equipment should be cleaned before and after each feed
- Shake/stir well before use

Complications of tube feeding

Commonly seen complications can be classified into: gastro-intestinal, mechanical, metabolic, and pulmonary. The table below provides a summary of the complications alongside prevention/management strategies.

Gastro intestinal complications	Prevention/management
Diarrhea	• Slow feeding rate • Supplemental fluid and electrolytes • Use lactose free formula • Prevent formula contamination • Consider different formula • Check antibiotic/drug therapy • Check flow rate of feed • Consider Enteral nutrition with added fiber • Use ant diarrheal agent • Check osmolarity of feeds (< 500mosl/l recommended
Constipation	• Give supplemental fluid. • Check if fiber inadequate or excessive • Check physical activity
Nausea or vomiting	• Reduce flow rate • Discontinue feeding until underlying condition is managed • Change to polymeric feeds if on elemental diet • Check gastric emptying and review narcotic medications, initiate low fat diet, reduce flow rate

Malabsorption/Mal-digestion	• Identify the cause (crohn's disease, radiation enteritis, HIV, pancreatic insufficiency etc) • Select appropriate Enteral product • PN may be necessary in selected patients
Abdominal distension	• Assess the cause • Check feed temperature (give at room temperature) • Do not give rapid formula administration
Medical complications of tube feeding	
Mechanical complications	**Prevention/management**
Tube placement	• To be placed by trained personnel using defined protocol to reduce complications
Feeding tube	• Use small bore feeding tube to minimize upper airway problems
Tube clogging	• Select appropriate tube size • Flash with water • Dilute formula with water
Dislocation of tube	• Ascertain tube placement before each feed • Clearly mark tube at insertion
Nasopharyngeal irritation	• Use small lumen tube. • Use pliable tube
Esophageal erosion	• Discontinue tube feeding • Recommend parenteral nutrition
Metabolic complications	**Prevention/management**
(Fluid and electrolyte imbalance, trace element, vitamin and mineral deficiencies, essential fatty acid deficiencies	• Check adequacy of daily nutrient supply of macro and micronutrients during EN. • Check possibility of Malabsorption
Hyperglycemia	• Reduce flow rate. • Give oral hypoglycemic agents or insulin. • Change formula
Tube feeding syndrome	• Reduce protein intake or increase water intake. • For conscious patients education and counseling is needed
Hypernatremia (dehydration)	• Increased water intake and reduce sodium • Replace sodium loses
Hyponatremia (over-hydration)	• Replace sodium loses • Re-asses nutrient requirement, check volume administration, change to nutrient dense formula

Pulmonary complications	Prevention/management
Pulmonary aspiration	• Incline head of bed 30^0 – 45^0 during feeding 1 hr after feeding. • Check tube placement. • Monitor symptoms of gastric reflux. • Check abdominal distension. • Check residual volumes before feeds. • Change to jejunal feeding. • Reduce volume of feed. • Change from bolus to continuous feeding

Monitoring tube fed patient

Monitoring tube fed patients targets to find out two things;

- Hydration status
- Nutritional response

The following activities should be applied and also those summarized in the Table below;

- Weight (at least 3 times/week)
- Signs/symptoms of edema (daily)
- Signs/symptoms of dehydration (daily)
- Fluid I/O (daily)
- Adequacy of intake (at least 2x weekly)
- Nitrogen balance: becoming less common (weekly, if appropriate)
- Serum electrolytes, BUN, creatinine (2 –3 x weekly)
- Serum glucose, calcium, magnesium, phosphorus (weekly or as ordered)
- Stool output and consistency (daily).

Checklist for monitoring patients recently placed on tube feeding

Action	Check
1. Before starting a new feeding	• Complete a nutrition assessment • Check tube placement
2. Before each intermittent feeding: 3. Every half hour 4. Every hour 5. Every 4 hours	• Check gastric residual • Check gravity drip rate when applicable • Check pump drip rate, when applicable • Check vital signs, including blood pressure, temperature, pulse, and respiration

6. Every 6 hours	• Check blood glucose, monitoring blood glucose can be discontinued after 48hrs if test results are consistently negative in a non-diabetic client
7. Every 4 to 6 hours of continuous feeding	• Check gastric residual
8. Every 8 hours	• Check intake and output • Check specific gravity of urine • Check tube placement • Chart clients total intake of, acceptance of, and tolerance to tube feeding
9. Every day	• Weigh clients where applicable • Check electrolytes and BUN when needed • Clean feeding equipment • Check all laboratory equipment
10. Every 7 to 10 days	• Check all laboratory Findings • Re-assess nutrition status
11. As needed	• Observe client for any undesirable responses to tube feeding; for example delayed gastric emptying, nausea, vomiting, and diarrhea • Check nitrogen balance • Check laboratory data • Chart significant details

TYPES OF ENTERAL NUTRITION FORMULA

There are various types of enteral feeds available as ready to use or powdered mixes specifically designed to meet the needs of the patient. The formulas are commonly categorized by the complexity of the proteins they contain. There are two major types of Enteral feeds namely: standard and hydrolyzed.

Standard Formulas

These are also known as polymeric or intact formula. They are made from whole proteins as found in the diet (e.g. eggs, meat) or protein isolates [semi-purified high biological value proteins that have been extracted from milk, soybean or eggs]. Because they contain whole complex molecules of protein, carbohydrate and fat, standard formulas are used for patients who have normal digestive and absorptive capacity. They come in variety such as standard, high protein, high calorie and disease specific.

Hydrolyzed Formulas

Partially hydrolyzed formulas contain proteins that are partially digested into small peptides. Completely hydrolyzed formulas are commonly known as elemental formula and they contain protein in its simplest form; free amino acids. Hydrolyzed formulas also provide other nutrients in simpler forms that require little or no digestion e.g. very low fat in form of medium-chain triglycerides (MCT). Hydrolyzed formulas are meant for patients with impaired digestion or absorption such as people with inflammatory bowel syndrome, short gut syndrome and pancreatic disorders.

Indications for Enteral Nutrition

During periods of decreased oral intake, anticipated less than 50% of required nutrient intake orally for 7-10 days as seen in severe dysphasia (difficulty swallowing), metabolic stress, major bowel resections, low-output fistulas and coma. Neurological disorders and psychological conditions.

- Malnourished patients expected to be unable to eat > 5 days
- Normally nourished patients expected to be unable to eat >5 days
- Adaptive phase of short bowel syndrome
- Following severe trauma or burns

Contraindications

- Intestinal obstruction that prohibits use of intestine
- Paralytic illus
- Intractable vomiting
- Peritonitis
- Severe diarrhea
- High output fistulas between the GI tract and the skin
- Severe acute pancreatitis
- Inability to gain access
- Aggressive therapy not warranted.

Formula selection

The suitability of a feeding formula should be evaluated based on

a) Functional status of GI tract
b) Physical characteristics of formula (osmolality, fiber content, caloric density, viscosity)
c) Macronutrient ratios
d) Digestion and absorption capability of patient.

e) Specific metabolic needs

f) Contribution of the feeding to fluid and electrolyte needs or restriction

g) Cost effectiveness

Factors to consider when choosing an enteral formula

- Gastrointestinal function

The type of carbohydrate, protein, fat and fiber in the diet are related to the patient's digestive and absorptive capacity

- Caloric and protein content of the formula
- Ability of the formula taken in the amounts tolerated, to meet the patient's nutritional requirements
- Sodium, potassium, magnesium and phosphorus content of the formula esp. for patients with cardiopulmonary, hepatic or renal failure
- Viscosity of the formula related to tube size and method of feeding

Determining nutrient requirements

The type of formula, volume and hence the total nutrient required are determined by the patients physiological condition. Several equations are available for estimating nutrient requirements of patients depending on their clinical condition.

The calorie to nitrogen ratio should be >150:1 (1g nitrogen is equivalent to 6.25g protein). If the C: N ratio is less than 200:1, then the protein supplied by such a feed will be inadequate for critically ill patients.

Determination of estimated daily fluid allowance

In order to meet the nutrient needs of a patient, the nutritionist/dietician needs to calculate the kcal, protein, fluid and nutrient needs according to age, sex, medical status. After the calculations, appropriate formula is selected based on nutritional needs, feeding route and GI function. Usually, enteral feeds are usually administered in fluid state and it is imperative to know the amount of fluids each patient should get (See Table below).

Methods of estimating daily fluid allowance

Basis of estimation	Calculation
<u>Body weight</u>	
Adults	
• Young active :*16 – 30 years*	• 40 ml/kg
• Average: *25 – 55 years*	• 32 ml/kg
• Older: 55 – 65 years	• 30 ml/kg
• Elderly:*> 65 years*	• 25 ml/kg

Children	
• 1 – 10kg	• 100 ml/kg.
• 11 – 20kg	• An additional 50ml per each kg > 10kg.
• 21kg or more	• An additional 25ml per each kg > 20kg
• Energy intake	• 1 ml per Kcal.
• Nitrogen plus energy intake	• 100 ml/g nitrogen intake plus 1 ml per Kcal*

How to determine energy and protein requirements

Kcal/ml x ml given = kcal

% protein x kcal = kcal as protein

Kcal as protein x 1 g/4 kcal = g protein

- Example: Patient drinks 200 cc of a 15.3% protein product that has 1 kcal/ml

1 kcal/ml x 200 ml = 200 kcal

0.153 % protein x 200 kcal = 30.6 kcal

30.6 kcal x 1g protein/4 kcal = 7.65 g protein

Water

Increase fluids as tolerated to compensate for losses due to:

- Fever or environmental temp
- Diarrhea/vomiting
- Ostomy output, fistulas
- Increased urine output
- Draining wounds
- Increased fiber intake, concentrated or high-protein formulas

Classification of enteral formulas

Enteral formula	Sub-category	characteristics	Indications
Polymeric	Standard	Similar to average diet.	Normal digestion
	High nitrogen	Protein > 15% of total Kcal.	Catabolism Wound healing
	Calorie dense	2 Kcal/ml	Fluid restriction Volume intolerance Electrolyte abnormalities
	Fiber containing	Fiber 5 – 15/l	Regulation of bowel function

Monomer	Partially hydrolyzed elemental peptide based	One or more nutrients are hydrolyzed, composition varies.	Impaired digestive and absorptive capacity
Disease specific	Renal	Whole protein with modified electrolyte content in a caloric dense formula.	Renal failure
	Hepatic	High BCAA, low AA,	Hepatic encephalopathy
	Pulmonary	High % of calories from fat.	ARDS
	Diabetic	Low carbohydrate	Diabetes mellitus
Immune enhancing Formulas	Critically ill	Arginine*, glutamine, Omega-3 fatty acids, anti-oxidants	Critically ill.

Nutrient composition of enteral formulas

Proteins

In case of burns, injury, after surgery and in severe malnutrition, large quantities of proteins (100-200gm) should be administered. Average patient suffering from other diseases will need 60-70g of protein. Administer protein diet to those with hepatic coma

Fat

Should be administered in form of emulsions

Carbohydrates

Sources such as glucose, cane sugar and dextri-maltose can be used

About 300-500g should be administered daily depending on the patient's calorie needs

Fluid

Daily requirements for an adult are about 2500-3000ml and are easily provided

Electrolytes

Added into food depending on the needs of the patient e.g. chloride, potassium chloride etc

Vitamins

Daily requirements should be given in the food

Calories

An average adult patient will require 1500-2000kcal every day. After surgical operation, injury, burns, in severe protein-calorie malnutrition, provision of 3000kcal may be necessary to meet the increased demand. If adequate calories are not supplied, wasting of body muscle will take place.

Enteral Nutrition Feeds

Products Name	Composition-100g Powder	Indications	Manufacturer
Infant feeding formulas 1.Prenan*	CHO-55.9% mainly Lactose and maltodextrin PRO-14.4% mainly protein and casein. FAT-24.0% MCT, milk fat, corn oil, soybean oil	For low birth weight, premature or light for date babies when breast milk is not available	Nestle
2. Nan*	CHO-56.2% PRO-12.5% FAT-27.7%	For infants of normal birth weight[mature, normal for date]when breast milk is not available	Nestle Kenya Limited
3. SMA*	CHO-55.4% PRO-11.4% FAT-27.7% corn oil, soyn oil, coconut oil	For infants and low birth weight light for date babies when breast milk is not adequate or not available	Wyeth
Lactose free infant formulas 1.Alsoy	CHO-55.4% mainly maltodextrin PRO-14.0% soy protein isolate FAT-25% palm, soya and coconut oils	For infants and adults when lactose or cows milk should be avoided	Wyeth
2. Nursoy	CHO-52% corn syrup solids PRO-41% soy protein isolate FAT-27% blend of vegetable oils	For infants and adults when lactose or cow milk should be avoided	Wyeth
3. Isomil	CHO-50% corn syrup, sucrose PRO-15.6% soy protein isolate FAT-28.1%	For infants and adults when lactose or cow milk should be avoided	Ross labs
4. Prosobee	CHO-40% glucose polymer and corn syrup solids PRO-12% soy isolate FAT-48% soy oil, coconut oil	For infants and adults when lactose or cow milk should be avoided	Mead Johnson

High protein powder supplement 1.Full cream powder milk	CHO-37.4% PRO-25% FAT-28%	A protein carolic supplement that can be inco-oporated in liquid or solid dicts	Nestle KCC
2. Dried skimmed milk powder[DSM]	CHO-54% PRO-36.4% FAT-1%	A protein carolic supplement useful where low fat diet is required	KCC
3. Sustagen	CHO-68% corn syrup solids, glucose, lactose PRO-24% Non-fat milk, Whole milk caseinate FAT-8% Milk fat	Controlled fat diets	Mead Johnson
4. Pregestmil	CHO-54% glucose and tapioca starch PRO-11% Hydrolysed casein and amino acids FAT-35% corn oil MCT oil	For oral or tube feedings. Useful in malabsorption and low fat modified diets	Lederle Labs
5. Gevral	CHO-6.7% Lactose, sucrose PRO-17.1% Calcium caseinate FAT-0.6%	Useful in high protein, low carolic low fat, low residual diets	Laderle Labs
6. Forceval	CHO-30% Protein-55% FAT-1% Calories per 100g-366 Keal	A protein, vitamin and mineral supplement ideal for high protein diets, low fat diets and cases of malabsorption useful for patients allergic to lactalbumins	Unigreg Limited
Nutritionally Complete Liquid Diets 1.Fresubin	CHO-13.8g=55% of Total Kcals PRO-3.8g=15% of total Kcals FAT-3.4g=30% of Total Kcals Energy-100Kcal/100 ml	Nutritionally complete liquid diet for total or supplemental feeding, tube feeding or oral feeding Low in lactose	Freseinius

2. Fresubin Isofibre	CHO-17g=54.6 of total kcals PRO-7.5g=15.1% of total kcals FAT-68g=30.3% of total kcals Energy-1 kcal per ml	High caloric formula suitable for tube or oral feeding especially where energy intake is increased, where fluid is restricted and for fat malabsorption	Fresenius
3. Fresubin Diebetic	CHO-12g=53% of total kcals PRO-3.4g-15% of total kcals FAT-3.2g=32% of total kcals Fibre-1.5g per 100 ml[90 kcal]	Nutritionally complete feed for oral or tube feeding in diebetics	Fresenius
4. Ensure [with fibre]	CHO-58% of total kcals PRO-15% of total kcals FAT-30% of total kcals	Nutritionally complete feed for oral or tube feeding as a total diet or supplemental diet Lactose free fibre	Abott
5. Ensure [Nutritional powder]	. CHO-61.5g=54% of total kcal PRO-15.8g=14% of total kcal FAT-15.8g=32% of total kcal Energy=100kcal per 100ml	Nutritionally complete feed for oral or tube feeding as a total or supplement diet Lactose free feed, low ion cholesterol and sodium	Abott

CASE STUDY

Sam a 67 year old man weighing 55kgs and 167cm tall presents with a four month history of post prandial vomiting, inability to swallow solids and liquid and can only swallow saliva. He also has dysphagia and complains of weight loss.

1. Which type of feed is appropriate for Sam
2. Prepare a feeding chart which is suitable for Sam's condition.
3. Determine the energy and protein requirements in Sam's enteral nutrition.

17.3.5.3 Self-Assessment

1. Define the following terms;
   A. Nutrient adequacy
   B. Refeeding syndrome
   C. Bolus feeding
2. The provision of food and nutrients to the patient when the conventional feeding methods are not adequate or cannot meet nutrition needs is_____
   A. Bolus feeding
   B. Parenteral feeding
   C. Enteral feeding
   D. Nutrition support
3. ______________ is a method of tube feeding whereby the tube is passed during the endoscopy from the nose past the pylorus into the jejunum.
   A. Nasojejunal tube
   B. Nasoduodenal tube
   C. Orogastric tube
   D. Nasogastric tubes
4. The following statements about continuous feeding method of enteral nutrition except;
   A. It is most suitable when feeding in to the duodenum or jejunum where elemental diets are most appropriate
   B. It may be suitable for feeding in to the stomach
   C. Method may increase peristalsis
   D. Feeds are better tolerated
5. State the types of tube feeding.
6. Describe enteral nutrition.
7. Discuss the factors to consider when selecting an enteral formula.
8. Classify enteral nutrition based on different categories of patients.
9. Discuss the indications and contraindications of enteral formula.
10. Differentiate between standard and hydrolysed formulas.

17.3.5.4 Equipment and materials used in enteral feeding

There are several enteral nutrition delivery systems which include both open and closed delivery systems

- Feed preparation equipment for kitchen made feeds and powder feeds include measuring jars and cups and spoons, mixing bowls, blender, flask, sterile water

- Ready to hang (RTH) feeds: giving sets for gravity or giving sets for the pump system, Enteral feeding pumps, dual port connector and a feeding bag where applicable
- Liquid diets in easy bags: giving sets (gravity or pump), feeding pump and/or dual port connector where applicable
- Feed delivery equipment; funnel especially in gastrotomy and Jejunostomy for controlling viscous flow, syringe for naso-gastric bolus or intermittent feeding and the feeding tubes where applicable
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Stationery
- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

***NB:** Feeding pump is recommended as it eases feeding workload because it flows without constant supervision, enhances accuracy, hygiene and sanitation.*

17.3.5.4 References

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17.3.6 Learning Outcome 5: Demonstrate understanding in parenteral nutrition

17.3.6.2 Learning Activities

Learning activity	Special instructions
i) Identify and describe terminologies in parenteral nutrition	➢ Explain the terms used in nutrition support ○ Parenteral ○ Infusion ○ Rate of infusion ○ Total parenteral nutrition (TPN) ○ Peripheral parenteral nutrition (PPN)
ii) Identify and describe parenteral nutrition routes	➢ Identify the routes through which parenteral feeds can be administered
iii) Identify and describe administration of parenteral nutrition	➢ Formulate specials feeds for parenteral nutrition ➢ Administer special feeds used in parenteral nutrition
iv) Identify and describe complications of parenteral nutrition and their nutritional management	➢ Monitor the patient during parenteral feeding ➢ Record any complications experienced during parenteral feeding ➢ Manage contingencies during parenteral feeding

17.3.6.2 Information Sheet

Meaning of terms in parenteral nutrition

- **Nutrition:** The ingestion and utilization of food by which growth, repair, and maintenance of activities in the body are accomplished
- **Parenteral nutrition** is the continuous infusion of a hyperosmolar solution containing carbohydrates, proteins, fat, and other necessary nutrients through an intravenous route
- **Infusion:** the introducing of a solution such as glucose especially into a vein
- **Rate of infusion:** refers to the desired rate at which a solution should be administered to achieve a steady state of a fixed dose which has been demonstrated to be therapeutically effective
- **Total parenteral nutrition (TPN):** a method of feeding that bypasses the gastrointestinal tract whereby fluids are given into a vein to provide most of the nutrients the body needs

- **Peripheral parenteral nutrition (PPN):** refers to the administration of nutritional solution is into veins outside the Superior Vena Cava.
- **Peripheral vein:** a vein that is near the surface of the skin.

Parenteral nutrition

This refers to nutrition directly into the systemic circulation, bypassing the gastro-intestinal tract (GIT) and the first circulation through the liver. Parenteral nutrition is used when the enteral route is unable to provide or sustain sufficient caloric intake. The primary objective of parenteral nutrition is to maintain or improve the nutritional and metabolic status of patients who have temporary or permanent intestinal failure.

Characteristics of parenteral nutrition

- Patients on TPN (Total Parenteral Nutrition) have similar requirements as enterally fed patients
- The six major nutrients covered are: carbohydrates, proteins, fats, vitamins, minerals and water
- Feeds must provide adequate calories
- Nutrient form must be specialized for infusion into blood count prior to digestion
- Standardized concentration may be modified to suit individual requirements

Indications for Parenteral Nutrition

Patients who are candidates for parenteral nutrition cannot eat adequately to maintain their nutrient stores. These patients are already, or have the potential of becoming malnourished.

Peripheral Parenteral Nutrition (PPN) may be used in selected patients to provide partial or total nutrition support for up to 2 weeks in patients who cannot ingest or absorb oral or enteral tube delivered nutrients or when central-vein parenteral nutrition is not feasible.

Parenteral nutrition (PN) support

EN is contraindicated or the intestinal tract has severely diminished function due to underlying disease or treatment. Specific applicable conditions are as follows:

- Paralytic ileus
- Mesenteric ischemia
- Small bowel obstruction
- GI fistula except when Enteral access may be placed distal to the fistula or volume of output (<200 mL/d) supports a trial of EN
- Diseases of the small intestine
- Intractable vomiting/diarrhea
- Massive small bowel resection

- Trauma
- Inflammatory Bowel Disease
- Enterocolitis (AIDS, chemotherapy, radiotherapy)
- Pancreatitis
- Burns
- Cancer
- Immaturity (premature babies).

As occurs in postoperative nutrition support, the exact duration of starvation that can be tolerated without increased morbidity is unknown. It has been suggested that wound healing would be impaired if PN is not started 5–10 days. This is for postoperative patients unable to eat or tolerate enteral feeding.

The patient's clinical condition is considered in the decision to withhold or withdraw therapy. Conditions where nutrition support is poorly tolerated and should be withheld until the condition improves are severe hyperglycemia, azotemia, encephalopathy and hyperosmolarity and severe fluid and electrolyte disturbances.

Contraindications

- Functional GIT
- Existence of an advanced terminal condition for which aggressive therapy is not provided

Parenteral nutrition in infants

Very preterm infants, who often have relatively delayed gastric emptying and intestinal peristalsis, may be slow to tolerate the introduction of gastric tube feeds. These infants may need intravenous nutrition while enteral nutrition is being established or when enteral nutrition is not possible—for example, because of respiratory instability, feed intolerance, or serious gastrointestinal disease.t is necessary when parenteral feeding is indicated for longer than 2 weeks, peripheral venous access is limited, nutrient needs are large, or fluid restriction is required, and the benefits of PN support outweigh the risks. Patient has failed Enteral Nutrition (EN) trial with appropriate tube placement (post-pyloric).

Examples of feeds for pediatrics:

- Protein source: Amino venous
- CHO source: dextrose
- LIPIDS (Fat) source: Lipovenous 10%

Total parenteral nutrition consists of a glucose and amino acid solution with electrolytes, minerals, and vitamins, plus fat as the principal non-protein energy source. Bloodstream infection is the most common important complication of parenteral nutrition use. Delivery of the solution via a central venous catheter rather than a peripheral catheter is not associated with a higher risk of infection. Extravasation injury is a major concern when parenteral nutrition is given via a peripheral cannula. Subcutaneous infiltration of a hypertonic and irritant solution can cause local skin ulceration, secondary infection, and scarring. Extravasation injury may occur when a peripheral cannula is used to deliver the parenteral nutrition solution.

Routes of administration of parenteral nutrition

Intravenous solutions can be provided in different ways. The methods used depend on the person's immediate medical and nutrient needs, nutrition status and anticipated length of time on IV nutrition support. They include:

- Peripheral Parenteral Nutrition (PPN)
- Central Parenteral Nutrition (TPN)

The general decisions to use PPN instead of CPN are based on comparative energy demands and anticipated time of use.

Peripheral Parenteral Nutrition

This refers to use of peripheral veins to provide a solution that meet nutrient needs for infusion. It has lower dextrose (5% to 10% final concentration) and amino acid (5% final concentration) concentration than CPN. It may provide full or partial nutritional requirements to patients.

PPN can be administered in to peripheral veins if solutions used have osmolarity below 800 - 900mosm/l for a brief period of less than 14 days. Short catheters (cannulas) and mid-way catheters are normally used. However, PPN administration is possible for several weeks with fine bore catheter.

PPN may be used in patients with mild or moderate malnutrition to provide partial or total nutrition support when they are not able to ingest adequate calories orally or enterally or when central vein PN is not feasible.

All in one admixture are highly recommended compared to the single bottle system during PPN.

Central Parenteral Nutrition (CPN)

CPN is often referred to as "Total Parenteral Nutrition" since the entire nutrient needs of the patient may be delivered by this route. It requires a central venous system for long term infusions.

The sites mainly used are the Vena jugularis external, Vena jugularis internal, Vena subclavia, Vena cephalica and Vena basilica for solutions with osmolarity above 800 - 900 mosm/l.

Peripherally Inserted Central Catheters (PICC) for short - and long term infusions are possible. Implantable system for central venous access (Ports) Lasts for years after implantation and patients may go on TPN for years with the catheters being changed every 5 - 10 years. Central Parenteral Nutrition is complete nutrition similar to physiological nutrition and can be provided for unlimited period (weeks to years). PN can be used in hospitalized patients and those who have returned home or are in assisted living, extended care facilities or nursing homes.

Access routes for parenteral nutrition include:

a. Peripheral Access Routes

One of the easiest and safest ways to access the vascular system is to place a cannula into a peripheral vessel. The adequacy of the vein limits the use of the peripheral system for infusion. Catheter tips that are located in a peripheral vessel are not appropriate for the infusion of PN formulas > 900 mosm/L.

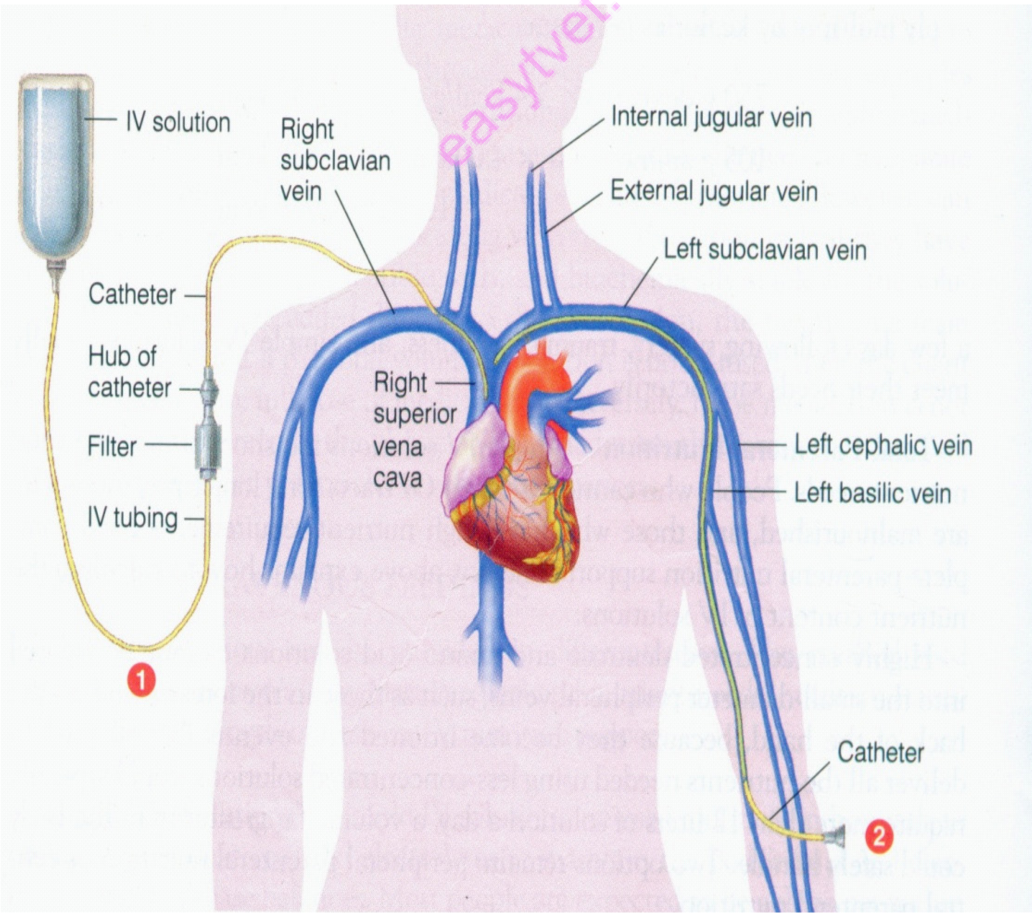
The indications for peripheral infusion are short-term access needs. Specially formulated PN may be administered by peripheral access. These solutions are based on a decreased dextrose concentration and osmolarity and have been reported to be used for short-term therapies (<-10–14 days) when fluid restriction is not necessary.

The leading complication associated with peripheral access is peripheral venous thrombophlebitis. The hallmark symptoms of infusion phlebitis (an inflammation of the cannulated vein) are pain, erythema, tenderness or a palpable cord. Peripheral devices have the lowest risk of catheter related infections.

b. Central Venous Access

Central venous access is defined as a catheter whose distal tip lies in the distal vena cava or right atrium. The most common sites of venipuncture for central access include the subclavian, jugular, femoral, cephalic, and basilic veins.

The figure below illustrates administration of PN through the sub-clavian vein.



Administration of parenteral nutrition through sub clavian vein

Calculating the nutrient content of Intra Venous (IV) formulas

The energy/nutrient requirements of patients on parenteral nutrition comprises of a complete nutrition similar to physiological nutrition. These requirements can be calculated using several different available formulas and no standard prescription provides an answer for all patients. Nutrient requirements are also adjusted at all times to suit the patient's current medical or surgical condition. One of the standard parenteral nutrition regime that is suited for 80% of patients and calculated as per the kilogram body weight is as shown in the table below:

Nutrient requirements for IV formulas

Nutrients	Requirements
Amino acids	1 - 1.5g
Energy (as fat and glucose) 25 - 30 kcal (NPE - Non Protein Energy)of which glucose	3 - 5g (>2g/kg, <7g/kg)
Fat (LCT)	1- 2g (<0.3g/kg, <3g/kg)
Vitamins and trace elements	Basic needs
Water and electrolytes	Basic needs

Note:

Protein Energy (NPE): Stand for energy from carbohydrate and fat only, excluding the energy from protein. The protein requirements are then calculated separately as per the patient's body weight.

The proportion of carbohydrate to fat is then calculated at a proportion of 70: 30 or 50: 50 depending on the patient's condition. This means that 70% of the NPE will be the required energy from Carbohydrate and 30% of NPE will be the required energy from fat.

Total energy (TE) requirements can also be calculated from e.g. the Harris Benedict Equation (HBE) or any other equation or formulas available. The ratio of energy to nitrogen is then calculated as follows:

Calorie nitrogen ratio – An adequate energy provision is necessary to support the use of protein for anabolism. The recommended non-protein calorie nitrogen ratio (C: N) for the different conditions is calculated as shown in the table X below.

Conditions	Calorie: Nitrogen Ratio (gN)
For normal body maintenance	300:1
Stressful conditions	150:1
Renal failure	250: 1
PPN	70:1
Children	300:1

The percentage of nutrient requirements can also be calculated from the TE as follows:

- 50 – 60% of the TE from Carbohydrate
- 15 – 20% of TE from Protein
- 25 - 30% of TE from FAT

Precautions in Parenteral Nutrition

Osmolarity – ensure appropriate osmolarity is infused via the appropriate veins to avoid thrombosis and small blood vessel damage. E.g. osmolarity > 900 should be administered centrally.

Calculation of the osmolarity of parenteral nutrition solutions

Multiply the grams of dextrose per liter by 5 mosm/g

Example: 50g of dextrose x 5 = 250mOsm/L

Multiply the grams of protein per liter by 10 mosm/g

Example: 30g of protein x 10 = 300mOsm/L

Fat is isotonic and does not contribute to osmolarity

Electrolytes further add to osmolarity for example: 1 mosm/me of individual electrolyte additive

Total osmolarity is then derived from the sum of the osmolarity of all nutrients infused

- **Infusion rate** – always check label and package inserts. The maximum infusion rate recommended for specific solutions should not be exceeded in order to avoid complications
- Vital signs should be monitored daily
- Discontinuation should also be gradual to avoid hypoglycemia
- Infuse parallel, it is best to infuse parallel. If parallel infusion is not possible then infuse directly
- First carbohydrates with electrolytes, second amino-acid with electrolytes, third fat

Examples of parenteral nutritional formulations:

You can have confidence in IV solutions if you know what they contain. The basic thing to remember is that the percentage of a substance in solution tells you how many grams of that substance are present in 100mL e.g. a 5% dextrose solution contains 5g of dextrose per 100 ml; a 3.5% amino acid solution contains 3.5g of amino acids per 100ml. A 0.9% normal saline solution contains 0.9g of NaCl per 100mL. Table A shows examples of parenteral formula feeds. Table B on the other hand, shows pediatric parenteral nutrition formulations.

Table A: Examples of parenteral formula feeds

Amino acid solutions	Features	Presentation
Standard Amino Acids • 5% (50g AA/L) • 10% (100g AA/L) • 15% (150g AA/L)	These are standard Amino acids for parenteral nutrition which contain WHO recommended ratio for essential and non essential amino acids and may contain electrolytes or may be electrolyte free Essential nitrogen balance	200ml,500ml and 1000ml bottles
Special Amino Acids	May be balanced AA solution containing Glutamine and tyrosine , Arginine	200ml, 500ml bottle
Special Amino Acids	Disease specific formulation containing AA glutamine	50ml, 100ml, 200ml bottles
Special AA for Hepatic insufficiency • 8% (80g AA/L)	These are disease specific formulations. Specially designed to compensate the AA disorders in hepatic insufficiency, rich in BCAA and quite low in AAA.	200ml, 500ml bottles
Special AA for renal insufficiency • 7% (70g AA/L) • 10% (100g AA/l)	Adapted to the metabolic AA disorder in renal failure and contains a balanced profile of EAA and NEAA and the dipeptide glycyl-tyrosine Well balanced AA pattern specifically designed for infants (preterm, new born, babies) and young children. Contains EAA and NEAA similar to human breast milk. Contains taurine an EAA for neonates	200ml, 250ml and 500ml bottles
Carbohydrates solutions	**Features**	**Presentation**
• 5% (50g /L) • 6% (60g/ L) • 10% (100g/L) • 20% (200g/L) • 25% (250g/L) • 50% (500g/L)	These carbohydrate feeds mainly contain glucose but some may contain xylitol and or sorbital	50ml, 100ml, 500ml, 1000mls bags or bottles
Solutions with both Carbohydrate and Amino acids.	These parenteral nutrition solutions contain both carbohydrate and amino acid including electrolytes and may be administered peripherally. e.g. 1) 3% AA and 6% carbohydrate plus electrolytes. 2) 5% AA and 5% sorbital.	200ml, 500ml, 1000ml bottle
Lipid Emulsions	**Features**	**Presentation**

• 10% • 20% • 30% • 20% MCT-LCT	These are lipid emulsions for parenteral nutrition with different special functions different lipid formulations may contain the following: • contains soybean oil (LCT) rich in EFA • contain EFA, MCFA & LCFA • contain mixture of MCT and LCT • Rapid clearance and energy production preference fuel in conditions like carnitine • Isotonic • Mean globule size similar to chylomicrons	200ml, 250ml and 500ml bottle or bag
Lipid Emulsion (fish oil)	• Contain fish oil • Rich in EPA and DHA • Has anti-inflammatory and immunomodulatory effect	50ml and 100ml bottles
All in One	**Features**	**Presentation**
All in One Parenteral Nutrition formulations	Three (triple) chamber bags with separate compartments for amino acids, fat and a combination of glucose or sorbital and electrolytes for central or peripheral parenteral Nutrition, depending on the osmolarity and specifications. Vitamins and minerals are added into the bag prior to infusion.	1000ml, 15000ml, 2000ml, 25000ml. bags
Two chamber bags	Two chamber bags with separate compartments for amino acid and glucose with or without electrolytes. Other nutrients may be added i.e. fat, vitamins, trace elements as per the specifications	1000ml, 1500ml, 2000ml bags

Vitamins • 9 water soluble vitamins • 4 fat soluble vitamins	Contains all the water soluble and or fat soluble vitamin based on international recommendations. These are added into the parenteral nutrition product prior to infusion, once daily. Water soluble vitamins to be added into water base products e.g. Dextrose, amino acids or the all in One PN bags but **NOT** to be added into the single bottle of fat emulsion. The fat soluble vitamins can only be added into the fat emulsion bottle or the All in One PN bags follow instructions as specified	10ml vials 10ml ampules.
Trace elements	Trace element in adults for parenteral nutrition based on international recommendations e.g. zinc, copper, chromium, manganese, selenium.	10ml ampoule 1ml, 3ml, 10ml vials

Table B: Paediatric parenteral nutritional formulations

Feed	Composition per 10 0mls	Presentation
Special AA for pediatrics 6.5% (65g AA/l) 7% (70g AA/L) 10% (100g AA/L)	• Well balanced AA pattern specifically designed for infants (preterm, new born, babies) and young children • Contains EAA and NEAA • Similar to human breast milk • Contains taurine an EAA for neonates	100ml, 250ml and 500ml bottles. Dosage: As per the child's age, weight and recommendations
Special Amino acids for hepatic and renal failure	• As above for children above 6 months of age	As above Dosage: As per the child's age, weight and recommendations
Carbohydrate solutions (presentations as Above for adults)	• The carbohydrate solutions mainly contain glucose	100ml, 500ml bottles Dosage: As per the child's age, weight and recommendations
Lipid emulsions	• As Adults • Dosage: As per the child's age, weight and recommendations	100ml bottles

Vitamins: Water soluble vitamins	• As Adults • Dosage: As per the child's age, weight • Requirements will be calculated as per the child's weight	10ml vial
Fat soluble vitamins for infants	• A multivitamin preparation of lipid soluble vitamins for parenteral nutrition for infants	10ml ampoule Dosage: As per the child's age, weight and recommendations
Trace elements for children	• Trace element additive for children in parenteral nutrition based on international recommendations, to meet the basal requirements of trace elements during intravenous nutrition in infants and children	10ml vial Dosage: As per the child's age, weight and recommendations

Current formulations in the market have the three chamber bags for peripheral and central parenteral infusion.

Vitamin requirements in Parenteral Nutrition

It is recommended that all adult/pediatrics PN patients, be supplemented daily with a standard multivitamin package. Table X below provides the standard vitamin package/requirement for parenteral nutrition.

Vitamins	Daily Requirements
B1	3.0 mg
B2	3.6 mg
Niacin	40.0 mg
Pantothenic Acid	15.0 mg
B6	4.0 mg
Biotin	60,0 mg
Folacin Acid	400.0 mg
B12	5.0 mg
C	100.0 mg
A	3,300 IU
D	200 IU
E	10 IU
K	300-500 mg

Source: AMA Recommendation, JPEN 1979

DETERMINING TRACE ELEMENT REQUIREMENTS

The trace elements zinc, copper, chromium, manganese, iodine, iron, and selenium must be provided in PN to prevent clinical deficiency. It is recommended that all adult PN patients be supplemented daily with a standard trace element package as shown in the table below.

Recommendations for trace elements in parenteral nutrition

Adult patients	mg/day	µmol/day
Chromium (Cr)	0.010-0.015	0.19-0.29
Cobalt (Co)		
Copper (Cu)	0.5-1.5	8-24
Fluorine (F)	1-3	53-158
Iron (Fe)	1-2	18-36
Iodine (I)	0.1-0.2	0.79-1.6
Manganese (Man)	0.15-0.8	2.7- 15
Molybdenum (Mo)	0.015-0.030	0.16-0.31
Selenium (Se)	0.03-0.06	0.38-0.76
Zinc (Zn)	2.5-4.0	38-61

Administration of parenteral nutrition

Parenteral Nutrition feeds can be administered in the following forms:

i) **Single bottle system**: These are single products/bottles providing either one of amino acid solution, dextrose solution or lipid emulsions or vitamins or trace elements or a combination of Amino acid and dextrose. The single bottle system may also contain electrolytes.

ii) **All in One (AIO) admixtures**: These formulations may be prepared as a single product by the hospital pharmacist or industrial admixtures. The industrial admixtures are mixed up at the factory and delivered to the hospital. Refrigeration is required and they have a short shelf life.

iii) **Chamber bags**: Two and three chamber bags. These AIO parenteral nutrition feeds have a much longer shelf life and are mixed prior to administration.

Monitoring of parenteral Nutrition

This is necessary to assess whether the regimen is suitable for the patient and also to confirm and, if necessary correct the prescribed regime. To prevent possible complications, for example, catheter related complications and metabolic related complications

Be careful to check:

- The general condition of the patient
- Patient’s daily body weight - bed weighing scales may be practical to check body weight daily at the same time.

- Nitrogen balance
- Fat elimination - check fat tolerance test and plasma triglycerides
- Blood electrolytes - including phosphate
- Blood glucose
- Micronutrients in the long-term parenteral nutrition patients

COMPLICATIONS OF PARENTERAL NUTRITION

These complications are mainly divided into two main categories as follows:

- Catheter related complications which involve:
- Occlusion of the catheter
- Catheter blockage (check the type, diameter, period of use)
- Catheter related infections - these infections may come from the skin or systemic circulation (gram negative organisms and fungi)
- Catheter related sepsis - there is need to use antiseptic techniques at all times
- Metabolic Complications
- Hepatibiliary or Gastrointestinal complications
- Abnormal liver function (caused by underlying diseases, i.e. sepsis, malignancy, IBD, pre-existing liver disease) bacterial overgrowth in the intestines, biliary sludge and gallstones. Steatosis which may be caused by sole infusion of dextrose as an energy source without fat emulsions or excessive glucose load (above or equals to 7g of glucose/kg/day). Sole glucose infusion without fat may also cause essential fatty acid deficiency (EFAD).

Macronutrient Complications

These are risks associated with underfeeding or overfeeding:

- Hyperglycemia - several factors may cause hyperglycemia including overfeeding
- Hypoglycemia - this may occur mainly if weaning off parenteral nutrition is not done appropriately or if there is excess insulin administration
- Azotemia can result from dehydration, excessive and/or inadequate non protein calories. Omission of fat emulsions during PN may cause EFAD
- Too much infusion may cause hyperlipidemia.

Micronutrient Related Complications

- Fluid imbalance (Dehydration from osmotic diuresis, fluid overload)
- Electrolyte imbalance
- Vitamin, mineral and trace elements deficiency may only occur

The above complications can greatly be reduced and avoided if there is a multi-disciplinary nutrition team with experienced clinicians available to insert the central feeding catheters, designated nurses to care for the catheters, and an experienced registered dietician to prescribe the right parenteral nutrition formulation and make the necessary follow ups, monitoring and necessary adjustments. The table below shows complications of total parenteral nutrition.

Complications of total parenteral nutrition

Catheter related complications	Metabolic complications
• Bacteraemia (staphylococcal)	• Cholestatic jaundice
• Invasive fungal infection	• Hyperglycaemia or glycosuria
• Thrombosis	• Vitamin deficiencies or excesses
• Extravasation injuries	• Hyperammonaemia
• Cardiac tamponade	

CASE STUDY

1. Tony is a 37 year old man who weighs 58 kg and is 157cm tall. He has recently undergone gastric bypass surgery. He is currently on parenteral nutrition support. Calculate his nutrient requirements in light of;

    A. Amino acids

    B. Glucose

    C. Fat

17.3.6.3 Self-Assessment

1. Define the following terms

    A. Parenteral nutrition

    B. Rate of infusion

2. Intravenous solutions

    A. Rarely contain vitamins   B. Usually contain cellulose

    C. Are usually given after surgery   D. Provide 2,000 calories per day

3. ______is a major concern when parenteral nutrition is given via a peripheral cannula.

    A. Refeeding Syndrome   B. Thrombosis

    C. Enterocolitis   D. Extravasation Injury

4. The general decisions to use PPN instead of CPN are based on

    A. The general status of the patients

    B. The medical condition of the patient

C. The availability of resources

D. Comparative energy demands and anticipated time of use.

5. One should ensure appropriate osmolarity is infused via the appropriate veins to avoid

   A. Thrombosis and small blood vessel damage

   B. Abnormal liver function

   C. Hyperglycemia

   D. Occlusion of the catheter

6. Differentiate between total parenteral nutrition (TPN) and peripheral parenteral nutrition (PPN).

7. Identify the characteristics of and indications for parenteral nutrition.

8. Describe the access routes for parenteral nutrition.

9. Discuss the forms in which parenteral nutrition can be administered.

10. Discuss how monitoring can be done on the parenteral nutrition administration.

11. Discuss the complications of parenteral nutrition.

17.3.6.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- Calculator
- Parenteral nutrition formulas
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Stationery
- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

17.3.6.5 References

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17.3.7 Learning outcome 6: Demonstrate understanding in nutritional management of surgery, trauma, and burn

17.3.7.1 Learning Activities

Learning activity	Special instructions
i) Identify and describe terminologie	• Demonstrate ability to define the terms o Surgery o Trauma o Burn o Preoperative nutrition o Postoperative nutrition
ii) Identify and describe burns pathophysiology and their nutritional management	• Describe the pathophysiology of burns • Classify burns • Determine nutritional requirements during burns • Offer nutritional management of burn patients o Formulate diets for burns
iii) Identify and describe surgery nutrition implications of surgery and management • Nutritional management in severe trauma	• Demonstrate ability to determine nutritional implications of surgery • Provide nutritional support in surgery • Perform diet formulations for surgery patients o Pre-operative nutrition o Post-operative nutrition

17.3.7.2 Information Sheet

Meaning of terms in surgery, trauma and burns

Surgery: the treatment of injuries or disorders of the body by incision or manipulation especially with instruments

Trauma: physical injury experienced after a surgical procedure

Burns: a result of the effects of thermal injury on the skin and other tissues

Preoperative nutrition: nutrition therapy provided before surgery which aims at meeting surgery demands

Postoperative nutrition: nutrition therapy provided after surgery which aims at replenishing surgery-induced physiological losses.

BURNS

Major burns result in severe trauma. Human skin can tolerate temperatures up to 42-44°C (107-111° F) but above these, the higher the temperature the more severe the tissue destruction

Below 45°C (113° F), resulting changes are reversible but >45°C, protein damage exceeds the capacity of the cell to repair A burn injury occurs as a result of destruction of the skin from direct or indirect thermal force. Burn are caused by exposure to heat, electric current, radiation or chemical. Scald burn result from exposure to moist heat (steam or hot fluids) and involve superficial. When a patient suffer from burn injuries the energy requirements can sometimes increase to as much as 100% above resting energy expenditure, depending on the extent of the burn (Total Burnt Surface Area - TBSA) and depth of the injury (degree of burns).

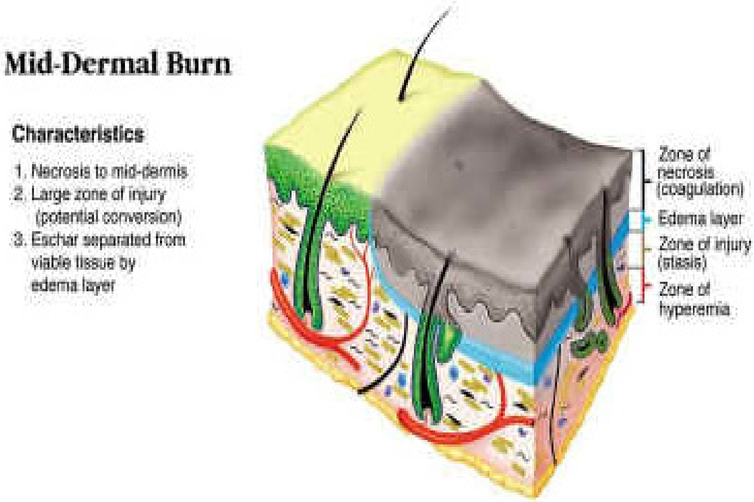
Causes

Burns can result from several causes. They include; fire, chemicals, contact with hot liquids, sunburn, electricity or lightning, prolonged exposure to hot liquids

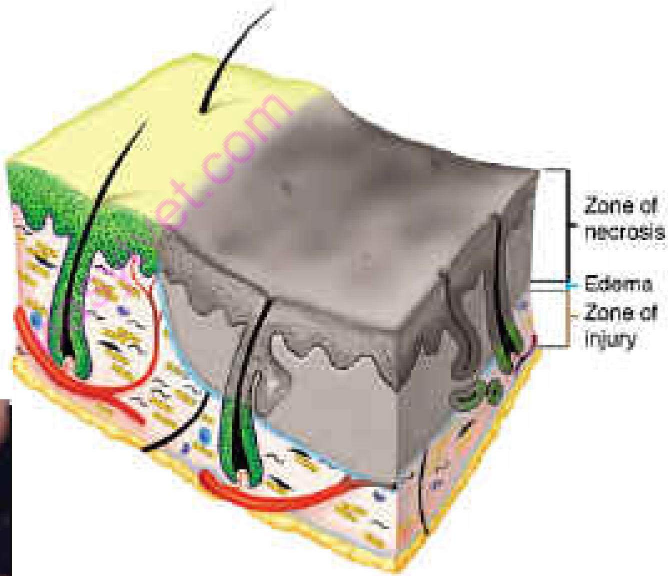
Degree and extent of burns

- The depth of the burn wounds affects its healing process. Burns are classified by degree;
  - ***1st degree:*** erythema (redness of the skin). Cell necrosis above the basal layer of the epidermis can regenerate new skin tissue.

– ***2nd degree:*** erythema and blistering, necrosis within the dermis



– ***3rd degree:*** a full thickness skin loss including the fat layer.

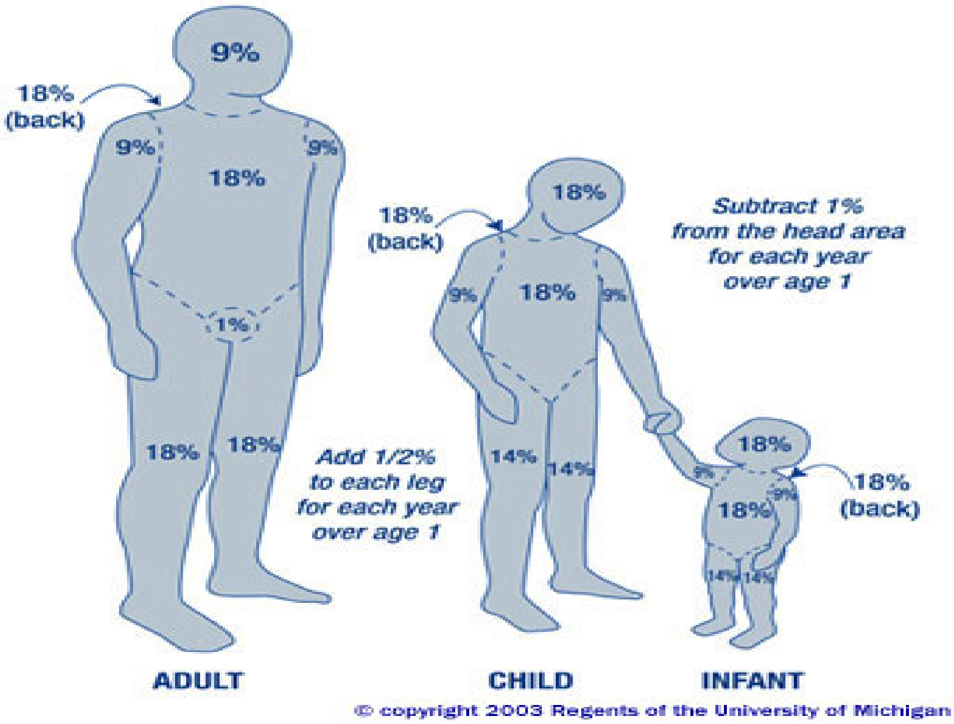


– Extensive full thickness burns require skin grafting.

– When the burn injury exceeds 15 to 20% of the total body surface area (TBSA), it results in systemic disturbances, including a major stress response, impaired immunity and extensive fluid redistribution

– 2nd & 3rd degree burns covering 15-20% or more of total body surface or 10% in children and elderly persons usually cause extensive fluid loss and require phototherapy.

– Burns of severe depths covering more than 50% of the body surface area are often fatal especially in infants and older persons.



Immediate 'ebb 'or shock period

- During the first 12-24hours following injury, patients with major burns require rapid replacement of lost fluid and electrolytes.
- The inflammatory process associated with injury increases permeability of the vascular endothelium (glucose free, balanced electrolyte solutions are used).
- A massive flooding edema occurs at the burnt site during the first hours to about the 2nd day

Following 'flow' or recovery period

- After about 48-72 hours, tissue fluids & electrolytes are gradually reabsorbed into the general circulation and excess fluid is excreted.
- The patient returns to the pre-injury weight by the end of the first week. Fluid balance is gradually re-established and patterns of massive tissue loss reversed.
- There is sudden diuresis(careful check of fluid intake and output is essential with constant checks for signs of hydration or over-hydration)

Secondary feeding period

- Towards the end of the first burn week, adequate bowel function returns and a vigorous feeding must ensue.
- The nutritional needs are high.

Implications of burns

- Catabolism of trauma
- Anorexia
- Generalized discomfort and depression
- Heat lost
- Demand of tissue regeneration
- Malnutrition
- Wasting and weight loss
- Failure to feed
- Loss of fluids and electrolytes
- Infections
- Anemia

Special concerns for burn patients

- Burn patients have all typical characteristics of hypermetabolic state and nitrogen losses exceed any other type of stress or trauma
- Hyper metabolism increase with size of the burnt area peaking up to 2 to 2.5 times above the normal metabolic rate for burns involving as much as 40% of the body surface
- When the skin surface is destroyed, the body's first line of defense against infection is lost
- Loss of skin also results in increased water and heat loss. The larger the burnt area the greater the loss of water vapor and heat
- Approximately 2.5-4l/day of water vapor may be lost from a major burnt wound
- The burnt surface allows leakage of a protein rich fluid containing approximately two thirds as much proteins as plasma
- Burn patients do not feed well because of pain, generalized discomfort and depression
- Many are anorexic and unable to consume a sufficient amount of kilocalories to satisfy energy requirements
- Large amounts of waste products (such as nitrogen and potassium) must be excreted by the kidney- fluids are required to keep these in solutions
- Curling ulcer or acute ulceration of the stomach or duodenum is frequently observed in burn patients-large amount of vitamin A can reduce incidence of stress ulcer.

Aims of Nutritional Management

- Achieving and maintaining optimum body weight
- Replacement of fluids and electrolytes to maintain circulatory volume and prevent renal failure
- Promote wound healing
- Prevent infection and rapid or severe weight loss
- Attain normal hydration status and electrolyte balance

Dietary Management

For burn patients a high protein high calorie diet is vital for faster recovery. In adults and children TBSA of more than 10%, protein should comprise 20% of the total caloric requirement. TBSA 1% to 10%, protein should provide 15% of the total caloric requirements. For children younger than 1 year of age, a conservative recommendation of 3g to 4g protein /kg can be given because of infant's inability to tolerate high renal solute loads. Excessive high protein intake could result in azotemia, Hyperammonaemia, or acidosis. The energy and protein needs of both adult and children burn patients is determined using the Curreri formula (1979).

Adults

Energy Needs: Daily calorie requirements = [24kcal x kg usual body weight] + [40 kcal x TBSA {% burn}]

Where: TBSA stands for the total % burn

Protein Needs: Daily protein requirement = [1g x body weight] + [3g x TBSA].

Children

Daily calorie requirement

= [60kcal x kg usual body weight] + [35kcal x TBSA]

Daily protein requirement

= [3g x Kg. Usual Body weight] + [1g x TBSA]

Nutrient Delivery

Nutrient could be delivered either through oral, enteral, or parenteral routes

Enteral

Continuous enteral feeding with or without oral intake is indicated for patients who are unable to meet a minimum of 75% Kcal and protein requirements via oral diets; for nocturnal tube feeding; for patients on ventilation and those with adequate bowel function.

Pediatric patients; For pediatric patients starting hourly feed should be 1ml to 2ml kg/day and the volume should be increased gradually to 5ml to 15ml every 8, 12, or 24 hrs depending on the patient's tolerance.

Adult patients; For adult patients start with 10ml to 40ml per hour depending on patient tolerance. Then increase volume gradually with 20ml to 25ml every 8, 12 or 24 hours depending on patient tolerance. Free water requirements can be met by intermittent prescribed water flushes.

NB: Check residual gastric volume every 4 hours when gastric feedings are given. If the residual is more than 1.5times the hourly rate, the enterable feeding should be stopped and parenteral feeding initiated.

Parenteral

Parenteral nutrition should be administered when the gastrointestinal function is not functional. It should be tailored to the nutrient recommendations.

Adult patients; For adult patients administer hypertonic solutions by infusion pump at 40ml/hr at the beginning. Then increase the rate by 20ml to 40ml every 8 to 12hrs as tolerated until energy, protein and fluid requirements are attained

Pediatric Patients; For pediatric patients, initiate infusion of dextrose at a concentration of 10% and advance this as tolerated to a maximum of 20% dextrose concentration. Alternatively infuse 20% dextrose at a rate of one half of maintenance fluid for 12 hours and then advance to full maintenance fluids as tolerated

Note: For patients on tube feeding and/or parenteral nutrition in non intensive care carefully monitor the following parameters daily: intake and output, urine sugar/acetone, blood glucose and consistency of bowel movements. For those patients in intensive care receiving parenteral feeds, tube feeding or both, the following parameters should be monitored closely on daily basis: sodium, potassium, BUN, creatinine, blood glucose, Hb, hematocrit, intake and output, urine sugar/acetone and consistency of bowel movement.

Surgery; nutrition implications of surgery, pre-surgery nutrition, post surgery nutrition, nutrition support in various surgical conditions, rehabilitation post surgery

Surgery

Surgery like any other injury to the body elicits a series of reactions including release of stress hormones and inflammatory mediators i.e. cytokines. This release of mediators to the circulation has a major impact on body metabolism. They cause catabolism of glycogen, fat and proteins with release of glucose free fatty acids and amino acids into the circulation so that substrate are diverted from their normal purposes e.g. physical activities to the task of healing and immune response. For optimal rehabilitation and wound healing the body needs to be in anabolic state. Measures to reduce stress of surgery can minimize catabolism and support anabolism throughout surgical treatment and allow patients to recover substantially better and faster even after major surgical operation.

Goal of nutritional management

To enhance recovery of patients after surgery

Objectives

- To avoid long periods of pre operative fasting
- To re establish oral feeding as early as possible after surgery
- To integrate nutrition into overall managements of patients
- To control metabolic processes

Preoperative nutrition care

- Encourage patients who do not meet their energy needs from normal foods to take oral nutrition supplements during the preoperative periods
- Administer preoperative enteral nutrition preferably before admission to the hospital
- Ensure the stomach is empty. It is important to empty the stomach at the time of operation to avoid the danger of aspiration during the induction of anesthesia or upon awakening
- Use a chemically defined or elemental liquid diet with minimal residue pre-operatively for patients with nutritional risks
- Patients who are scheduled to undergo surgery and who are considered to have no specific risk for aspiration may drink clear fluids until 2 hrs before anesthesia. Solids foods are allowed until 6 hrs before anesthesia.
- For elective cases, no food is allowed by mouth (nil by mouth) for at least six hours before surgery
- Low fiber foods should be administered orally, a liquid diet for 2 – 3 days preceding surgery

Postoperative nutrition care

The aim of postoperative nutrition care is to reduce nutritional deficiencies that ordinarily develop in untreated patients during the period of post operation. Note;

- Length of nil by mouth after surgery may be influenced by the patients pre-existing nutritional status, severity of operative stress and the nature and severity of the illness
- If the period of post operative starvation is expected to be longer than one week, parenteral nutrition support maybe beneficial even for a mildly malnourished individual
- Introduction of solid foods depends on condition of the GI tract, oral feeding is often delayed for the first 24 – 48hrs following surgery to await the return of the bowel sounds or passage of flatus
- Initiate normal food intake or enteral feeding earlier after gastro intestinal surgery
- Oral intake including clear liquids can be initiated within hours after surgery to most patients undergoing colon resections
- Oral intake should be adopted to individual tolerance and to the type of surgery carried out
- Apply tube feeding in patients whom early oral nutrition cannot be initiated with special regard to those undergoing major head and neck or gastrointestinal surgery for cancer.

Severe trauma

For patients with obvious under-nutrition at the time of surgery and for whom oral intake will be inadequate (<60%) for more than 10 days;

- Initiate tube feeding for patients in need within 24 hours after surgery

- Start tube feeding with a low flow rate (e.g. 10ml/hr to maximum of 20ml/hr) due to limited intestinal tolerance
- It may take 5-7 days to reach the target intake and this is not considered harmful
- Reassess nutritional status regularly during the stay in the hospital and if necessary continue nutritional support after discharge in patients who have received nutritional support preoperatively
- Progress over a period of several meals from clear liquids, and finally to solid foods.

CASE STUDY

Betty is a 5 year old girl who really loves playing. One evening, when she was playing with her brother, Betty's clothes caught fire. Before she could be rescued, she had already sustained 42% burns and mostly at 2^{nd} degree. At the time of the accident, Betty weighed 17kg.

a. Calculate the amount of energy required for Betty's diet

b. Calculate the protein requirements for Betty

c. Explain why Betty's protein intake should be increased

17.3.7.3 Self-Assessment

1. Define the following terms;

   A. Trauma　　B. Burn　　C. Surgery

2. Continuous enteral feeding with or without oral intake is indicated for burn patients who

   A. Have >20% tbsa

   B. Are unable to meet a minimum of 75% kcal and protein requirements via oral diets

   C. Cannot tolerate parenteral nutrition

   D. Has normal hydration status

3. Indicate whether the following statements about postoperative nutrition care are **true** or **false**

   A. Chemically defined or elemental liquid diet with minimal residue pre-operatively for patients with nutritional risks should be used

   B. Patients who are scheduled to undergo surgery and who are considered to have no specific risk for aspiration

   C. For elective cases, no food is allowed by mouth (nil by mouth) for at least one hour before surgery

   D. Patients who do not meet their energy needs from normal foods should be put on parenteral nutrition

4. Design a preoperative nutrition care plan for a surgery patient.

5. Explain the special concerns for burn patients regarding their nutrition status.
6. Discuss how you would handle surgical patients with under-nutrition and for whom oral intake will be inadequate.
7. Identify the implications of burns on the patients.

17.3.7.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Stationery
- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

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17.3.8 Learning outcome 7: Demonstrate understanding of palliative and hospice care

17.3.8.1 Learning Activities

Learning activity	Special instructions
i) Identify and describe terminologies in palliative and hospice care	➢ Define the various terms in palliative and hospice care ○ Hospice ○ Hospice care ○ Nutrition support
ii) Identify and describe nutrition support during palliative and hospice care as per resource materials, policies and guidelines	➢ Provide nutrition support for the palliative and hospice patients

17.3.8.2 Information Sheet

Definitions

Hospice: a special concept of care designed to provide comfort and support to patients and their families when a life-limiting illness no longer responds to cure-oriented treatments

Palliative care: specialized medical care focused on identifying and relieving the pain and other symptoms of a serious illness.

Nutrition support: refers to enteral or parenteral provision of calories, protein, electrolytes, vitamins, minerals, trace elements, and fluids.

Hospice

The hospice team collectively focuses on the care of the patient with a unique focus on his or her individual wishes. At the moment, hospice care includes;

- Physical care
- Psychosocial care
- Spiritual care
- Emotional care

Palliative care

The goal of palliative care is to improve quality of life for such patients at any stage of illness regardless of current treatment plans, and it is tailored to the needs of the patient and the family.

This kind of care focuses more on the quality of life rather than curing disease. When a cure or control is not possible and death is likely, palliative care (comfort measures) is offered.

The goals are to relieve pain and physical symptoms; alleviate isolation, anxiety and fear; and help those with cancer maintain independence as long as possible. Patients may be eligible for hospice care, either in an inpatient unit or at home. Hydration needs are usually met, and pain control is attempted. Patients are made as comfortable as possible in the dying process. Generally with palliative care, nutrition support is not initiated.

Nutrition support during palliative and hospice care.

Nutrition support aims at meeting nutrient needs of the patient during palliative care hence improving their quality of life. Acute critical illness is usually characterized by catabolism exceeding anabolism leading to excess weight loss. However, with better management of underlying conditions and pain, calorie consumption can be reduced significantly.

A major barrier to providing nutrition support for patient's on palliative care is stigma experienced by these patients. Many people have misconception that end of life care is too expensive. Since the purpose of palliative care is to allow patients to die with dignity and minimal suffering while maintaining control and support for families, nutrition support should also be included to complete care.

Palliative care encourages the alleviation of physical symptoms, anxiety, and fear while attempting to maintain the patient's ability to function independently. Hospice home care programs allow the patient to stay at home and delay or avoid hospital admission. Quality of life is the critical component. A dietitian's intervention may benefit the patient and family as they adjust to issues related to the approaching death. Families who might be accustomed to a modified diet should be reassured if they are uncomfortable about easing dietary restrictions. Ongoing communication and explanations to the family are important and helpful.

Barriers to providing nutrition support

- Misconception that nutrition support for the terminally ill is not beneficial
- Lack of clinical benefit to palliative care patients
- Nutrition support may cause complications that may add to the burden of patient.

Benefits of nutrition support for terminally ill

- Reduces physical deterioration
- Improves quality of life for the terminally ill
- Prevents emotional effects of a feeling like one is starving the patient to death
- Improves nutrient intake and fluid status.

Home enteral nutrition

Enteral nutrition may be done at home. Orders that specify protocols for administration and monitoring will be written by a provider or dietitian. Most protocols require the prescriber to indicate the formula for feeding, strength, how quickly to feed, and delivery method. Delivery methods include the following: gravity controlled and pump assisted.

Gravity controlled feeding refers to any feeding method that uses manually controlled devices to deliver a feeding which is almost always a gastric feeding. This may include a continuous gravity feeding that is manually controlled with a feeding bag and a roller clamp to help control the rate; and intermittent gravity feeding where 200-300 mL are delivered over 30-60 minutes every 4-6 hours; and, a bolus feeding where a specific volume of feeding is infusing via bag or a syringe rapidly over several minutes, usually at a rate of about 60 mL/minute.

Pump assisted feeding utilizes an electric pump device to more precisely control the rate of delivery in patients who are at a higher risk of inadvertently getting formula in their lungs, sensitive to volume, have delayed gastric emptying or are being fed into the small intestine.

Choice of the delivery methods for a particular person depends on the type of enteral access device as well as the person's individual needs. Water flushes should be administered to prevent clogging and ensure adequate hydration.

Feeding tubes should be flushed with water before and after medication delivery and before and after every feeding or every 4 hours during continuous feeding.

Often a dietitian, nurse or home care company will teach the patient how to prepare, administer, and monitor tube feeds. In addition, a home care company may be available to explain the supply options available and help to arrange for home supplies and equipment.

17.3.8.3 Self-Assessment

1. Define the following terms;
   A. Nutrition support
   B. Palliative care
   C. Hospice care
2. The goal of palliative care is ____________
   A. To improve quality of life for such patients at any stage of illness regardless of current treatment plans
   B. To assure a good prognosis for the patients on palliative care
   C. To eliminate pain entirely
   D. To treat and cure the disease
3. Gravity feeding includes the following except?
   A. Continuous gravity feeding
   B. Intermittent gravity feeding
   C. Oral feeding
   D. Bolus feeding
4. Identify the challenges associated with implementation of nutrition support for the terminally ill.
5. Describe home enteral nutrition support of the palliative care.
6. How would a palliative care patient benefit from nutrition support?

17.3.8.4 Tools, Equipment, Supplies and Materials

- Food pump
- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre
- Feeding bag and roller clamp

17.3.8.5 References

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17.3.9 Learning outcome 8: Demonstrate understanding in nutrient drug interactions

17.3.9.1 Learning Activities

Learning activity	Special instructions
i) Identify and describe terminologies in nutrient drug interactions	➢ Define the terms; o Pharmacodynamics o Pharmacokinetics o Pharmacogenomics o Food drug interaction
ii) Identify and describe specific drug nutrient interactions with nutrition implications	➢ Demonstrate understanding pharmacokinetics and pharmacodynamics ➢ Demonstrate ability to prevent adverse effects of nutrient-drug interactions ➢ Demonstrate the ability to advice on drug nutrient interaction

17.3.9.2 Information Sheet

Meaning of terms in nutrient drug interactions

- o **Pharmacodynamics:** the study of the physiologic and biochemical effects of a drug or combination of drugs
- o **Pharmacogenomics** the study of genetically determined variations that are revealed solely by the effects of drugs in the body
- o **Pharmacokinetics** the movement of a drug through the body by absorption, distribution, metabolism, and excretion
- o **Food-drug interaction** a broad term that includes drug-nutrient interactions and the effect of a medication on nutritional status
- o **Absorption** the process of movement of a drug from the site of administration into the systemic circulation
- o **Drug-nutrient interaction** the result of the action between a drug and a nutrient that would not happen with the nutrient or the drug alone.

DRUG-NUTRIENT INTERACTIONS

A nutrient-drug interaction may impact the body in several ways. Certain foods can affect the rate at which the body uses a medication. A drug will not work as well if a certain nutrient in a food speeds up or slows down its absorption.

Drugs and nutrition

Drugs taken either on prescription or as self- medication can directly or indirectly affect the nutrition status of the patient. On the other hand, food constituents can influence the action of a drug. The result of the two- way interaction may bring about malnutrition or compromised performance of the drug. The negative impact of such an interaction may be aggravated by pathophysiological state of the victim.

The effect of drug - food interaction are physical, nerve or chemical mediated and involve various mechanisms as outlined below.

<u>Effects of drug to nutrition</u>

Alteration or inhibition of taste and oduor perception

Penicillin- based antibiotics, metronidazole (amoebecide), allopurinol (antigout), chloroquine (antimalarial) and many others produce bitter or varying degrees of bad taste in the mouth.

Potassium iodide and other halogen containing salts cause unpleasant after taste that make feeding undesirable

Inhibition or excessive stimulation of secretions

Atropine drugs like (hyoscine spasmolytic) inhibits secretion in the gastrointestinal tract (GIT). This interferes with food lubrication and digestion. Aspirin (antipyretic analgesic) lowers gut PH steeply and causes physical corrosion of the mucosa. The victim suffers severe epigastric irritation and depressed appetite.

Function of a drug

A drug is taken to prevent or treat sickness and disease. It is important to know what happens in the body when a drug is taken in order to better understand the interaction between nutrients and drugs. The action of a drug taken orally generally occurs in four steps: (1) the drug dissolves in the stomach, (2) the drug is absorbed into the blood and moves via the blood to the area of the body that needs it, (3) the body reacts to the medicine, and (4) the body gets rid of the drug by way of detoxifying it either in the kidney, liver, or both.

Adverse effects of nutrient-drug interactions

Some drugs may affect the absorption of nutrients, while some foods—for example, those containing caffeine—can amplify or modify the effects of certain drugs. Taking drugs with hot beverages could also make them less effective. Short- or long-term instances of nutrient-drug interactions may be life threatening. A nutrient-drug interaction may also impact the nutritional status of the body. Nutrient-drug interactions can occur with both prescription and over-the-counter medicine.

Impact of food on effectiveness of a drug

Medication has ingredients, just as food does, that allow it to function correctly when taken in order to help the body in some way. A food may interfere with the effectiveness of a drug if the food interacts with the ingredients in the medication, preventing the drug from working properly. Either nutrients in food may delay absorption into the body or speed up elimination from the body, either or which can impact a drug's effectiveness. For example, the acidic ingredients in fruit juices are capable of decreasing the power of antibiotics such as penicillin. Tetracycline, another infection-fighting drug, is impacted by the consumption of dairy products. Many medications that are taken to fight depression can be dangerous if mixed with beverages or foods that consist of tyramine, which is found in items such as beer, red wine, and some cheeses.

Food can also impact the effectiveness of a drug due to the way it is consumed. Generally, medicine is to be taken at the same time food is eaten. This is because the medicine may upset the stomach if the stomach is empty. However, sometimes taking a drug at the same time that food is eaten can interfere with the way the medicine is absorbed by the body.

Impact of drug-nutrient interaction on nutritional status

A drug has the capacity of interfering with a person's nutritional status. Appetite may be stimulated by a certain drug, resulting in an increase in nutrient intake due to more food being eaten. However, drugs may also cause a decrease in appetite, leading to a decrease in nutrient intake. In this case, a drug could possibly cause a nutritional deficiency. Nutritional status may also be impacted by a drug's effect on the three main nutrients: carbohydrates, fat, and protein. A drug may speed up or slow down the breakdown of these three nutrients, which are essential to the body's functioning. When a drug affects the absorption of nutrients from food into the body, less energy is available to be used by the body. The impact of the nutrient-drug interaction may vary according to the medicine taken, the dose of the medicine given, and the form taken (e.g., pill, liquid).

The elderly and nutrient-drug interactions

Elderly persons are at a significant risk for nutrient-drug interactions. This population often takes the highest amount of medications, and with the use of multiple drugs, certain problems may exist. A loss of appetite, a reduced sense of taste and smell, and swallowing problems all may result from medication use in elderly people.

Malnutrition is a common problem among older adults. Therefore, nutritional status may be already impacted by decreased nutrient intake. This may only worsen the effect of a possible nutrient-drug interaction. Elderly people who take many drugs on a routine basis for long periods are at greatest risk of nutrient depletion and nutritional deficiencies.

A nutrient-drug interaction may impact the body in several ways. Certain foods can affect the rate at which the body uses a medication. A drug will not work as well if a certain nutrient in a food speeds up or slows down its utilization.

Drug and food intake

- Some drugs alter the appetite especially amphetamines reducing nutrient intake
- Methotrexate drugs interferes with taste or smell and may cause mouth sores and inflammation
- Digitalis can induce nausea and vomiting hence leading to nutrient loss
- Phenobarbital can cause dry mouth
- Cyclophosphamide induces mucosal ulcers

Drugs and nutrient absorption

- Antacids can interfere with iron absorption by changing the acidity of the digestive tract
- Climetidine can improve fat absorption by altering digestive juices
- Laxatives speed motility of the digestive tract causing malabsorption of many nutrients
- Neomycin may reduce lipase activity hence interfering with fat digestion
- Chemotherapy drugs can damage mucosal cells thereby affecting nutrient absorption
- Some antacids bind phosphorus hence hindering its' absorption.

Drugs and nutrients interaction

- Acting as structural analogs e.g. anticoagulants and vitamin K
- Competing with each other for metabolic enzyme systems e.g. phenobarbitol and folate
- Altering enzyme activity and contributing pharmacological active substance e.g. monoamine oxidase inhibitors and tyramine.

Drugs and nutrient excretion

- Some diuretics increase the excretion of sodium and potassium
- Aspirin displaces folate from its' plasma protein carrier hence affecting its' excretion
- Some drugs inhibit of stimulate excessive secretions
- Atropine drugs (e.g. hyoscine spasmolytic) inhibit secretions in the gastrointestinal tract. Interfering with food lubrication and digestion
- Aspirin (antipyretic analgesic) lowers the gut PH steeply and causes physical corrosion of the mucosal lining. Patients with ulcers should not use aspirin.

Alteration of nutrient biotransformation and bioavailability

- Tetracycline inhibit protein synthesis while chloramphenicol (antibiotic) and amphotericin B antifungal) are potent catabolic agents

- Insulin (ant diabetic) and certain anabolic steroids promote protein synthesis
- Carbohydrates biotransformation is interfered with by glucagon which demolishes glycogen reserves in the liver
- Sulphonamides (anti-infective) produce hypoglycemia as a side effect by enhancing insulin production
- Chlorpromazine (antipsychotic) promotes lipid synthesis while carbamazepine (anticonvulsant) stimulates its' breakdown
- Fat soluble vitamins are mopped up by drugs formulated with mineral oils and are rendered unavailable for beneficial biotransformation.

Chemical reactions

- Minerals in dairy products (calcium, magnesium, iron) combine with tetracycline to form insoluble complexes of no nutritional value. Tetracycline causes severe nausea and vomiting that makes food repulsive
- Aluminum-containing antacids bind phosphates from the body thus reducing ATP energy reserves. The client becomes weak and disoriented.

Effects of food on drugs

- Pyridoxine in food blocks the effects of levodopa used in the treatment of parkinsonism
- Foods rich in dopamine (cheese, chicken, liver, red wine, bread, beans etc) cause hypertensive crisis and life threatening cerebrovascular accidents when taken alongside certain antidepressants ; procarbazine and isoniazid
- Alcohol when taken with metronidazole, chloramphenicol or nitrofurantoin cause disulfiran reactions
- Alcohol produces prolonged hypoglycemic effects when taken with insulin and oral hypoglycemic agents
- Some foods e.g. candy can change the acidity of the gastrointestinal tract thereby causing the slow acting asthma medication to dissolve too quickly
- Foods that stimulate secretion of digestive juices increases absorption of some drugs e.g. griseofulvin
- Aspirin is absorbed more slowly when taken with food
- Vitamin C can alter urinary PH and limit the excretion of aspirin.

Avoiding drug-nutrient interactions

Drug-food interactions which are a potential threat to good nutrition should be avoided at all costs, unless the benefit expected outweighs the potential risk. Ensure the following;

- Take drugs at correct dose and frequency to reduce the severity of the side effects
- Take a gut-irritating drug with or after meals to reduce the chances of discomfort
- Drug administration and meal times may be staggered to avoid unintended interactions

- A drug likely to interact unfavorably with food may be given parenterally
- A drug causing epigastric pain may be given likewise or rectally or as a necessary
- Taking syrup or a liquid drug may prevent prolonged stay of the drug in the gastrointestinal tract hence reducing chances of interaction with food
- If taking phenelzine drug (antidepressant) abstain from eating liver.

Benefits of minimizing drug interactions

- Medications achieve their intended effects.
- Patients do not discontinue their drug.
- The need for additional medication is minimized.
- Fewer caloric or nutrient supplements are required.
- Adverse side effects are avoided.
- Optimal nutritional status is preserved.
- Accidents and injuries are avoided.
- Disease complications are minimized.
- The cost of health care services is reduced.
- There is less professional liability.
- Licensing agency requirements are met

The table below shows common drug nutrient interactions:

Common drug nutrient interactions

Therapeutic Class	Drug	Nutrient Interaction
Alcohols	Ethanol	Reduced absorption of fat, retinol, thiamin, cobalamin and folate; impaired utilization and storage of retinol; increased urinary excretion of zinc and magnesium.
Analgesics	Aspirin	Increased urinary excretion of ascorbic acid; may cause GI bleeding and subsequent iron deficiency; increased folate and vitamin D requirements.
Antacids	Al or Ca containing	Reduced iron, copper, phosphate and magnesium absorption.
Antibiotics	Penicillin's Amino glycosides Chloramphenicol	Increased urinary excretion of amino acids; reduced intestinal vitamin K and cobalamin synthesis; possible malabsorption of fat, cobalamin, calcium, magnesium and carotenoids.
Anticoagulants	Coumadin	Vitamin K decreases & tocopherol increases drug effect.

Anticonvulsants	Phenobarbital Phenytoin	Folate antagonists; Increased vitamin D, vitamin K and pyridoxine requirements; Impaired vitamin D metabolism leading to hypomagnesaemia, hypocalcemia and hypophosphatemia.
Antidepressants	Imipramine	May induce riboflavin deficiency; increased appetite.
Antihypertensive	Hydralazine	Pyridoxine antagonist; increased urinary excretion of manganese and pyridoxine.
Antimalarials	Pyrimethamine Sulfadoxine	Folate antagonists.
Antineoplastics	Methotrexate	Folate antagonist; may impair fat, calcium, cobalamin, lactose, folate and carotene absorption.
Antitubercular	Isoniazid	Accelerated metabolism of pyridoxine - subsequent pyridoxine deficiency blocks conversion of tryptophan to niacin leading to niacin deficiency; reduced calcium absorption; reduced conversion of Vitamin D by the liver.
Antiulcer	Cimetidine	Impaired cobalamin absorption.
Cardiac Glycosides	Digoxin Hydrocortisone Prednisone Dexamethasone	Increased urinary excretion of calcium, magnesium and zinc, Anorexia. Reduced calcium and phosphate absorption; increased urinary calcium, potassium, ascorbic acid, and zinc and nitrogen excretion. Increased pyridoxine and vitamin D metabolic requirements.
Diuretics	Furosemide Thiazides Spironolactone	Increased urinary potassium, sodium, and chloride, magnesium, zinc and iodine excretion; reduced calcium excretion leading to hypercalcemia and hypophosphatemia with Thiazides, increased calcium excretion with furosemide. Increased urinary sodium and chloride; reduced urinary potassium excretion.
Hypocholesterolemic Agents	Cholestyramine Colestipol	Reduced absorption of fat, fat soluble vitamins, calcium, cobalamin, and folate.
Laxatives	Bisacodyl Phenolthalein Mineral Oil	Abuse leads to general malabsorption, steatorrhea and dehydration. Malabsorption of fat soluble vitamins, electrolytes, calcium.
Oral Contraceptives	Conjugated estrogens Ethinyl estradiol Mestranol	Increased folic acid & possibly pyridoxine & ascorbic acid requirements; reduced calcium excretion, altered tryptophan metabolism.
Stimulants	Caffeine	Increased urinary calcium excretion.

ANTIRETROVIRAL DRUGS AND FOOD RECOMMENDATIONS

To reduce unfavorable food –drug interactions special food recommendations are given for various ARV drugs, as shown in the table below;

ARV Drugs and Food Interactions

Drug	Food recommendation
Efavirenz	Can be taken without regard to meals Avoid high fat meals and alcohol and st john's wort
Nevirapine	Can be taken without regard to meals. avoid st john's wort
Lamivudine	Can be taken without regard to meals. Avoid alcohol
Stavudine	Can be taken without regard to meals. Avoid alcohol
Zidovudine	• Take without food • If it causes nausea and vomiting take with low fat meal • May require Zinc and copper supplementation • Avoid alcohol
Abacavir	Can be taken without regard to meals. Avoid alcohol
Didanosine	• Take on an empty stomach (30 minutes before or 2 hours after eating) • Take with water only (food reduces its' absorption) • Avoid alcohol, Grape fruit juice, Antacids containing aluminum or magnesium
Tenofovir	Take with a meal. Avoid alcohol
Indinavir	• Take on an empty stomach (1 hour before or two hours after a meal or with a light non-fat meal • Take with plenty of water to avoid kidney problems-at least 1.5 liters of fluids daily to prevent kidney stones • Avoid grape fruits and st john's wort
Lopinavir	• Take with food • Should be taken with a moderate fat meal for better absorption • Avoid john's wort
Nelfinavir	• Take with food • High fat food preferred for better absorption • Avoid john's wort
Saquinavir	• Take with a meal or light snack • Take within 2 hours of a high fat meal • Avoid john's wort garlic and supplements

• Sulfonamides, • Sulfamethoxazole, • Cotrimoxazole, antibiotics for treating/prophylaxis for pneumonia and toxoplasmosis.	• Take with food • Take on an empty stomach, one hour before or two hours after meals • Avoid alcohol
Isoniazid	• One hour before or two hours after meals • Supplement with 50mg pyridoxine in all TB/HIV pts (to prevent peripheral neuropathy and anaemia)

17.3.9.3 Self-Assessment

1. Define the following terms
    A. Food-drug interaction
    B. Drug-nutrient interaction
    C. Pharmacokinetics
2. Antidiabetics________________
    A. Inhibit protein synthesis
    B. Are potent catabolic agents
    C. Promote protein synthesis
    D. Boost the appetite
3. Analgesics affect nutrients in the following ways except
    A. Increased urinary excretion of amino acids
    B. Increased urinary excretion of ascorbic acid
    C. may cause GI bleeding and subsequent iron deficiency
    D. Increased folate and vitamin D requirements.
4. Stavudine should be_____
    A. Accompanied with zinc and copper supplementation
    B. Taken with water only
    C. Taken on an empty stomach
    D. Taken without regard to meals
4. Discuss the impact of food on effectiveness of a drug.
5. Describe the impact of drugs in food intake.
6. Using relevant examples discuss how drugs influence nutrient excretion.

7. What are some of the effects of food on drugs?
8. Outline the benefits of minimizing drug interactions .

17.3.9.4 Tools, Equipment, Supplies and Materials

- Stationery
- Reference materials
- Clinical guidelines
- WHO guidelines
- MOH policies and guidelines
- Ministry of Education
- Skills lab
- Projectors, video clips, charts and other teaching aids
- Food exchange lists
- Food guide pyramid
- Invitation of competent expertise
- Computers with internet
- Library and resource centre

17.3.9.5 References

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CHAPTER1 8:

CONDUCT NUTRITION ASSESSMENT AND SURVEILLANCE

18.1 Introduction of the Unit of Learning / Unit of Competency

This unit specifies the competencies required to examine client nutrition status. It includes carrying out anthropometric assessments, analyzing biochemical lab results, conducting clinical and physical assessments, conducting dietary assessment, carrying out socio economic evaluation and conducting functionality assessment.

18.2 Performance Standard

By the end of this unit of learning/competence, the trainee should be able to identify and conduct anthropometric assessment using the appropriate tools and equipment as per the SOPs and user needs; interpret biochemical assessment results while considering sensitivity and specificity based on biological variation knowledge and WHO guidelines; conduct clinical examination and assess risks as per organizational procedures; conduct dietary survey based on resource materials and workplace procedures; Conduct nutrition surveillance in line with resource materials, WHO guidelines and organizational procedures

18.3 Learning Outcomes

18.3.1 List of learning Outcomes

i. Carry out anthropometric assessments

ii. Analyze biochemical laboratory results

iii. Conduct clinical and physical assessments

iv. Conduct dietary assessment

v. Conduct nutrition surveillance

18.3.2 Learning Outcome 1: Carry out anthropometric assessments

18.3.2.1 *Learning Activities*

Learning Activity	Specific instructions
Determine anthropometric measurement Determine the anthropometric measurements to collect considering age, client's medical condition & gender.	Identify the client in need of nutritional assessment Create rapport with the client Consider the setting of the nutrition assessment Determine prior medical history of the client Observe and maintain confidentiality
Determine anthropometric method Adults: Take weight, height, waist/Hip circumference, skinfold thickness and Mid Upper Arm circumference (MUAC), body fat composition and distribution and bone densities Paediatrics/children: Take weight, height, head circumference, Z-scores, MUAC	Observe client's privacy Observe anthropometric measurement procedures
Identify anthropometric tools based on the anthropometric measurement method(s) selected	Select tools which are calibrated Verify the functionality of the anthropometric measurement tool
Evaluate anthropometric measurements	Determine nutritional indices Compare the anthropometric results with the reference standards

18.3.2.2 *Information Sheet*

Definitions

Anthropometric measurements: This refers to a set of non-invasive, quantitive techniques for determining an individual's body composition by measuring, recording, and analyzing specific dimensions of the body.

Weight: is how heavy a person is, measured in units such as kilograms or pounds

Height: measurement of a client from head to toe

Client: any individual whether child or adult that is under any form of nutritional management

Body Mass Index: a person's weight in kilograms divided by his/her weight in meter squared.

MUAC: the circumference of the left upper arm measured at the mid-point between the tip of the shoulder and the tip of the elbow

BIA: Bioelectric impedance analysis is a method used to estimate body compartments through a mechanism of resistance and reactance. The compartments measured include body cell mass, fat mass, extracellular tissues and fat-free mass

Nutrition assessment is the process by which the nutritional status of an individual is determined. It usually includes dietary history and intake data, biochemical data, clinical examination and health history, anthropometric data, psychosocial data.

Purpose

To obtain adequate information in order to:

Identify nutrition-related problems, make nutrition diagnoses and take appropriate action

Evaluate patient/client/group's knowledge, readiness to learn, and potential for changing.

Identify deviation from normal within a given population, e.g a proportion of children with severe malnutrition greater than 4% is an indication of an emergency (sphere standards).

Types of anthropometric measurements

- Measurements that assess body size
    - Height
    - Head circumference
    - Weight
- Measurements of circumferences
    - Waist circumference
    - Hip circumference
    - Mid Upper Arm Circumference(MUAC)
- Measurements that assess body composition
    - Measurements of fat mass (Skinfold thickness, MUAC)
    - Measurements of fat-free mass (protein and mineral)
    - Measurement of total body water

Other methods for measuring body composition;

- densitometry- clients are weighed in air and immersed in water; appropriate equations are used to calculate body fat from the difference in weights
- Imaging techniques- use computed tomography or magnetic resonance imaging, to visualize discrete deposits of body fat, especially in visceral region. Dual energy X-ray examination (DEXA) can also be used to predict visceral fat deposits
- Bioelectric Impedance analysis (BIA)- measures the resistace to a small electric current passed through electrodes attached to the hands and feet. The impedance is related to the level of total body water and fat-free mass, which is inversely related to fat mass. This technique is subject to error related to food intake, level of hydration and environmental temperature.
- Dilution techniques- estimation of body water from the concentration of the radioactive isotopes injected into thebody
- Urinary excretion of metabolites-such as creatinine and nitrogen indicates turnover of body protein and is an indicator of the fat-free mass.

For New Born & Young Children	Adults
Weight	Weight (in Kg)
Recumbent length	Height (in cm)
Head Circumference	Mid Upper Arm Circumference (MUAC) (in cm)
Chest Circumference	Waist Circumference (in cm
Mid Upper Arm Circumference (MUAC)	Hip Circumference (in cm)
	Fat fold thickness

Anthropometric procedures

Measuring height

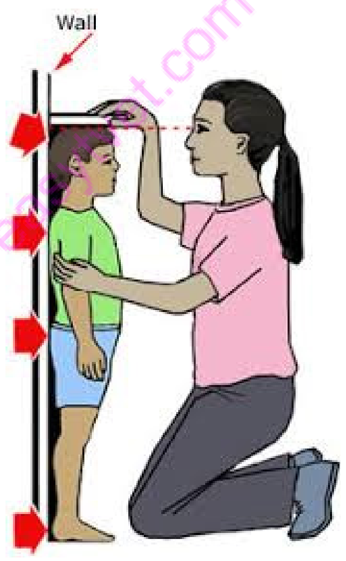
The height of eligible clients is taken to help determine their body mass index (BMI)- which is their weight relative to their height. Being overweight or obese is a significant risk factor for chronic disease.

Equipment

- Height board
- Length measuring board/mat
- Stadiometer

Procedure

- Ask the client to remove their:
    - Footwear (shoes, slippers, sandals etc)
    - Head gear (hat, cap, hair bows, comb, ribbons, etc)- take on light fabric if not possible to remove everything
- Ask the client to stand on the board facing you
- Ask the client to stand with feet together, heels against the back board and knees straight
- Ask the client to look straight ahead and not look up.
- Make sure eyes are the same level as the ears.
- Move the measure arm gently down onto the head of the participant and ask the participant to breathe in and stand tall
- Read the height in centimetres at the exact point
- Ask the client to step away from the measuring board.
- Record the height measurement in centimetres.



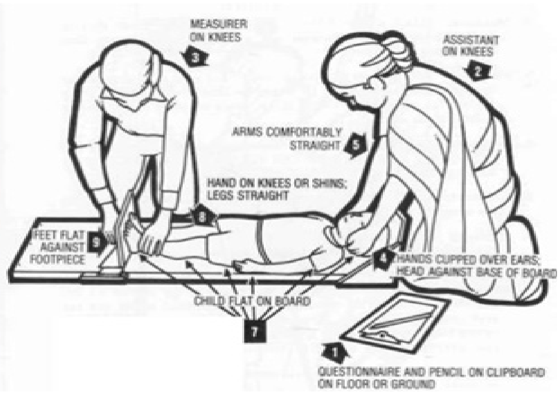
Source: cdc.gov

Measuring length of children <24 months

Recumbent length refers to the distance measured from crown of the head to the bottom of the feet of infant using infantometer while for adults, a vertical measuring rod or anthropometric rod is used. The measuring rod is fixed on a stable, flat, horizontal surface.

- Child is straightened with the dorsal surface in contact with the surface and oriented along the measuring rod.
- Head bar is placed touching the top of the child's head.

- Eye-angle-external ear canal should be vertical.
- The child's knees should be straightened and footboard placed in contact with the feet.
- The reading is taken followed by second reading and the average is then obtained.

Source: https://www.slideshare.net/kirugo/growth-monitoringanthropometric-measurements?from_action=save

Arm span or total arm length

Measurement arm span is useful those situation in which height is difficult to measure. (Children with cerebral palsy, bed-ridden scoliosis or in aging person).

Measuring weight

Weight helps in determination of the body mass index. The health worker is encouraged to ensure the scales are placed on a firm, flat surface.

Equipment

- Electronic weighing scale
- Beam balance
- Spring balance
- Bathroom scales
- Salter spring machine

Procedure

- Ask the client to remove their footwear (shoes, slippers, sandals etc) and socks.
- Ask the client to step onto scale with one foot on each side of the scale.
- Ask the client to stand still, face forward, place arms on the sides and wait until asked to step off
- Record the weight in kilograms on the participant's Instrument (If the participant wants to know his/her weight in pounds, convert by multiplying the measured weight by 2.2).

Source: whattoexpect.com

Taking weight of children

Infants should be weighed on a paediatric balance-beam that is accurate to within 10g. Any cloth used on pan should either be in place when the zero adjustments are made on the scale or its weight should be subtracted from the infant's weight.

Weighed nude or with minimum clothing. Excessive infant movement can make it difficult to obtain an accurate weight, in which case the weighing can be differed until later in the examination.

Taking weight of infants using a hanging scale

Scale is hung onto a stable support such as a tree by the upper hook.

Ensure the dial is at the eye-level.

Weighing parts are hung on the scale and the pointer of the scale adjusted to '0.'

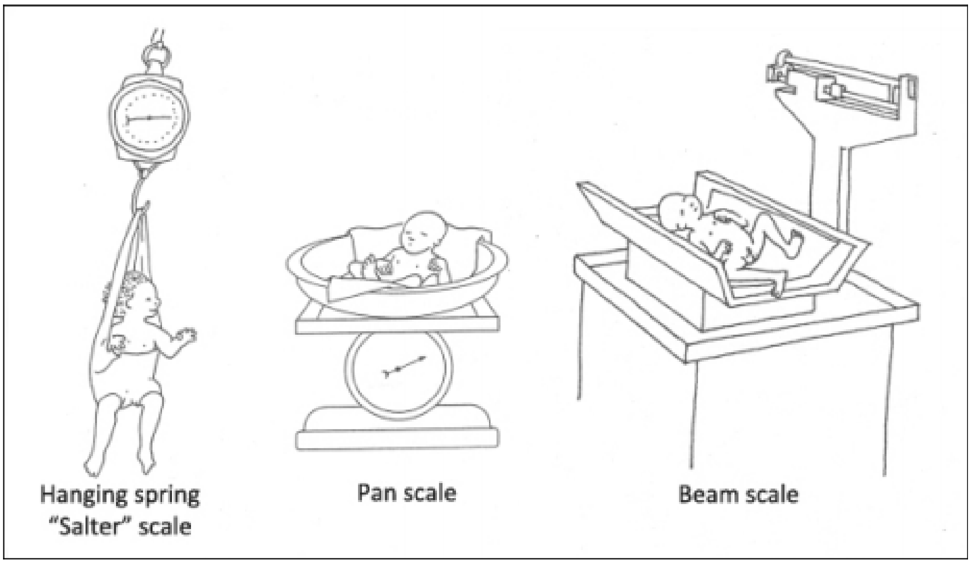
The child is undressed such that (s)he is devoid of heavy clothing.

The child is dressed with the weighing parts.

Straps attached to the scale by the lower hook.

Ensure feet are not in contact with the ground.

Another measurement is taken with the final value obtained by calculating the average.



Source: Ghana Nutrition assessment, counselling and support (NACS): Training Materials for facility-Based Service Providers (Republic of Ghana, 2013)

Body Mass Index (BMI)

The body mass index (BMI) for adult is a proxy measure for human body fat based on an individual's weight and height, and is calculated by dividing one's weight in kilograms by height squared in meters. BMI provides a reliable indicator of body fatness for most people and is an easy to perform and inexpensive method used to screen for weight categorized that may lead to health problems.

The formula is:

The formula is: BMI = Weight (kg)

Height $(m)^2$

Example: An adult weighing 80kg, and with a height of 165(1.65m)

BMI calculation: 80 ÷ (1.65)2 = 29.35Kg/m^2

Classification of body fatness, based on BMI

BMI Range(kg/m^2)	Classification	Risk of Co morbidities
<18.5	Underweight	Low (but risk of other clinical problems)
18.6 – 24.9	Normal range	Average
25 – 29.9	Overweight	Increased
30 – 34.9	Obesity class I	High
35 – 39.9	Obesity class II	Severe
>= 40	Obesity class III (morbid obesity)	Very severe

Source: WHO 2003

From the example above, a person weighing 80kg and with a height of 165cm (1.65m) will have a BMI of 29.38. This individual falls within the pre-obese range for BMI and has a moderate risk for comorbidities.

Measuring waist circumference

Waist circumference (W.C) is used in addition to BMI for a greater prediction of variance in health risk. The larger the waist circumference (high fat deposition), the higher the risk of onset of non-communicable diseases e.g. diabetes and cardiovascular diseases. Waist circumference measurements are also taken to provide additional information on overweight and obesity. It is taken midway between the lower rib margin and the iliac crest, taken at the end of expiration, reflects visceral adiposity, and is sensitive to weight changes. The arms should be relaxed at the sides.

Equipment

- Color coded tape measure
- Pen
- Chair for clients to place their clothes

Privacy

A private area is necessary for this measurement. This could be a separate room, or an area that has been screened off from other people within the household.

Preparing the client

This measurement should be taken without clothing, that is, directly over the skin or over light clothing. It must not be taken over thick or bulky clothing which must be removed.

Procedure

This measurement should be taken without clothing, that is, directly over the skin. If this is not possible, the measurement may be taken over light clothing. It must not be taken over thick or bulky clothing. This type of clothing must be removed.

With a tape measure, find the midpoint and mark the point. This is a tape measure and mark the point.

Apply the tension tape over the marked midpoint and ask the participant to wrap it round themselves.

Ask the client to:

- Stand with their feet together,
- Place their arms at their side with the palms of their hands facing inwards, and

- Breathe out gently.
- Measure waist circumference and read the measurement at the level of the tape to the nearest 0.1 cm.

Source: medicalnewstoday.com

Record the measurement on the client's assessment tool.

Action levels for weight loss, based on waist circumference

Action level	Waist circumference (women)	Waist circumference (men)
Normal	<80cm	<94cm
Level 1- no further weight gain	80-88cm	94-102cm
Level 2- high risk, needs medical advice	>88cm	>102cm

Measuring Hip circumference

Hip circumference is measured at the largest part of the buttocks, with the arms relaxed at the sides. It forms an important component of waist hip ratio (WHR) which can indicate the distribution of body fat between central and peripheral regions. This measurement should be taken without clothing, that is, directly over the skin. If this is not possible, the measurement may be taken over light clothing. It must not be taken over thick or bulky clothing. This type of clothing must be removed.

Equipment

- Color coded measuring tape
- Pen
- Chair for client to place their clothes

Privacy

A private area is necessary for this measurement. This could be a separate room, or an area that has been screened off from other people within the premises. Hip measurements are taken immediately after waist circumferences.

Procedure

- Stand to the side of the client, and ask them to help place the tape around below their hips.
- Position the measuring tape around the maximum circumference of the buttocks.
- Ask the client to: stand with their feet together; place their arms at their side with the palms of their hands facing inwards, and breathe out gently.
- Check that the tape position is horizontal all around the body.
- Measure waist circumference and read the measurement at the level of the tape to the nearest 0.1 cm.
- Record the measurement

Source: thl.fi

Interpretation of Waist Hip Ratio (WHR)

Waist Hip Ratio (waist circumference divided by the hip circumference)

Is an indicator used to complement the measurement of BMI, to identify individuals at increased risk of obesity-related morbidity due to accumulation of abdominal fat. The larger the waist hip ratio, the higher the risk of onset of non-communicable diseases. The hip circumference measurement should be taken around the widest portion of the buttocks. waist measurement >80% of hip measurement for women and >95% for men indicates central (upper body) obesity and is considered high risk for diabetes & CVS disorders. A WHR below these cut-off levels is considered low risk (See the following Table).

WHO cut-off points for waist hip and risk of metabolic complications

	Men	Women	Risk of metabolic Complications
Waist hip ratio	>0.90	>0.85	Substantially Increased Risk

(Source WHO, 2008)

Mid Upper arm circumference

This is a measure of the circumference at the midpoint of the upper arm, which is used, together with the measurement of subcutaneous body fat (by the skinfold thickness at the mid-triceps), to assess muscle circumference and therefore indicate wasting

Equipment

- MUAC tape

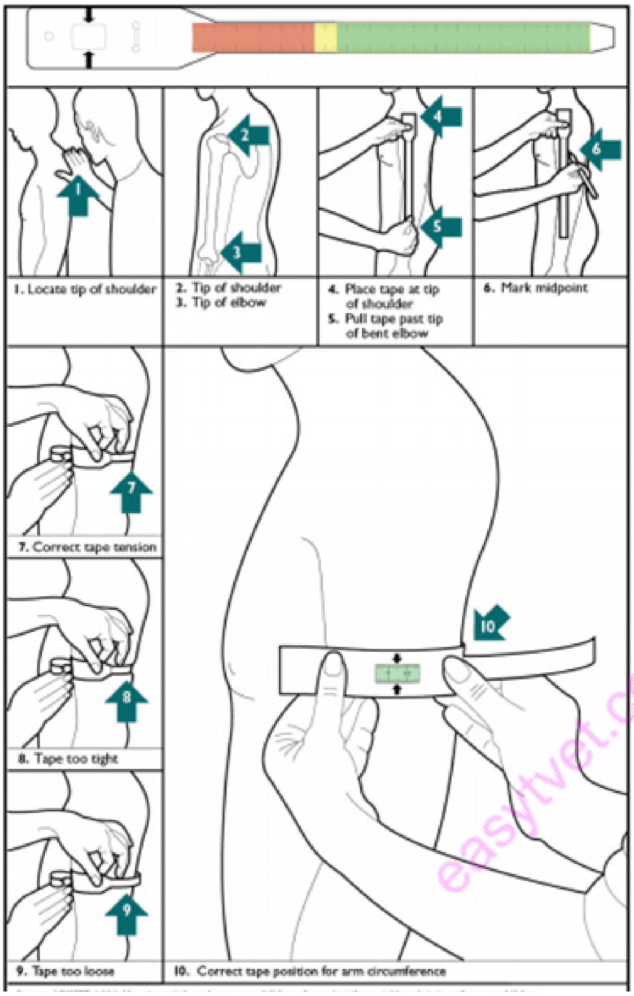
Procedure

- Ask the mother to remove any clothing covering the child's left arm.
- Calculate the midpoint of the child's left upper arm: first locate the tip of the child's shoulder with your fingertips.
- Bend the child's elbow to make the right angle.
- Place the tape at zero, which is indicated by two arrows, on the tip of the shoulder and pull the tape straight down past the tip of the elbow
- Read the number at the tip of the elbow to the nearest centimetre. Divide this number by two to estimate the midpoint.
- Mark the midpoint with a pen on the arm
- Straighten the child's arm and wrap the tape around the arm at the midpoint.

Source: unicef.org

Inspect the tension of the tape on the child's arm. Make sure the tape has the proper tension and is not too tight or too loose

When the tape is in the correct position on the arm with correct tension, read the measurement in the window and record the measurement to the nearest 0.1cm



Source: Ghana Nutrition assessment, counselling and support (NACS): Training Materials for facility-Based Service Providers (Republic of Ghana, 2013)

MUAC cut-offs for SAM, MAM and Normal Clients

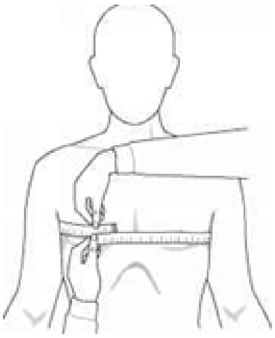
Group	Severe acute malnutrition (SAM)	Moderate acute malnutrition (MAM)	Normal
Children (6-59 months old)	< 11.5 cm	≥ 11.5 to < 12.5 cm	Substantially Increased Risk
Children (5-9 years)	< 13.5 cm	≥ 13.5 to < 14.5 cm	≥ 14.5 cm
Children (10-14 years old)	< 16.0 cm	≥ 16.0 to < 18.5 cm	≥ 18.5 cm
Adolescents (15-17 years old)	< 17.5 cm	≥ 17.5 to < 19.5 cm	≥ 19.5 cm

Pregnant/Post-partum women	< 21.0 cm	≥ 21.0 to < 23.0 cm	≥ 23.0 cm
Adults who are too sick to stand	< 19.0 cm	≥ 19.0 to < 21.0 cm	≥ 21.0 cm

Head circumference

This is a good measure of brain growth especially in the first two years of life.

It is of great value in follow-up of low birth weight infants, and children with Central Nervous System abnormalities like suspected post meningitic hydrocephalus. The charts aren't included in the countries growth monitoring cards. Normal head circumference at birth is 34 – 36 cm. Head circumference should increase by 2cm/month for the first 3 months, then by 1 cm/month from 3 – 6 months, then by 0.5c/month from 6 – 12 months. (12 cm for 1st year of life).



Chest circumference

It is usually measured at the level of nipples, preferably in mid inspiration-Xiphisternum

In children;

≤ 5years - lying down position

> 5 years - standing position

Skin fold thickness

Advantages of Anthropometric method

Relatively unskilled personnel can be trained to take the measurements

Equipments are relatively cheap and can be used over and over

Equipment is portable and durable

Procedures are simple, safe and applicable in large surveys

Measure are objective and accurate provided that standardized techniques and procedures are used

Some techniques can be used for screening to identify individuals at high risk e.g. MUAC

Procedures can identify mild, moderate and severe state of malnutrition

Disadvantages of anthropometric method

It's difficult to identify micronutrient deficiencies

Some nutritional problems are not associated with body parts

Those severely ill might be difficult when using anthropometry

Physically challenged and elderly might pose a problem when doing anthropometry

Might give false positive measurement especially edema due to severe PEM

Sources of error in anthropometry

Faulty equipment which gives inaccurate measurements

Inadequate training

Measurement difficulties

Poor recording

Rectifying errors of anthropometry

Adequate training using standardized and evaluated techniques

Equipment should be accurate in measurements and in good order

Make sure that saunter scale is calibrated at zero to ensure no movement of the pointer.

Indices of nutrition status

An index is calculation derived from combination of anthropometric measurement.

The age specific measurement, sex, height and weight, MUAC can be combined to give a better meaning. Indices are important in making conclusions about specific measurements.

Nutritional indices are developed through comparing the measurement to standard measurements.

The reference data for children has been developed from the children of the same age, weight and height who is assumed to be normal.

Nutrition indices for children

They include;

weight for age W/A general appreciation of nutritional status

combined measurement

NO individual diagnosis but trend assessment

For growth monitoring

height for age H/A measure of linear growth deficit or STUNTING

not sensitive to change

slow progress

Community diagnosis

weight for height/length W/H measure of weight deficit according to

length WASTING

Individual diagnosis

Community diagnosis

Sensitive to change

Weight for height

Weight for height measures wasting or acute malnutrition. It is an expression of the weight of the child as proportion of the expected weight for the standard reference child of the same height and sex.

A low weight for height is characterized by wasting and loss of muscle fat. It is an indicator of thinness and identifies acute malnutrition.

A high weight for height is referred to as obesity.

This is the most useful index in emergencies for screening and targeting vulnerable groups.

It is appropriate for examining short term effects/impact such as seasonal changes in food supply, short term nutritional stress brought about by illness

It is also used in evaluation of supplementation feeding

Also used in monitoring &reporting progress of intervention

Characteristics of weight for height

Wasting is an indicator of thinness

A measure of acute or recent malnutrition like kwashiorkor and Marasmus

It is appropriate to measure the effect of the seasonal food supply or short term nutrition Stress due to illness

It is used to report the progress of intervention programs.

Its short term and easily managed

Provide adequate food treatment of disease helps correct wasting.

Height for age

Height for age is referred to as stunting.

It is an indicator of past under nutrition & chronic malnutrition

It is an expression of the height of the child as proportion of the expressed height of standard reference child of the same height and sex.

It is a measure of chronic malnutrition i.e. long term and persistent malnutrition normally associated with long term factors as poverty and frequent illness.

It is not appropriate for growth monitoring. A stunted child normally has low height for age.

It cannot measure short term malnutrition because skeleton growth is slow.

It is also not useful for monitoring growth of children and impact of nutrition programme such as supplementary feeding

For children below 2 years or children below 85cm we take their length for age. But for those above 2yrs or 85cm we take their height for age.

Weight for age

It is the comparison of Child’s weight to reference weight of a child of the same age and sex.

It measures underweight.

It combines both stunting and wasting and thus a valuable index for use in young children.

It shows the severity of malnutrition.

It is used in monitoring growth of children

Advantages & disadvantages of weight/age

Advantages

It is sensitive to small changes and thus used for growth & monitoring among children

It will reflect both chronic and acute malnutrition.

Limitation

It does not distinguish between adipose tissue or skeletal mass.

It does not indicate whether malnutrition is acute or chronic

It is sensitive to age thus if the age is not well indicated may lead to errors

Cases of edema and ascites may be misleading.

Anthropometric indicators for children

Indicator	Definition	Implication and use
• Birth weight	The weight at which a baby is born	It is an indicator of maternal nutrition and health status, but has implications for the baby's health and survival
Weight	Measured in kg	Mainly affected by acute infection and/or acute food shortage. The child may experience rapid growth after recovery from the infection
Head circumference	Measured around the head	Applicable mainly in the first two years as a measure for brain development
Mid upper arm	Measured on the left arm	MUAC is a measure of adequacy in nutrition. A useful measure for screening acute malnutrition in the community. Also applicable for bed ridden patients
Weight for age	Is a measure of the weight compared to the weight of children of the same age and sex from a reference population	An indicator for acute and chronic malnutrition

Height-for-age	Measure of the height compared to the height of children of the same age and sex form a reference population.	Indicator for chronic malnutrition and is used to identify stunted children
Weight-for-height	Measure of the weight compared to the weight of children of the same height and sex from a reference population	Indicator for acute malnutrition and used to identify wasted children
Underweight	Weight is below -2SD of expected weight of children of same age from a reference population	Moderate and severe-below minus 2 SD from median weight for age of reference population
Stunting	Height is below -2SD expected height of children of same age from a reference population	Moderate and severe-below minus 2 SD from median height for age of reference population
Wasting	Weight is below -2SD of expected weight of children of same height from a reference population	Moderate and severe-below minus 2 SD from median weight for height of reference population
Failure to thrive	The failure of the child to gain weight for more than 2 months	Important in detecting children who are at risk of malnutrition due to disease or inadequate food intake
Body surface area(BSA)	√(height-cm*(weight (kg) 3600	Used mainly for drug prescription for children
Body Mass Index (BMI for age)	Weight (kg) Height (m2)	An indicator of nutrition status

Growth monitoring in children

Interpretation of growth curves

This is determining whether the child is growing appropriately or not, this is done by watching the direction of the child's growth pattern.

Normal growth curve; a healthy child's growth curve is parallel to the printed curves on the chart. important consideration on premature infants where growth failure can be over diagnosed, this can be avoided by subtracting the weeks of prematurity from postnatal age when plotting the growth measurements. The direction of the growth curve is more important than the position of the curve on the chart.

A horizontal growth curve (static); this indicates danger, this means the child is not growing, a sign of disease, especially malnutrition, this makes them prone to recurrent infection as they cannot resist disease, a thorough history should be taken to establish the cause of growth failure, then intervene; relevant and practical guidance to the mother within her means to ensure continuation of normal growth. thereafter growth monitoring helps to determine the adequacy of catch-up growth (successful nutritional rehabilitation associated with growth spurt)

Downward growth curve; indicates a very dangerous situation where the child is losing the weight, this requires extra care immediately, could indicate malnutrition, tuberculosis, AIDS or other medical conditions. Investigations and treatment necessary. Any infant who does not gain weight for a month or a child in 2 months should receive urgent attention, an indicator of the child being malnourished.

Plot points for growth indicators

In order to plot points, one needs to understand the following:

The horizontal reference line at the bottom of the graph which indicates the age of the child.

The vertical reference line at the far left of the graph which indicates weight or length/height.

Plotted point – the point on the graph where a line extended from a measurement on the horizontal line intersects with a line extended from a measurement on the vertical line.

Plotting weight for age

Plot completed weeks, months and years on a vertical line (not between the verticallines) on the mother and child health booklet.

For horizontal line, plot weight for age on or between the horizontal line as precisely as possible.

When points are plotted for 2 or more visits join/connect the adjacent points with a straight line to better observe the trend.

Plot length/height –for-age

Length /height for age reflects attained growth in length or height at the child's age at a given visit. This indicator can help identify children who are stunted (short) due to prolonged under-nutrition or repeated illness. Children who are tall for their age can also be identified, but tallness is rarely a problem unless it is excessive and may reflect uncommon endocrine disorders.

Age is plotted in completed weeks from birth until age 3 months; in completed months from 3 to 12 months; and then in completed years and months.

To Plot length/height –for-age:

Plot completed weeks, months or years and months on a vertical line (not between vertical lines). For example, if a child is 51/2 months old, the point will be plotted on the line for 5 months (not between the lines for 5 and 6 months)

Plot length or height on or between the horizontal lines as precisely as possible. For example, if the measurement is 60.5 cm, plot the point in the middle of the space between horizontal lines.

When points are plotted for two or more visits, connect adjacent points with a straight line to better observe the trend.

Judge whether a plotted point seems sensible, and if necessary, re-measure the child. For example, a baby's length should not be shorter than at the previous visit. If it is, one of the measurements was wrong.

Note WHO child growth standards, 2008

> **Note**
>
> Plot measurements (weight/height) once per month on the child's growth chart
>
> If the measurements are taken more than once in a period of 4 weeks, the subsequent measurements should be recorded on the clinical notes and not plotted.

Interpretation of the weight/height for age

Z-score lines on the growth charts are numbered positively (-1, -2, -3) or negatively (-1, -2, -3). In general, a plotted point that is far from the median in either direction (for example, close to the 3 or -3 z-score line) may represent a growth problem, although other factors must be considered, such as the growth trend, the health condition of the child and the height of the parents.

Anthropometric indicators for adults

Indicator	Definition	Explanation/Use
Weight and change in weight	Measured as weight in kg. A change in weight is measured as % of initial weight. Several measurements have to be recorded for tracking changes in nutritional status	Excessive weight loss may indicate wasting and presence of chronic illnesses. A 5-10& unintentional decrease in weight is an indication of a health problem
Weight measurement in pregnant women	Measured as weight in kg	In this population weight gain of about 1.5kg per month in the last trimester is consistent with positive pregnancy outcomes in developing countries

Mid-upper arm circumference	Measured on the less active hand	MUAC is a measure of inadequacy in nutritional status. The indicator is useful for assessing acute adult undernutrition to determine prevalence of acute malnutrition at the population level and identify those at highest risk of mortality
Body mass index	Weight in kg divided by height (M2)	An indicator of nutritional status for non-pregnant individuals.

Body Mass Index (BMI)

This is the way of comparing an individual's weight with that of the reference population. It is the international standard for assessing body size in adults

The main assumption of BMI is that it represents an indirect index of body composition which is fatness correlated with health.

Mainly used for protein energy malnutrition and obesity as it is considered a good index of body fat and protein stores.

BMI = BODY WEIGHT (KGS)/ HEIGHT (M2) (Kg/M^2)

It indicates wasting

For adults 20 years old and older, BMI is interpreted using standard weight status categories that are the same for all ages, and for both men and women

Example

If a person is 74 kg and the height is 162cm then the BMI can be calculated as

BMI = body weight

Height (m^2)

= 74

1.69 *1.62

=25.87 kg/m^2

Thus the person is overweight

BMI cut-offs for adults

<16.0 kg/m^2 Severe malnutrition

16.0-16.9 kg/m^2 moderate malnutrition

17.0-18.4 kg/m^2 mild malnutrition

<18.5 kg/m^2	underweight
18.5-24.9 kg/m^2	normal
25.0-29.9 kg/m^2	overweight
>30 kg/m^2	obese

Advantages of BMI

BMI testing, unlike many of the other methods used to assess weight, requires no special training. Although the calculation may seem complicated on first view, with practice it can be completed easily in just a few moments.

The results are easy to understand; it's simply a matter of looking up your score on a standardized chart.

BMI testing does not require one to remove any clothing, other than shoes during weight taking, which makes it ideal for users who might otherwise be put off by a more invasive procedure

Disadvantages of BMI

The body weight includes a number of components, such as muscle mass, fat, internal organs, water and skeletal weight. BMI does not differentiate between these components, so some populations will score badly when, in fact, they are quite healthy.

Muscle and bone weigh significantly more than fat, so it's possible to be heavy but still carry a low amount of body fat e.g. football players, competitive weightlifters, those with large skeletal frames and other very muscular people.

Conversely some athletes may have a very low BMI, possibly classifying them as underweight.

BMI may also be a poor indicator of whether the patient is at risk nutritionally, as an apparently normal weight can mask severe muscle wasting

18.3.2.3 Self-Assessment

1. Define the following terms:

    i. Anthropometric measurements

    ii. Client

    iii. Body Mass Index

    iv. MUAC

2. ____________________ is a method used to estimate body compartments through a mechanism of resistance and reactance

A. MUAC

B. BIA

C. BMI

D. XRAY

3. The following measurements are used to assess body composition except

A. Total body water

B. MUAC

C. Fat-free mass

D. Skinfold thickness

4. Indicate whether the following statements are true or false for waist circumference

5. Larger the waist circumference (high fat deposition), the lower the risk of onset of non-communicable diseases

6. Waist measurement are taken to provide additional information on overweight and obesity

7. The arms should be relaxed and lifted at 180°C

8. It is taken midway between the lower rib margin and the iliac crest and is taken at the end of expiration

9. The WHO cut off points for hip/waist ratio among men is____

A. >90

B. >85

C. >0.85

D >0.90

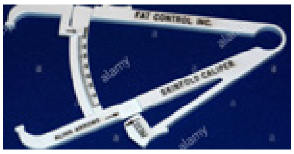
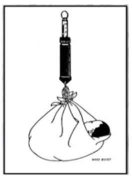
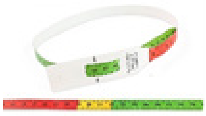
10. What are the methods used in determining nutritional assessment and surveillance?

11. What are some of the tools used in determining nutrition assessment and surveillance?

12. A 5 year old boy weighs 20kg and is 130cm tall. The boy has a MUAC of 13cm. Determine his nutritional status.

15. Highlight the advantages and disadvantages of anthropometric methods

18.3.2.4 Tools, Equipment, and Materials

Microtoise 	Measured on the less active hand 	Calipers 
Spring balance 	Height Boards 	Beam balance 
Adult MUAC tapes 	Color-coded measuring tapes 	Salter scale 
Children MUAC tapes 	Bathroom scale 	Length Boards 

Computers with internet

Library and resource Centre

WHO guidelines

MOH policies and guidelines

Skills lab

LCDs, video clips, charts and other teaching aids

Stationery

Invited experts

18.3.2.5 References

Ministry of health (MOH) guidelines

Integrated management of acute malnutrition (IMAM) guidelines, UNICEF, 2015

https://www.who.int/ncds/surveillance/steps/Section%204%20Step%202%20Physical%20 Measurements.pdf - World Health Organization (WHO)

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18.3.3 Learning Outcome 2: Analyze biochemical laboratory results

18.3.3.1 Learning Activities

Learning activity	Special instructions
Interpret laboratory results as per reference ranges • Serum tests for iron • Plasma albumin test for protein • Urinary tests for thiamin and riboflavin • Amino acid test for protein	Compare the actual results with the cut off points
Evaluate laboratory results as per biological variation knowledge	Consider differences in physiological status, genetics, immune status, dietary variables and age.
Determine influence of errors • Random and systematic errors • Preanalytical variation • Analytical imprecision • Biological variation	Carry out assessment against reference change values (RCV) Identify any inter and intra-observer variations
Identify diagnostic sensitivity and specificity	

18.3.3.2 Information Sheet

Definitions

Biochemical/Laboratory tests: biological tests of blood and urine to determine levels of particular nutrients or by-products of their utilization.

Biological variation: the natural variability in laboratory parameters due to physiologic differences among subjects and within the same subject over time

Albumin: the most abundant (55% to 650/o of total) plasma protein; a negative acute-phase respondent with a long half-life; maintains plasma oncotic pressure and acts as a transport protein.

Sensitivity: is a measure of test's ability to accurately generate a positive result for subjects who have the condition that is being assessed

Specificity: refers to a measure of test's ability to correctly generate a negative results for the subjects who do not have the condition being assessed

Lipid profile: is a blood test that measures the amount of cholesterol and fats called triglycerides in the blood

Complete blood count (CBC): blood tests used to evaluate the overall health of a client and detect a wide range of disorders such as anemia.

Creatinine: a chemical breakdown product of creatine phosphate; used as a marker of renal function and muscle mass

Ferritin: a protein that sequesters iron in a form readily activated for transport; found primarily in the liver and other iron storage sites; plasma ferritin is proportional to intracellular ferritin and useful in assessing iron status

Laboratory data can be used by the nutrition professional to support subjective judgment and clinical assessment findings. To add to this, because numeric values do not themselves connote personal judgment, this kind of data can often be passed on to a patient or client without perceived blame. Laboratory test results provide objective data for use in the process to assess nutrition status, identify nutrition diagnoses, and monitor and evaluate nutrition care outcomes.

Laboratory tests are ordered to diagnose diseases, evaluate treatment plans, monitor medication effectiveness, and evaluate medical nutrition therapy (MNT).

Specimen types

Whole blood: collected with an anticoagulant if entire content of the blood is to be evaluated; none of the elements are removed; contains red blood cells, white blood cells, and platelets suspended in plasma.

Serum: the fluid obtained from blood after the blood has been clotted and then centrifuged to remove the clot and blood cells.

Plasma: the transparent (slightly straw colour) liquid component of blood, composed of water, blood proteins, inorganic electrolytes, and clotting factors

Blood cells: separated from anticoagulated whole blood for measurement of cellular analyte content

Erythrocytes: (red blood cells).

Leukocytes: (white blood cells) and leukocyte fractions.

Blood spots: dried whole blood from finger or heel prick that is placed on paper and can be used for selected hormone tests and other tests such as infant phenylketonuria screening.

Other tissues (obtained from scrapings or biopsy samples)

Urine (from random samples or timed collections): contains a concentrate of excreted metabolites

Stool (from random samples or timed collections): important in nutritional analyses when nutrients are not absorbed and therefore are present in the stool.

Constituents of the common serum chemistry panels

Analytes	Reference range	Significance
Serum electrolytes		
Na+	135-I+5 mEq/Ll	monitor various patients, such as those receiving total parenteral nutrition or who have renal conditions, chronic obstructive pulmonary disease, uncontrolled diabetes mellitus (DM), various endocrine disorders, ascitic and edematous symptoms, or acidotic or alkalotic conditions; decreased K* associated with diarrhoea, vomiting or nasogastric aspiration, some drugs, licorice ingestion, and diuretics; increased K+ associated with renal diseases, crush injuries, infection, and hemolyzed blood specimens
K+	3.6-5 mEq/Lf	
Cl-	l0l-111mEq/Lf L	
HCO-3	21-31mEq/	
Glucose	70-99 mg/dl (fasting)	Fasting glucose >125 mg/dl indicates DM (oral glucose tolerance tests are not needed for diagnosis); fasting glucose >100 mgldl is indicator of insulin resistance Monitor levels along with triglycerides in those receiving total parenteral nutrition for glucose intolerance
Creatinine	0.6-1.2 mgldl; 53-106 umol/L (males) 0.5-1.1 mg/dl;44-97 umol/L (females	Increased in those with renal disease and decreased in those with PEM (i.e., blood urea nitrogen/creatinine ratio >15:1)
Blood Urea Nitrogen (BUN)	5-20 mg urea nitrogen/dl 1.8-7 mmol/L	Increased in those with renal disease and excessive protein catabolism; decreased in those with liver failure and negative nitrogen balance and in females who are pregnant
Albumin	3.5-5 mg/dl	Decreased in those with liver disease or acute inflammatory disease
Serum enzymes		
Alanine aminotransferase (ALT)	4-36 units/I- at37” C; 4-36 units/L	Increased in those with any of a variety of malignant, muscle, bone, intestinal, and liver diseases or injuries
Gamma glutamyltransferase	4-25 units (females) 12-38 units (males	
Alkaline phosphatase (ALP)	30-120 units/L; 0.5-2.0 uKat/L	AST and ALT useful in monitoring liver function in those receiving total parenteral nutrition

Aspartate aminotransferase (AST)	0-3 5 international units/L; 0-.58 uKatll	
Bilirubin	Total bilirubin 0.3-1.0 mgl dL; 5.1-17.0 pmol/L Indirect bilirubin 0.2-0.8 mg/ dL; J.+-12.0 pmol./L Direct bilirubin 0.1-0.3 mgl dL 1.7-5.1pmol/L	Increased in association with drugs, gallstones, and other biliary duct diseases; intravascular haemolysis and hepatic immaturity: decreased with some anaemias
Total Calcium	8.5-10.5 mgldl	Hypercalcemia associated with endocrine disorders, malignancy, and hypervitaminosis D Hypocalcemia associated with vitamin D deficiency and inadequate hepatic or renal activation of vitamin D, hypoparathyroidism, magnesium deficiency, renal failure, and nephrotic syndrome
Total cholesterol	<200	Decreased in those with protein-calorie malnutrition, liver diseases, and hyperthyroidism
Triglycerides	40-160mg/dl and sex dependent	Increased in those with glucose intolerance (e.g., in those receiving total parenteral nutrition who have combined hyperlipidemia) or in those who are not fasting
Constituents of the hemogram: CBC		
Red blood Cells	+.3-5.9 x 106/mm3 (men) 3.5-5.9 x 106/ mm3 (women)	In addition to nutritional deficits, may be decreased in those with hemorrhage, hemolysis, genetic aberrations, marrow failure, or renal disease or who are taking certain drugs; not sensitive for iron, vitamin B12 or folate deficiencies
Hemoglobin concentration	14-17 g/dl (men) 12-15 g/dl (women) < 1l g/dl (pregnant females) 14-24 g/dl (newborns)	In addition to nutritional deficits, may be decreased in those with hemorrhage, hemolysis, genetic aberrations, marrow failure, or renal disease or who are taking certain drugs; not sensitive for iron, vitamin B12 or folate deficiencies

Hematocrit	42%-52% (men) 35%-47% (women) <33% (pregnant females) 44%-64% (newborns)	In addition to nutritional deficits, may be decreased in those with hemorrhage, hemolysis, genetic aberrations, marrow failure, or renal disease or who are taking certain drugs; not sensitive for iron, vitamin B12 or folate deficiencies
Mean Cell Volume (MCV)	80-99 fl 96-108 fl (newborns)	Decreased (microcytic) in presence of iron deficiency, thalassemia trait and chronic renal failure, anaemia of chronic disease; increased (macrocytic) in presence of vitamin B12 or folate deficiency and genetic defects in DNA synthesis; neither microcytosis nor macrocytosis sensitive to marginal nutrient deficiencies
Mean cell hemoglobin (MCH)	27-31pg/cell 23-34 pg (newborns)	Causes of abnormal values similar to those for MCV
Mean cell hemoglobin concentration (MCHC)	32-36 g/dl 32-33 g/dl (newborns)	Decreased in those with iron deficiency and thalassemia trait; not sensitive to marginal nutrient deficiencies
White blood cell count (WBC)	5-10 x l0r/mmr (>2 yr) 6-17 x l0rlmmr	Increased (leukocytosis) in those with infection, neoplasia, and stress decreased (leucopenia) in those with PEM, autoimmune diseases, or overwhelming infections or who are receiving chemotherapy or radiation therapy
Chemical tests in urinalysis		
Specific gravity	1.010-1.025 mg/ml	Can be used to test and monitor the concentrating and diluting abilities of the kidney; low in those with diabetes insipidus, glomerulonephritis, or pyelonephritis; high in those with vomiting, diarrhea, sweating, fever, adrenal insufficiency, hepatic diseases, or heart failure
pH	6-8 (normal diet	Acidic in those with a high-protein diet or acidosis (e.g., uncontrolled diabetes mellitus [DM] or starvation), during administration of some drugs, and in association with uric acid, cystine, and calcium oxalate kidney stones; alkaline in individuals consuming diets rich in vegetables or dairy products and in those with a urinary tract infection, immediately after meals, with some drugs, and in those with phosphate and calcium carbonate kidney stone

Protein	2-8 mg/dl	Marked proteinuria in those with nephrotic syndrome, severe glomerulonephritis, or congestive heart failure; moderate in those with most renal diseases, preeclampsia, or urinary tract inflammation; minimal in those with certain renal diseases or lower urinary tract disorders
Glucose	Not detected (2-10 g/dl in DM)	Positive in those with DM; rarely in benign conditions
Ketones	Negative	Positive in those with uncontrolled DM (usually type 1); also positive in those with a fever, anorexia, certain GI disturbances, persistent vomiting, or cachexia or who are fasting or starving
Blood	Negative	Indicates urinary tract infection, neoplasm, or trauma; also positive in those with traumatic muscle injuries or hemolytic anaemia
Bilirubin	Not detected	Index of unconjugated bilirubin; increase in those with certain liver diseases (e.g., gallstones)
Urobilinogen	0.1-1 units/dl	Index of conjugated bilirubin; increased in those with hemolytic conditions; used to distinguish among hepatic disease
Nitrite	Negative	Index of bacteriuria
Leukocyte esterase	Negative	Indirect test of bacteriuria: detects leukocytes

Types of biochemical tests

Static: measure of a nutrient or its metabolite in *blood, urine, or body tissue* (an actual measure of the nutrient

Examples: Iron or vitamin A

Limitations: may fail to reflect the overall nutrient status (serum may not reflect level of nutrient in tissues)

Functional: reflects the failure of function or physiologic process of the body as a result of nutritional deficiency (somewhat indirect measure)

Examples of functional assessment:

Immune response will be compromised by protein deficiency; visual adaption to dark will be compromised by vitamin A deficiency

Limitations: May be nonspecific; indicates a general nutritional status, but may not allow id of specific nutrients

Methods processes/ procedures/ guidelines and content

Initial laboratory assessment

Laboratory tests are based on blood and urine which play the role of indicators of nutritional status, but they are influenced by non-nutritional factors as well

Laboratory results may be affected by medications, hydration status, and disease states or other metabolic processes, such as stress.

Data obtained should be viewed as part of a whole.

Haemoglobin estimation is the most important test, & useful index of the overall state of nutrition. Beside anaemia it also tells about protein & trace element nutrition.

Stool examination for the presence of ova and/or intestinal parasites

Urine dipstick & microscopy for albumin, sugar and blood

Specific lab tests

- Measurement of individual nutrient in body fluids (e.g. serum retinol, serum iron, urinary iodine, vitamin D).
- Detection of abnormal amount of metabolites in the urine (e.g. urinary creatinine/ hydroxyproline ratio).
- Analysis of hair, nails & skin for micro-nutrients.

Type of blood work/ Lab Panel	Components	Comments
CBC (Complete Blood Count)	RBC, Hgb, Hct, MCH, MCV (mean corpuscular volume) and can give some idea of anemias	Red blood cells carry oxygen White blood cells fight infection Hemoglobin is the oxygen carrying protein in red blood cells Platelets help in blood clotting Hematocrit is the proportion of red blood cells to the fluid component or plasma in the blood CBC is done; To review overall health To diagnose a medical condition To monitor a medical condition

		Monitor medical treatment Abnormal red blood cell, hemoglobin, or hematocrit levels may indicate anemia, iron deficiency, or heart disease Low white cell count may indicate an autoimmune disorder, bone marrow disorder, or cancer High white cell count may indicate an infection or reaction to medication However, diet, activity level, medications, a women's menstrual cycle, and other considerations can affect the CBC results.
Metabolic Panels or Chem profile/panels (liver profile or comprehensive)	Minerals Na, K, P, Cl, Ca, Alb, total proteins, globulins and liver enzymes (alkaline phosphatase, ALT, AST), byproducts of metabolism (BUN, creatinine, CO2), blood glucose	ALT (alanine aminotransferase) is a liver enzyme; when elevated may signal a liver problem or disease Alkaline Phosphatase (ALP) enzyme indicates a problem in liver, bone, placenta, intestine AST (aspartate aminotransferase) indicates MI, liver disease, drug exposure, musculoskeletal injuries Bilirubin is the pigment in bile, produced from the breakdown of hemoglobin; when elevated may indicate liver problem and results in jaundice BUN (blood urea nitrogen) is the byproduct of protein metabolism; when elevated can signal renal disease or dehydration Creatinine becomes elevated with renal disease Calcium stays very tightly controlled; if low may indicate hypoparathyroidism, renal disease, or pancreatitis; high levels can indicate excessive vitamin D intake. When out of normal range indicates a metabolic problem rather than a true deficiency of dietary calcium. Carbon Dioxide (CO2) indicates acid/base balance in body. Too high indicates alkalosis; too low indicates acidosis Chloride (Cl) works with Na to help with acid-base balance and fluid pressure. Low level may indicate alkalosis and low K; High level may indicate kidney disease or heart disease Glucose (Normal is 70-100 mg/dl) is considered the normal range for a fasting blood glucose level. If a fasting blood glucose level determines 100-125 mg/dL, the person is considered to have impaired fasting glucose, a type of prediabetes

		A random blood glucose test usually will be below 125 mg/dL; when elevated, may signal diabetes. A1C test is a common blood test used to diagnose type 1 and type 2 diabetes. The A1C test may be referred to as hemoglobin A1C, HbA1C, glycated hemoglobin, glycosylated hemoglobin. The test reflects the average blood sugar level for the past two to three months and measures the percentage of your hemoglobin (protein in RBC that carries oxygen) is coated with sugar (glycated). NOTE: Normal A1C 4.5-6% (5% = 97 mg/dL as estimated average blood glucose level) Prediabetes A1C 5.7-6.4% (6% = 126 mg/dL as estimated average BG level Diabetes A1C >6.5% (7%= 154 mg/dL as estimated average BG level) Phosphorus (P) closely relates to Ca; when high may indicate renal failure; when low may indicate a bone disease (rickets or osteomalacia) Sodium (Na) maintains acid-base and fluid balance. Low level may be from vomiting, diarrhea, or diuretics, or overhydration; High level may be seen with dehydration. Terms: hypernatremia, hyponatremia Potassium (K) plays a key role in acid-base and fluid balance; nerve impulses. High level may be seen with renal disease. Low levels may be caused by diuretics, vomiting, diarrhea, eating disorders. Terms: hyperkalemia, hypokalemia
Lipid Panels	Total cholesterol, triglycerides, LDLs, HDLs, VLDLs	**Total cholesterol:** This is a sum of your blood's cholesterol content; An estimate of all the cholesterol in the blood (good HDL plus bad LDL, for example). Thus, a higher total cholesterol may be due to high levels of HDL, which is good, or high levels of LDL, which is bad. So knowing the breakdown is important. **Triglycerides:** A type of blood fat. When you eat, your body converts calories it doesn't need into triglycerides, which are stored in fat cells. High triglyceride levels are associated with several factors, including being overweight, eating too many sweets or drinking too much alcohol, smoking, being sedentary, or having diabetes with elevated blood sugar levels.

		High-density lipoprotein (HDL): Good cholesterol that helps protect against heart disease because it helps carry away LDL cholesterol, thus keeping arteries open and blood flowing more freely. **Low-density lipoprotein (LDL):** Bad cholesterol and a major contributor to clogged arteries. Too much of it in the blood causes the buildup of fatty deposits (plaques) in the arteries (atherosclerosis), which reduces blood flow. These plaques sometimes rupture and can lead to a heart attack or stroke.

Advantages of Biochemical Method

- It is useful in detecting early changes in body metabolism & nutrition before the appearance of overt clinical signs.
- It is precise, accurate and reproducible.
- Useful to validate data obtained from dietary methods e.g. comparing salt intake with 24-hour urinary excretion.

Limitations of Biochemical Method

- Time consuming
- Expensive
- They cannot be applied on large scale Needs trained personnel & facilities
- Requires trained personnel and facilities.

CASE STUDIES

An 83-year-old woman was brought in to the emergency department of Kenyatta National Hospital suffering from mental confusion. Her past medical history showed that she had hypertension, peripheral atheromatosis, and had experienced a previous transitory ischemic attack.

Over the last year, she complained of an inability to perform normal cognitive functions and

Had experienced frequent falls. Her existing medications included ramipril 2.5 mg/day, lansoprazole 30 mg/day and acetylsalicylic acid 100 mg/day.

The patient's blood pressure was 170/100 mmHg and heart rate 70 b.p.m.;

Laboratory measurement	Results	Normal range
At admission		
Glucose (mmol/L)	5.16	3.6–6.3
Serum [Na+] (mmol/L)	120	135–146
Serum Urea (mmol/L)	4.1	3.5-6.6
Haemoglobin (g/L)	109	120–160
Haematocrit (proportion of 1.0)	0.32	0.36–0.46
Serum creatinine (μmol/L)	56.6	35.4–79.6
Serum uric acid (μmol/L)	131	208–387
Serum [K+] (mmol/L)	4.1	3.5–5.3

Comment on these results.

What further investigations would you recommend and why?

18.3.3.3 Self-Assessment

1. Define the following terms;
   i. Biochemical/Laboratory tests
   ii. Biological variation
   iii. Lipid profile
   iv. Complete blood count(CBC)
2. ______________________ are the blood tests used to evaluate the overall health of a client and detect a wide range of disorders such as anaemia.
   A. Biochemical tests
   B. Lipid profile
   C. Biological variation
   D. Complete blood count
3. What is the reference standard for fasting glucose for a normal person?
   A. >125 mg/dl
   B. 3-5 mg/dl
   C. 70-99 mg/dl
   D. >100 mg/dl

4. Chloride (Cl) works with Na to help with acid-base balance and fluid pressure. Low level may indicate____________________

   A. Alkalosis and low potassium

   B. Acidosis

   C. Renal disease

   D. Liver problem

5. Describe the different types of biochemical tests

6. You are the nutritionist at a national referral hospital and have done a lab request on Complete blood count for your client. The client does not understand why she has to go to the lab. Explain how you would address this matter.

7. Explain the possible explanations for;

8. Presence of Alkaline Phosphatase (ALP) enzyme during liver function test

9. Elevated BUN (blood urea nitrogen)

10. Discuss the factors that may influence discrepancies in biochemical results

18.3.3.4 Tools, Equipment, Supplies and Materials

Computers with internet

Library and resource Centre

WHO guidelines

MOH policies and guidelines

Skills lab

LCDs, video clips, charts and other teaching aids

Stationery

Invited expert

18.3.3.5 References

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18.3.4 Learning Outcome 3: Conduct clinical examination

18.3.4.1 Learning Activities

Learning activity	Special instructions
Obtaining Patient medical history Take patients complete medical history from the patient, caretaker/relative privy of the patient's condition, referral notes, treatment sheet, nurses cardex and patients files	Elicit current concerns Resist the tendency to interrupt Probe Ask about medications, diet, Ask about functional status Consider life history.
Physical examination and review of systems. Head to toes examination of the patient including psychosocial assessment.	Physical observation of the body, hair, nails, eyes, lips, skin, prominence of bones for a clue to a nutrition related condition or deficiencies e.g. wasting, anemia, dehydration Documenting the findings as per work procedure.
Conduct and document physical examination e.g., paleness of the palm and duration for refill upon pressing the palm, color, texture and distribution of the hair, paleness of the conjunctiva and edema.	Ensure privacy Get patients consent Observe confidentiality Observe hygiene Have a chaperone.

18.3.4.2 Information Sheet.

Definitions,

Clinical examination: a physical examination that looks for clue to poor nutrition status by assessing the superficial tissues/organs near the body surface

Edema: swelling caused by excess fluid trapped in your body's tissues

Pallor; an unusual lightness of skin colour compared with your normal complexion. Paleness may be caused by reduced blood flow and oxygen or by a decreased number of red blood cells

Chaperone; a person who looks after and accompany a person or group of people or takes care of another one.

Codex; quick summary of individual patient needs that is used by nurses and updated at every shift change or any change in patient's condition.

Clinical examination

It is an essential feature of all nutrition surveys. It is the simplest & most practical method of ascertaining the nutritional status of a group of individuals

It utilizes a number of physical signs that are known to be associated with malnutrition and deficiency of vitamins & micronutrients. Every part of the body can be examined to offer clue e.g. hair eyes skin posture tongue, fingernails, and others.

General clinical examination, with special attention to organs like hair, angles of the mouth, gums, nails, skin, eyes, tongue, muscles, bones and thyroid glands.

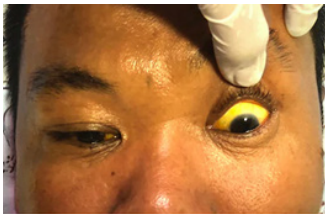
The examination requires skill because many physical signs can reflect more than one nutritional deficiency or toxic in the body or even nutrition conditions.

Like other assessment techniques, a physical examination does not by itself provide conclusion but instead may reveal possible nutrient imbalances for other assessment techniques to confirm data collection from other assessment measures.

Clinical data provides information about the individual's medical history, including acute and chronic illness and diagnostic procedures, therapies, or treatments that may increase nutrient needs or induce malabsorption .

Current medications need to be documented, and both prescription drugs and over-the-counter drugs, such as laxatives or analgesics, must be included in the analysis.

Vitamins, mineral, and herbal preparations also need to be reviewed. Physical signs of malnutrition can be documented during the nutrition interview and are an important part of the assessment process.

Physical exam.	Procedure.	Illustration.
Hair	Look; spare, thin, coiled and corkscrews Touch/feel; texture and easy to pull out.	
Eyes	Look; pallor and jaundice on the patient's sclera and conjunctiva. Ask for signs of photophobia, night blindness or blurring vision.	

Mouth.	Look for glossitis, leukoplakia, sore mouth and tongue, angular stomatitis, cheilosis and fissured tongue, bleeding and spongy gums.	
Nails.	Look for spooning and transverse lines.	
Skin.	Look for pallor, follicular hyperkeratosis flanking dermatitis, pigmentation desquamation, bruising pupura.	
Muscles and bones	Wasted appearance of muscles swollen bumps on skull or ends of bones; small bumps on ribs; bowed legs or knock knees	
oedema	Place the client to lie on the examination couch then apply pressure using your thumb to the swollen skin for about 15 seconds to check for lasting indentation	

Clinical signs and nutritional deficiency

Body system	Healthy findings	Healthy findings	What the findings reflect
Tongue	Red, bumpy, rough	Sore, smooth, Oedema, purple/scarlet color or swollen	Vitamin B2 and niacin deficiency
Skin	Smooth, firm, good color	Patches, edema, in-elastic flaky, dermatitis	PEM esp. kwashiorkor Vitamin B3/ C deficiency/pellagra
Teeth and gums	No pain or caries, gums firm teeth bright	Mottled enamel, Missing, discolored, decayed teeth; gums bleed easily and are swollen and spongy	Excessive fluorine/ scurvy Mineral and vitamin status
Internal systems	Regular heart rhythm, heart rate, and blood pressure; no impairment of digestive function, reflexes, or mental status	Abnormal heart rate, heart rhythm, or blood pressure; enlarged liver, spleen abnormal digestion; burning, tingling of hands, feet; loss of balance, coordination, mental confusion, irritability, fatigue	PEM and mineral status
Nails	Firm, Pink	Spoon-shaped, brittle, ridged, pale	Iron status
Muscles and bones	Muscle tone; posture, long bone development appropriate for age	"Wasted" appearance of muscles swollen bumps on skull or ends of bones; small bumps on ribs; bowed legs or knock knees	PEM, mineral, and vitamin D status

Edema

It is not an index but just a sign of severe malnutrition especially presence of kwashiorkor.

It is the presence of excessive fluid in the intracellular tissues of the body.

Nutritional edema is bilateral (on both feet) and is diagnosed using thumb pressure for three (3) seconds then releasing the pressure.

If a depression is left shows signs of edema

It is an indicator of high risk of mortality.

Grade +(mild)	Grade ++ (moderate)	Grade +++(severe)
There is bilateral pitting oedema in both feet Consider checking the legs and face too to rule out grade ++ or+++	Both feet plus the lower legs, hands, and lower arms are swollen. This is grade ++ bilateral pitting oedema	It is generalized, including both feet, legs, arms, hands and face

Advantages of clinical assessment

- Less time consuming
- Relatively cheaper than other methods
- Does not require highly skilled man power
- Doesn't require any elaborate laboratory equipment
- One can easily train people on checking signs and symptoms
- Non-invasive
- Fast and easy to perform

Limitations of clinical assessment

- Does not detect early cases
- Specificity is low
- Sensitivity is low-not show severity
- Large inter-observer variation
- Large intra-observer variation
- Observer assessment tends to shift with prevalence of the sign in the population applying stringent criteria when prevalence is high

CASE STUDY

Patient X was referred from mbale dispensary to the nutrition clinic presenting with complains of bilateral swelling of the lower limbs from the level of the ankle joint to the level of the knee, un evenly distributed hair, sunken alert eyes, sagging skin and irritability

- Identify any key physical observation in patient X
- What are the procedures that you will need to follow during history taking
- Explain the procedure of head to toe examination in patient X
- What are the tools, materials and supplies required during physical examination?

18.3.4.3 Self-Assessment

1. Define the following terms;

   i. Codex

   ii. Pallor

2. The following are signs of a healthy tongue except;

   A. Red

   B. Bumpy

   C. Rough

   D. Smooth

3. Patches and edema on the skin may reflect_______________

   A. Kwashiorkor

   B. Vitamin E deficiency

   C. Dehydration

   D. Vitamin B deficiency

4. The type of oedema where both feet and arms are swollen is known as ____________

   A. Grade +

   B. Grade ++

   C. Grade +++

   D. Grade ++++

5. What are the factors considered when doing physical examination on a client
6. What systems are reviewed during physical examination of a patient

7.What do you elicit for in the following areas during physical examination

i. Eyes

ii. Hair

iii. Mouth

iv. Nails

18.3.4.4 Tools, Equipment, Supplies and Materials

Examination couch.	Screen
	

Computers with internet

Library and resource Centre

WHO guidelines

MOH policies and guidelines

Skills lab

LCDs, video clips, charts and other teaching aids

Stationery

Invited expert

18.3.4.5 References

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18.3.5 Learning Outcome 4: Conduct Dietary assessment

18.3.5.1 Learning Activities

Learning activity	Special instructions
Determine dietary method 24 hour recall Food frequency questionnaire Food diary Food records Food history	Select the correct method of dietary assessment Determine the tools for assessing dietary diversity Be keen to identify any possible errors in dietary assessment
Conduct dietary recall questionnaire	Carry out a pilot study on the foods commonly consumed by individuals/households Design and administer a food frequency questionnaire Interpret the data obtained
Obtain diet history	Design and administer diet history questionnaire Interpret the data obtained Address any contingencies

18.3.5.2 Information Sheet

Definitions

Dietary assessment; is data collected that is used to asses a client's food and nutrient intake, lifestyle and medical history within a certain period of time.

24 hour recall: This is a structured interview intended to recall and report all food and beverages consumed by the client in the past 24 hours

Food frequency questionnaire (FFQ): This is a questionnaire used to obtain frequency and sometimes portion size information about food and beverage consumption over a certain period of time

Dietary records: This is a prospective open ended survey method collecting data about food and beverages consumed over a previously specified period of time

Dietary history: This is a structured interview method consisting of questions about habitual/ usual intake of food and beverages over a long period of time.

Dietary intake: data about food consumption, including information on appetite, eating patterns, and estimations of typical nutrient intake

Food diary: a record that is written to show all the foods and drinks consumed during a set time, usually 3 to 7 days, often including information on eating time, place and situation

Nutrient intake analysis (NIA): a process by which food, beverage, and supplement intake is evaluated for nutrient content over a specified period of time

Food frequency questionnaire: a method of dietary assessment in which the data collected relate to how often and in what amount foods are consumed (e.g., servings per week, month, or year)

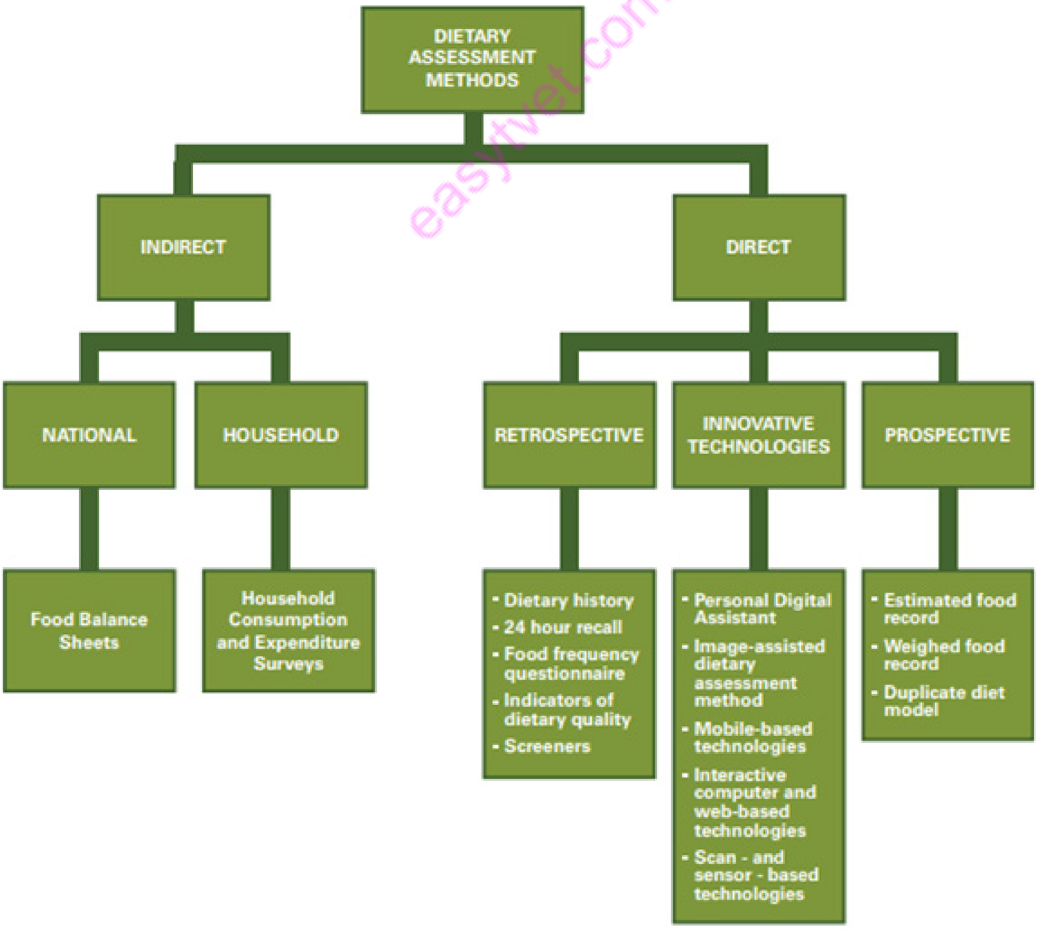
Household food consumption: defined as "the total amount of food available for consumption in the household, generally excluding food eaten away from the home unless taken from home"

Content

Dietary assessment

Dietary assessment method is an evaluation of food and nutrient intake and dietary pattern of a client(s) in the household or population group overtime

Dietary assessment is usually categorized according to the nature of method used i.e. indirect and direct methods.



Overview of dietary assessment methods to estimate food and nutrient consumption at national, household and individual level

Indirect methods

Use secondary information such as food supply, agricultural statistics and food expenditure to estimate food availability at national and household levels.

At national level, food balance sheets (compiled by FAO annually) are used while household consumption and expenditure surveys are used at household level

Direct methods

Use primary information which are collected using individual based dietary assessment

They are classified into two; retrospective direct methods and prospective direct method.

Three retrospective methods are commonly used to assess the nutritional intake of humans and they collect information on foods and beverages already consumed. They include;

- 24 hours dietary recall
- Food frequency questionnaire (FFQ)
- Dietary history since early life

Prospective methods assess current food intake and they include;

- Food dairy technique
- Observed food consumption
- Duplicate meal method

Estimates obtained from direct methods are used to identify trends in food consumption, food and nutrient intakes, eating patterns, and to evaluate diet–disease associations. Information provided by such methods can also be used to calculate relevant food-based indicators for monitoring and evaluation purposes.

24-hour dietary recall

24-hour recall a method of dietary assessment in which an individual is asked to remember the specific food eaten during the past 24 hours. This method involves a trained interviewer asking the client to remember all food & drink taken during that period. Information on 24-hour recall is collected using an open-ended format. Quantitative information on food intake, as described using portion size, allows for the calculation of energy and nutrient intakes. Estimation of portion size is facilitated by the use of measurement aids such as standard household measures, photo atlases, food models, etc. To calculate energy and nutrient intakes, the estimated portion size or the amount of food intake is multiplied by the values of nutrient content in foods as found in the food composition tables. The interviewer then analyses the information. Food models and food photos albums are used when estimating the food portion size consumed. The respondent is presented with a standard food model or food size in the photo album and then the amount of food taken is compared to this standard food size to estimate what was actually consumed.

How to collect data using 24-hour recall

Project objectives and budget will determine the study design and sample size. It is important to:

- Understand the characteristics of the target population.
- Define the purpose and research questions of the study.
- A trained nutritionist and dietician is required to conduct this form of assessment

Target population group

Characteristics: population groups (e.g. toddlers, pregnant women, elderly, etc.), age, literacy level, numeracy skills and cognitive abilities of the respondents assessed will have an impact on the mode of administration used.

Parents can act as a proxy for children less than eight years old and can assist older children.

Surrogate reporters can be used as proxies for the elderly if there is evidence of cognitive decline. Note that this increases the chances of error, particularly if the individual is under the care of multiple caregivers during the day.

Food intake and meal patterns. It is important to:

Understand the food intake and meal patterns of the target population group and also identify specific subgroups of the population (e.g. shift workers, pregnant and lactating women) who may have different meal patterns.

Mixed diets (composite diets). It is important to

Understand local recipes, identify and record all ingredients consumed and have a strong appreciation of how to measure portion sizes of mixed dishes

Information on dietary supplements (e.g. vitamins, minerals)

Mode of administration

- Face-to-face interview, computer-assisted recall or telephone administered recall.
- The researcher should explain to the participants that the goal of this interview is to record everything that the participant ate (meals and snacks) the day before, starting with the first thing eaten by the respondent in the morning until the last food item consumed before he/she got up the next morning.
- Method used for recording information (e.g. pen and paper, scannable format)
- Number of recorded days
- Selecting the number of days that will allow for an appropriate estimation of an individual's usual intake.
- A single 24-hour recall does not represent an individual's usual diet (hence multiple days are needed), nor does it take into account daily, weekly or seasonal variations of an individual's food intake.

- The time frame for a 24-hour cycle needs to be defined using reference points applicable to the target population (e.g. first food/drink consumed after waking up in the morning to the last food/drink consumed before going to sleep at night).
- Days selected for conducting the assessment (weekday vs. weekend)
- Non-consecutive days are preferable, helping to capture more of the variability in an individual's diet.
- Including one weekend day in a week is desirable, to capture variability of food intakes during weekends.
- Knowledge and skills of the interviewer. Interviewers should;
- Receive training on conducting a 24-hour recall with standardized procedures, including practice interviews prior to the start of the study.
- Know how to probe the respondent using standardized and non-leading questions that are specific to the food consumption patterns of the target population.
- Ideally have knowledge of local foods, eating patterns, food preparation methods and the specific cultural practices of the study population.

Conducting a pilot study

Select subjects and geographic sites that are representative of the actual target population for the pilot study.

Identify any logistical and/or technical problems in the pilot study in order to fine-tune the survey procedures and to identify problems that may occur in the interviews prior to the actual survey, such as discrepancies in interview protocol, recalling and recording of composite dishes and food matching with food composition data.

Estimating portion sizes

Using food models, photographs (photographic atlas) or standard household measures to help estimate portion sizes and food intake.

For liquids (e.g. soups or beverages), record quantities as volumes, preferably using the respondents' own household utensils after these have been calibrated.

Conversion factors or a food composition database are required to convert household measures to weight equivalents

It is necessary to have access to a food composition database which is up to date, complete and includes locally available foods as much as possible for nutrient estimation

It is important to assess validity and reproducibility

Procedures to minimize errors

Train interviewers prior to the recall to become familiar with the dietary patterns of the study population.

Create a standardized interview protocol.

Calibrate utensils in the home and use standardized methods for portion size estimates.

Use effective probes/prompts to reduce respondent memory lapses.

Utilize multiple-pass interviewing techniques.

Reviewing the recall data

Check and identify errors in the dietary data with the respondent during the interview. This should be conducted at the same time as the interview in order to ensure the most accurate information is obtained and to limit missing data.

Analysis of data from 24-hours recall

A computer software package is used to analyze the amount of various nutrient consumed per day.

It uses the information from food composition table where the amount of nutrient in 100 grams of a food sample is already known.

It computes the amount of nutrient in each meal component and then calculate the total amount consumed per day.

Advantages:

- It is quick, easy, & depends on short-term memory, but may not be truly representative of the person's usual intake.
- This method is quick thus can be used in large surveys.
- Can be used even with illiterate people
- The method is relatively inexpensive/ it is cheap.
- It does not require too much room the respondent hence compliance is high.

Disadvantages:

- The respondent may lack the ability to recall accurately the kinds and quantities of food eaten
- Interviewer may experience difficulty in determining whether the day being recalled represents an individual's usual intake
- Risk of exaggeration low intakes and under reporting of high intakes

- It is recommended that this method be used concurrently with the food frequency questionnaires in order to get more accurate intake estimates.

Food frequency questionnaires(FFQs)

This is a method of obtaining qualitative description information about usual food intake. It has a set of frequency of consumption by respondent. In this method the subject is given a list (usually closed ended) of around 100 food items to indicate his or her intake (frequency & quantity) per day, per week & per month. This method assesses the frequency with which foods are consumed over a certain period of time so as to determine the diet diversity. Before carrying out study one may need a preliminary survey to determine the foods consumed. The data can be collected either daily, weekly, monthly or yearly depending on the study objectives.

Key considerations when selecting a food list for FFQs

Foods selected should encapsulate the objectives of the assessment, e.g. to measure intake of only a few foods and nutrients, or to undertake a comprehensive dietary assessment

Whether to rank individuals' consumption or provide a measure of absolute nutrient intakes.

It is often preferred to put together a comprehensive list of foods and/or of food groups to allow for energy adjustments. Aggregating foods into food groups can be used as a technique to capture specific nutrient(s) or non-nutrient(s) when these nutrients are confined to a relatively small number of foods. However, aggregation of foods into small groups may lead to underestimation of intakes, whereas larger food groupings can lead to overestimation of intakes. Aggregating food can further lead to over counting due to difficulties in reporting combined frequency for a particular food eaten both alone and/or in mixed dishes

The choice of foods in a list is partly data driven and partly a question of scientific judgment. Selected foods can be used to capture the major sources of energy and/or nutrients consumed by the study population, variability in food intake between persons, and of course the study objectives

How to collect data using FFQs

Project objectives and budget determine the study design and sample size

One will need to:-

- Define the target population (elderly, children, adolescents etc.), literacy level, and cognitive ability
- Determine frequency categories in the FFQ: times per day, times per week, times per month, rarely, never etc.
- Developing a survey protocol
- A survey should be adapted to local cultural context, e.g. meal patterns, shared dishes, non-standard eating and serving tools.

- A validation exercise can be applied to test the efficiency of the protocol.

Identifying sources of information

Information on foods consumed by a population can be obtained from national or regional survey data, databases, or from undertaking a focus group discussion with the target population.

Development of a food list and assigning food codes

Foods selected should represent those commonly consumed by the target population and the food list should be in line with the study objectives.

Adapting an existing food list

If a similar FFQ already exists, it can be used in its original form or modified/ adapted by adding or replacing foods with items more commonly consumed in the target population, or by adapting the food list to target a specific nutrient. However, changes to an FFQ will require a validation study.

Update the database as required to include all the food components of interest.

Assessing the need for portion size estimation (non-quantitative, semi-quantitative or quantitative)

Determining if the FFQ should collect quantitative information on food intake would depend on the objectives of the study, age of respondents, homogeneity of the target population, standard units available, and the type of information to be collected.

Estimation of portion size (semi-quantitative or quantitative FFQ)

- Using food models, photographs or household measures to help estimate portion size.
- Supplementary questions (about cooking methods, brand names, etc.)
- Open ended section
- Respondents may record consumption of other foods that are not included in the close-ended food list.

Mode and time of administration

- Self-administered using paper or web-based formats, or interviewer administered via face-to-face or telephone interview.
- To account for seasonality, the survey can be administered at different times of the year (different foods may be available for consumption during different seasons).
- Method used for recording (e.g. pen and paper, scannable format).

Length of FFQ

To reduce respondent fatigue and reporting error, FFQ length should not be too drawn out and food items should be carefully selected.

Increase the number of foods included in a FFQ and at the same time keep the length of the questionnaire short by grouping together items based on food classification or nutrient similarity.

Reference period for the FFQ: e.g. previous weeks, months, etc. Bear in mind that FFQ may not be suitable for recalling diet in the distant past (e.g. the previous year)

Availability of a food composition database

Ensure that a food composition database is available which is up-to-date and complete, and includes locally available foods.

Advantages of FFQs

- It is inexpensive, more representative & easy to use.
- Covers long period, not influenced by short term changes
- Can capture a range of foods
- It does not affect eating behaviour because it is retrospective
- Has the ability to capture portion sizes

Limitations of FFQs

- Long Questionnaire
- Errors with estimating serving size.
- Needs updating with new commercial food products to keep pace with changing dietary habits.
- Reflects more of people's desire than reality
- It is not possible in children<7yrs
- Risk of misinterpreting the self-administered questionnaires

Diet History

Dietary history is a detailed dietary record; may include a 24- hour recall, food frequency questionnaire, food diary and other information such as weight history previous diet changes, use of supplements, and food intolerances. It aims to discover the usual food intake pattern of individuals over a relatively long period of time. It is an accurate method for assessing the nutritional status. The information should be collected by a trained interviewer. Details about usual intake, types, amount, frequency & timing needs to be obtained. Cross-checking to verify data is important.

It is an interview method composed of two parts:

The first part establishes the overall eating pattern and includes a 24h recall: questions like "what did you have for breakfast yesterday?" coupled with "what do you usually have for breakfast?" following through the entire day in this way. Clients are asked to estimate portion sizes in household measures with the aid of standard spoons and cups, food photographs or food models.

The second part is known as the "cross check". This is a detailed list of foods that are checked with the client.

Questions concerning food preferences, purchasing and the use of each food serve to verify and clarify information given in the first part.

How to collect data using Diet history

Project objectives and budget determine the study design and sample size

It is very important to understand the specific target population, and the purpose and guidelines for the study.

Population characteristics

Consider age (e.g. toddlers, adolescence, elderly, etc.), pregnant/lactating, literacy level and cognitive abilities of the respondents will have an impact on the mode of administration.

Food and meal patterns

The nutritionist/dietician needs to understand the food and meal patterns of the target population and identifying specific subgroups of the population who may have different meal patterns (e.g. shift workers, pregnant and lactating women).

Mixed diets (composite diets)

It is important to have an understanding of local recipes and to identify all ingredients consumed.

Gather information on dietary supplements (e.g. vitamins, minerals) as well.

Mode of administration for diet history

Face-to-face with an interviewer or computer-administered (interviewer-based or self-administered).

Length of assessment

To reduce respondent fatigue and over-reporting, interview length should be kept short.

Reference period for the interview, e.g. previous weeks or months. Keep in mind that recalling diets from the distant past (e.g. previous year) may result in recall bias

Recording method

Use of food models, photographs and/or standard household measures.

Brand names, a complete description of the method of preparation and cooking, and the recipes for composite dishes should all be recorded.

Capacity of the dietary assessment coordinator

A trained nutritionist is needed to conduct the interview.

The nutritionist should have experience in gathering detailed information on the consumption of food and drink, and information related to the respondents' food habits, e.g. food allergies, seasonal variations and dietetic preferences, etc.

They should know how to probe the respondent using standardized and non-leading questions.

The dietitian or nutritionist needs knowledge of local foods (including brands), preparation methods, recipes and portion size.

Availability of a food composition database

Ensure a complete and up-to-date food composition database is available which also includes locally available foods.

Advantages of diet history

- It estimates nutrient intakes over a long period of time
- Provides quantitative estimates of energy and nutrient intakes
- Does not rely on the literacy of the respondent
- Provides information on foods that are not regularly consumed
- Does not interfere with normal eating habits
- Provides details of meal patterns, individual foods consumed and usual food intake after completing a single interview

Disadvantages of diet history

- It takes about one hour of careful questioning, and the interviewer must be a nutritionist or dietitian experienced in obtaining diet histories.
- Labour-intensive, time-consuming, may not be suitable for young children and elderly respondents
- To obtain detailed information on food intake, longer interview times are needed, resulting in high respondent burden
- Portion size estimation of past meals can be difficult, even with the use of aids
- Requires trained personnel with knowledge of local food culture and eating patterns (interview-based dietary history)
- Requires literate respondents with the ability to estimate portion size (self-administered dietary history).
- Expensive to administer
- Data entry and coding is time consuming and requires trained personnel

Prospective direct methods

These methods involves recording of the all the food and beverages consumed at the time of consumption, hence allowing for current food intake to be recorded.

The methods involve weighing and recording food, estimating and recording food and duplicate meal method.

Food diary

Food intake (types & amounts) should be recorded by the subject at the time of consumption. The length of the collection period range between 1-7 days. Reliable but difficult to maintain.

Observed food consumption

The most unused method in clinical practice, but it is recommended for research purposes.

The meal eaten by the individual is weighed and contents are exactly calculated.

The method is characterized by having a high degree of accuracy but expensive & needs time & efforts.

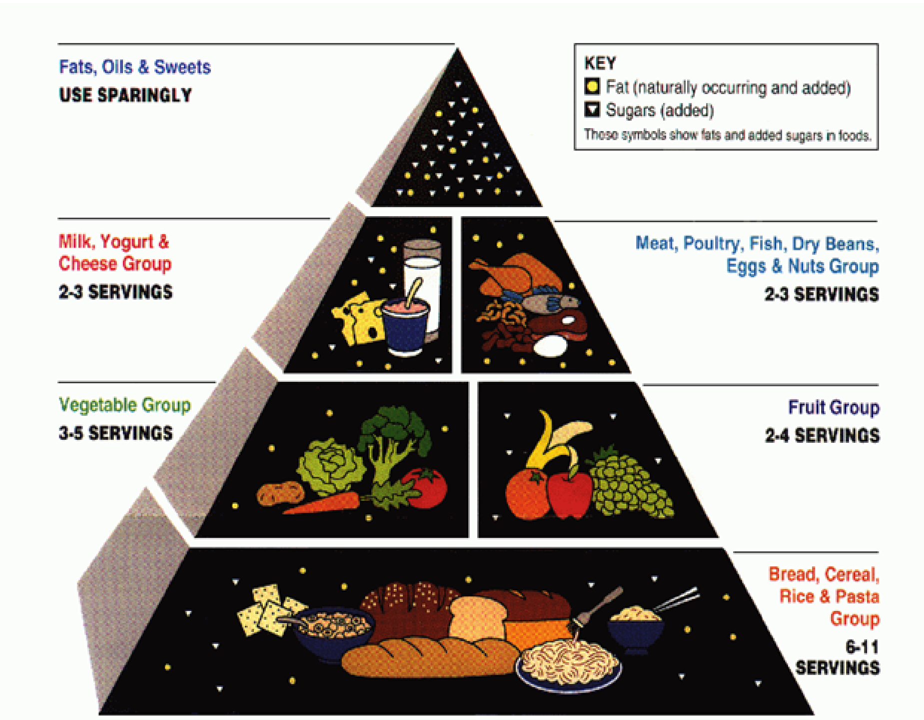
Interpretation of dietary data

Qualitative Method

Using the food pyramid & the basic food groups method.

Different nutrients are classified into 5 groups (fat & oils, bread & cereals, milk products, meat-fish, poultry, vegetables & fruits)

Determine the number of serving from each group & compare it with minimum requirement.



Quantitative Method

The amount of energy & specific nutrients in each food consumed can be calculated using food composition tables & then compare it with the recommended daily intake.

Evaluation by this method is expensive & time consuming, unless computing facilities are available.

Illustrations

Food Diary

Daily Calorie Goal 2150

Date	Meal	Food / Drink	# of Servings	Serving Size	Protein (g)	Carbs (g)	Sugar (g)	Fat (g)	Calories
Tue, Aug 15, 2017	L	Peanut Butter Sandwich	1	1	10.3	42.2	12	14.2	327
165		DAILY TOTALS (Calories Remaining: 1823)			10.3	42.2	12	14.2	327

Date	Meal	Food / Drink	# of Servings	Serving Size	Protein	Carbs	Sugar	Fat	Calories
Wed, Aug 16, 2017									
		DAILY TOTALS							

Date	Meal	Food / Drink	# of Servings	Serving Size	Protein	Carbs	Sugar	Fat	Calories
Thu, Aug 17, 2017									
		DAILY TOTALS							

CASE STUDY

George is 42 years COPD has been referred to your clinic for dietary assessment. He lives alone and he is always anxious and depressed, his health affects day to day function and is very limited on what he is able to do. He attends physiotherapy twice a week. He has never seen a dietician.

Weight 61.0 kg, height 183 cm

Weight loss has occurred gradually over the last 6 years and has had 5 hospital admissions this year.

To receive lung transplant George must reach a goal weight of 67.0 kg

Diet history

- B/F Tea with bread
- Lunch small meal of rice and soup
- Dinner Ugali manage (sometimes too tired to eat)
- Snacks rarely

Questions

Prepare a dietary plan to evaluate the effectiveness of your intervention

18.3.5.3 Self-assessment

1. Define the following terms;

   i. Dietary history

   ii. Nutrient intake analysis

   iii. Household food consumption

2. _______________ is a structured interview method consisting of questions about habitual intake of food and beverages over a long period of time

   A. Food diary

   B. Diet history

   C. Food frequency questionnaire

   D. Dietary records

3. Which one of the following methods of dietary assessment is in the prospective direct method category?

   A. Duplicate meal method

   B. Household consumption and expenditure surveys

   C. Dietary history

   D. Food balance sheets

4. The procedures to minimize errors during 24-hour recall include;

   A. Create a standardized interview protocol.

   B. Calibrate utensils in the home and use standardized methods for portion size estimates.

   C. Use effective probes/prompts to reduce respondent memory lapses.

   D. All of the above

5. Differentiate between;

   A. Indirect methods and direct methods of dietary assessment

   B. Prospective and retrospective methods of direct methods of dietary assessment

6. Describe the factors you would need to put into consideration when collecting dietary data using;

   i. 24-hour dietary recall

   ii. Food frequency questionnaire (FFQ)

7. Highlight the advantages and disadvantages of using diet history as a method of collecting dietary data

8. Outline the prospective direct methods which are used to assess food intake

18.3.5.4 Tools, Equipment, Supplies and Materials

A file/archive with the name and telephone numbers of the participants and when they can be contacted (which days, and time of the day)

Computerised interview program (alternatively lists with predefined questions)

Picture brochure for food quantification

Telephone equipped with headset

Quiet surroundings

Computers with internet

Library and resource Centre

WHO guidelines

MOH policies and guidelines

Skills lab

LCDs, video clips, charts and other teaching aids

Stationery

Invited expert

18.3.5.5 References

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18.3.6 Learning Outcome 5: Conduct nutrition surveillance

18.3.6.1 Learning Activities

Learning activity	Special instructions
Determine method of nutrition surveillance Meaning of nutrition surveys Identify and describe the steps in conducting nutrition surveys (nutrition survey designs, sampling methods, determining sampling size, data collection tools etc	Select the correct method of dietary assessment Determine the tools for assessing dietary diversity Be keen to identify any possible errors in dietary assessment
Obtain surveillance information Identify the sources of surveillance information Determine the steps to follow during nutrition surveillance	Conduct nutrition surveillance
Determine type of nutrition surveillance systems	Apply nutrition surveillance systems

18.3.6.2 Information sheet

Definitions

Importance of nutrition surveillance

Establish the baseline of a health condition

Understand trends and pattern of disease

Detect outbreaks or emergence of new disease

Estimate the magnitude of health problem

Identify resources needed during and after public health emergencies

Evaluate public health programs and control measures

Determine nature and history of disease

Monitor changes in infectious agents

Set research priorities

Stimulate research

Inform research plan and implementation

Support public health program planning

Monitor changes in public health practice

Methods of nutrition surveillance

The methods of data collection in Nutritional Surveillance systems are usefully grouped into four categories:

1. Repeated surveys (national sample surveys and smaller-scale surveys),
2. Growth monitoring (clinic based and community based),
3. Sentinel site surveillance (community based and centrally based)
4. School census data.

Repeated surveys at national level

The main strength of national surveys is that they are representative of an entire population and can therefore be used to assess the impact of national nutrition-related programs. Survey results may also be useful in determining geographical areas for targeting on the basis of high levels of malnutrition.

Weaknesses include the very high costs of implementation, the frequent lack of contextual information, the exclusion of some population groups and the inability to disaggregate data on the basis of gender or socio-economic groupings.

National-level surveys can be expanded or adapted to capture the impact of a major crises and to determine where resources are most needed.

Repeated small-scale surveys

The advantage of repeated small-scale surveys is that they are relatively quick to implement and to analyze.

In emergency contexts, this is particularly important as data on the prevalence of wasting can be used to trigger specific interventions, although this may be problematic in situations of chronic emergency.

The weaknesses of using repeated smaller-scale surveys relate to the often limited scope for data disaggregation which may not be sufficient to allow targeting of particular population groups (targeting may in any case be difficult for political reasons).

The costs, in terms of human resources and staff time, are also high when surveying in widely dispersed communities. Obtaining statistically representative samples in areas of insecurity may also be a problem

Growth monitoring

Growth monitoring refers to the continuous monitoring of growth (usually weight for age) in children.

Growth monitoring can be conducted by health professionals at Maternal and Child Health (MCH) clinics (clinic-based) or by trained members of the community in villages (community-based).

The main objective of growth monitoring is to monitor and manage the nutritional status of individual children and to mobilize local resources to support nutrition-related activities.

Families with children at risk may be given a food supplement and/or nutrition counseling. Children are usually measured once per month. Community based growth monitoring is mainly used in UNICEF supported programs or by international NGOs

Clinical-based growth monitoring

An important strength of clinic-based growth monitoring data is that it is frequently the only regular source of nutritional data available nationally.

Furthermore, as it is frequently an established part of the national health information system, it is an easily accessible source of data providing a potential source of information on trends and allowing comparison between geographical areas.

Through identifying vulnerable geographic areas, targeting decisions can be made. Clinic-based growth monitoring data may be especially useful in emergencies where there is insecurity and it is not possible to carry out surveys.

It may also provide early warning of a deterioration in health and food security.

A major weakness with using clinic-based growth monitoring data is that the population who attend clinics is not representative of the total population.

There are several reasons for this.

Firstly, only 'healthier' children tend to attend clinics for growth monitoring.

Secondly, fewer children over the age of one year attend clinics for growth monitoring as vaccinations are complete and mothers may see no reason to attend.

Thirdly, weighing and recording by clinic staff can be inaccurate.

Nevertheless, the problems of under reporting at clinics is likely to be true in all clinics, thus information collected from different regions of the country can still be usefully compared and changing levels of malnutrition can be assessed.

There are, however, some reported cases in the literature where this is not the case

A further problem with clinic-based growth monitoring is that MCH staff often do not have the time or the training to be able to analyze and act on the population data which they are collecting.

Usually it is necessary for a central body to collect and analyze data sent in from the clinics. This requires resources that many governments do not have. Unless donor funding is forthcoming, therefore, vast amounts of data can be collected but are not analyzed or used.

The system may be unsustainable without outside donor funding and so the system collapses. Clinic-based growth monitoring data also suffers from the constraint that information, which could explain the causes of malnutrition, is not necessarily available.

Growth monitoring data alone is of limited use.

Community based growth monitoring

Community-based growth monitoring is widely supported by UNICEF, international NGOs and, more recently, World Bank supported nutrition programs.

An important element of this approach is to empower communities to gather, interpret and act on nutrition-related information. The strengths of a community-based growth monitoring system is that it can work very well when community nutrition mobilisers are adequately resourced, trained and supported to facilitate communities to deal with nutritional problems.

They can also provide a more comprehensive coverage of the under-five population compared to clinic-based growth monitoring.

The weaknesses of this approach include problems of data accuracy, delays in analysis, lack of contextual information to complement the growth monitoring data and difficulties in ensuring that information receives attention from the district or regional level

Sentinel site surveillance

Sentinel site surveillance refers to the monitoring of purposively selected communities or service delivery sites in order to detect changes in context, program and outcome variables.

Communities are purposively selected for a number of reasons. For example, a community may be of particular interest because of its innovative farming practices or a community may be particularly vulnerable to food insecurity in times of crop failure.

Data can be collected and analyzed centrally (centrally-based) or by trained members of the community (community-based). Clear distinction may be difficult as centrally based systems may have elements of community involvement.

Centrally based systems are more likely (but not always) to carry out statistically valid anthropometric surveys.

Centrally-based sentinel site surveillance

Centrally-based systems are less costly than national surveys and can reveal more in-depth information on the causes of malnutrition.

Data collectors tend to spend a longer period in the targeted communities (as they are covering fewer areas) and, where the results are pre-processed in the field, rapid feedback can be given to the community.

Where the surveillance targets the most vulnerable communities, this can provide good early warning of crises.

The main weaknesses of the approach are: the lack of inclusion of population groups which may also be of interest but have not been selected; the fact that the data collected is not representative of the wider population and cannot be generalized; and the risk that the data may not be comparable with other survey data

Community-based sentinel site surveillance

Community-based surveillance, as with community-based growth monitoring has the potential advantage of empowering the community whilst at the same time being of relatively low cost when compared to centrally based systems.

This kind of system is particularly useful in emergencies when insecurity prevents representative sampling. The major constraints of the method are that the areas selected may not be representative of the wider population and that data quality may not be high.

These constraints may mean that data are not used by decision-makers because of their unreliability, and that as a result of inaction, the level of community participation is reduced.

Another constraint may be the 'opportunity cost' to those collecting data as there may be no remuneration.

School census data

Nutritional indicator monitoring is occasionally undertaken in schools.

The usual form of measurement is height for age (height retardation or stunting). First grade children are often measured through censuses that are carried out every two to three years.

The method has been used to identify high-risk populations with poor health, malnutrition and low socio-economic status.

The main strengths of this method are that it is both cheap and provides very good population coverage.

Importance of nutrition surveillance information

The general purpose of surveillance is to reduce mortality and morbidity through timely prevention and control through;

- Understanding the problem
- Defining priorities
- Setting objectives
- Determining strategies
- Evaluating control/prevention
- Suggesting further research

Initiating surveillance system activities

- Choose a condition that has proved control measures available
- Define how data collected shall be used
- Set a standard case definition
- Use existing system

- Visit those who supply data
- Develop a database
- Develop a regular reporting system for distribution

Sources of surveillance data

- Mortality
- Morbidity
- Case reports
- Epidemic reporting
- Epidemic field investigations
- Demographic and environmental data
- News media

Surveillance processes involve;

- Routine surveillance
- Active reporting
- Sentinel physician reporting
- Laboratory surveillance
- Hospital surveillance
- Data analysis
- Reports and evaluation

Principal Users of Nutrition Surveillance Systems Information

1. Government departments
2. Research Institutions
3. International Organizations- WHO, UNICEF
4. Regulatory, advisory and professional bodies

Nutrition surveys

Despite all efforts undertaken both nationally and internationally, poor nutritional status is still a fundamental cause of disease and shortened life-span.

Most people are aware that many factors are either directly or indirectly responsible for undernutrition, including insecure food supply, lack of basic education, inadequate health services, deteriorated environment, low income, and inadequate empowerment.

The factors contributing to malnutrition vary from community to community

To improve the nutritional status and improve living conditions in communities, it is necessary to determine the nature, magnitude and causes of malnutrition.

Anthropometric indices are internationally accepted as nutrition key indicators of populations. Additionally, they have been recommended repeatedly as a suitable key indicator for poverty as well.

The use of anthropometric indicators is based on the extensively observed phenomena that a growing child who lacks an adequate intake of food and is repeatedly ill, does not have the body height corresponding to its genetic potential.

Furthermore, inadequate food availability, caring capacity, basic education, health systems, housing and environmental conditions have been proven to be underlying causes of inadequate food intake and repeated episodes of diseases.

To measure the impact of nutrition-oriented programs/projects, i.e. self-standing nutritional programs/projects and nutrition-related programs/projects, it is necessary to collect quantitative information.

Therefore, projects/programs must start with a baseline survey, and such survey must be repeated periodically.

The purpose of nutrition survey findings is to:

Identify emergency affected populations and confirm the occurrence of a food and nutrition emergency.

Estimate the number of malnourished individuals, the kind of malnutrition and target the most vulnerable populations for intervention. It is essential to standardise nutrition survey methods so that findings can be compared to findings of surveys in other areas and over time (see Tables 9-6 and 9-7);

Monitor the adequacy of food and nutrition emergency interventions and improvement in the nutritional status of the affected population. The first survey in an area can be used as a baseline.

Objectives of a nutrition survey

To provide information that contributes to the analysis of causes and associated factors and therefore permits a selection of preventive measures, which may or may not be nutritional.

To promote decisions by governments concerning priorities and the disposal of resources to meet the needs of both “normal development” and emergencies.

To enable predictions to be made on the basis of current trends in order to indicate the probable evolution of nutritional problems. Considered in conjunction with existing and potential measures and resources, these predictions will assist in the formulation of policy.

To monitor nutritional programmes and to evaluate their effectiveness.

In emergency settings, the objectives specifically focus on:

A warning system. This is used as a means of highlighting an evolving crisis.

Identification of appropriate response strategies. These may include non-food as well as food assistance to address the underlying causes of malnutrition.

Triggering a response. Nutrition surveillance systems provide a trend analysis focusing on the magnitude of change. This may trigger an in-depth assessment, which in turn may lead to a response.

Targeting. Nutrition information can help target areas that are more at risk or in greater need of assistance.

Identification of malnourished children. Some forms of surveillance can identify acutely malnourished children.

Challenges

The most important aspect of a food and nutrition surveillance system is to ensure effective links between information and action. However, the reliability of data, timeliness of reporting, efficient action management and sustainability are challenging. A further challenge is the interpretation of findings. Similar levels of acute malnutrition have different significance, depending on the context. Unless the underlying causes of nutritional disorders are understood, an appropriate response may not be provided.

Sustainability

One of the biggest challenges is ensuring effective continuity of the system. One of the main reasons for the failure of surveillance systems in the past was that national or local governments were unable to provide the resources needed to maintain them. When establishing a surveillance system, it is essential to consider and plan for long-term sustainability, especially in areas where there is a high probability of prolonged crisis. Ideally, if a system proves to be effective and sensitive in monitoring change over time, there should be no difficulty in justifying long-term resource provision. An accurate early-warning mechanism that triggers a response is far more cost

Types of nutrition surveys

There are four types of nutrition surveys (rapid appraisal, rapid assessment, baseline survey and follow-up survey); each is important for a different type of project or a different phase of a project.

Rapid appraisal.

Rapid appraisal methods are quick, low-cost ways to gather the views and feedback of beneficiaries and other stakeholders, in order to respond to decision-makers' needs for information of the nutritional situation, information on the nutritional condition of the target community should first be obtained during the planning phase using qualitative method. Qualitative methods are used. Anthropometric data (such as height and weight) are not recorded in this type of survey.

Advantages of rapid appraisal:

- Low cost.
- Can be conducted quickly.
- Provides flexibility to explore new ideas.

Disadvantages:

- Findings usually relate to specific communities or localities—thus difficult to generalize from findings.
- Less valid, reliable, and credible than formal surveys.

Time Required:

Four to six weeks, depending on the size and location of the population interviewed and the number of sites observed.

Methods of rapid appraisal

Selected for their knowledge and experience in a topic of interest. Interviews are qualitative, in-depth, and semi-structured. They rely on interview guides that list topics or questions.

Focus group discussion - a facilitated discussion among 8–12 carefully selected participants with similar backgrounds. Participants might be beneficiaries or program staff, for example. The facilitator uses a discussion guide. Note-takers record comments and observations.

Community group interview - a series of questions and facilitated discussion in a meeting open to all community members. The interviewer follows a carefully prepared questionnaire.

Direct observation - use of a detailed observation form to record what is seen and heard at a program site. The information may be about ongoing activities, processes, discussions, social interactions, and observable results.

Mini-survey - a structured questionnaire with a limited number of close ended questions that is administered to 50–75 people. Selection of respondents may be random or 'purposive' (interviewing stakeholders at locations such as a clinic for a health care survey).

Rapid assessment

Anthropometric data are measured to obtain information on the type of nutritional problems using quantitative methods.

However, the sampling selection and sampling coverage do not allow quantitative conclusions to be made concerning the prevalence of nutritional problems that can be generalized for a broader population.

Both the rapid appraisal and the rapid assessment are suitable for a pre-feasibility study for the assessment of the nutritional situation.

One of these two types of surveys should be used for identification of the project during the planning phase.

Baseline surveys

The objective of a baseline survey is not to undertake pure research.

As the fundamental causes of malnutrition are known, it is unnecessary to gather scientifically supportable proof of a causal relationship for a nutritional problem.

A survey should record all possible important variables known from literature to be responsible for nutritional problems.

If, for example, no statistical relationship can be identified between nutritional indicators and early weaning in a project area under survey due to the small sample size, the higher percentage of early weaned children should, nevertheless, be included in a problem tree and suitable intervention measures, e.g., nutritional advice, should be considered.

Of course, these variables must be tested for their relevance no later than a pilot testing.

Importance of baseline studies

Baselines surveys are important for any project for the following reasons:

It is a starting point for a project: One important, and recommended, way of starting a project is to carry out a baseline study. Through its results, a baseline serves as a benchmark for all future activities, where project managers can refer to for the purposes of making project management decisions.

Establishing priority areas/planning: Baseline studies are important in establishing priority areas for a project. This is especially true when a project has several objectives.

Attribution: Without a baseline, it is not possible to know the impact of a project. A baseline study serves the purpose of informing decision makers what impact the project has had on the target community. Accordingly, along with other strategies such as use of control groups, it also helps in attributing change in the target population to the project

Baseline tools are used for evaluation: the tools used during a baseline study are normally the same tools used during evaluation.

Donor requirement: In most cases, it is a donor requirement that a baseline study is carried out as part of the program process.

Since M&E is integral for any donor to establish future project success, they might, and always do compel implementing organizations to carry out baseline studies.

Objectives of nutrition survey

The following individual activities are part of the process of a baseline survey:

- to initiate dialogues among all groups participating in a project (target group, non-governmental organizations, governmental authorities, donors, and project implementation personnel) concerning the living situation of the poor,

- to assess the needs of the poor, in particular, about their problems in daily life,
- to increase the awareness and sensitivity of the specialists involved in the project and also those responsible for programs designed to improve the basic need situation of the poor,
- to reveal the nature, magnitude and severity of the nutrition- and poverty-related problems and their possible causes,
- to identify the particularly affected target groups,
- to arrive at a causal model (problem tree),
- eventually to propose additional smaller in-depth surveys that are necessary to be carried out to diagnose important causes of poverty problems,
- to identify the appropriate scope of intervention for the improvement of the poverty situation,
- to identify project-defined indicators (poverty-related socioeconomic determining factors) for evaluation,
- to determine the impact of project measures on living conditions of the observed risk groups, and finally to obtain data for cross-sectional comparisons between the country and the project target groups.

Follow up survey

A follow-up survey (or multi-round survey or multi- phase survey) is a type of survey in which households included in it are repeatedly interviewed in the second, third, fourth or more visits, to obtain information on vital events by noting the changes in composition of the households that have taken place between successive visits.

The follow-up survey assesses the impact of the project or individual project measures on the nutritional condition of a community (for further information)

Types of evaluation

Context evaluation: Context evaluation is concerned with the assessment of existing information of the funding agency, the target group and the general programme environment.

Formative evaluation: This is the day to day running of the programme towards acquisition of short term objectives therefore assess programme input, output or services and the general events in the programme environment

Impact evaluation: Determine the ultimate effect on the beneficiaries in the long term. It is concerned with ultimate programme indicators.

Reasons for evaluation

- Provide useful information for other ongoing or future programme in the community
- To provide useful information to stakeholders
- To determine whether the programme was successful or not

Evaluation indicators should be specific, independent and valid. The evaluators are either insiders who implemented, took part in the planning of the programme and are more knowledgeable about the programme or external people who did not take part in the planning and implementation of the programme.

The external people are more objective than insiders.

Indicators for nutrition survey

Anthropometry e.g. weight, height, sex, edema, and age

- Global Acute Malnutrition (GAM)
- Severe Acute Malnutrition (SAM)
- Edema (bilateral edema)

Coverage of feeding centers: check out how well populations have enrolled in feeding programs.

Micronutrient deficiencies: check out for signs of anemia and other micronutrient deficiencies such as goiter for iodine, rickets for vitamin D etc

Mortality: this is most applicable where surveillance systems of deaths are lacking and entails listing all household members with their gender, age and births/deaths

Morbidity: this indicator focuses on the total incidences of diarrhea and acute respiratory illness within a period of two weeks.

Measles and vitamin A coverage

Breastfeeding and complementary feeding practices

Steps in conducting nutrition surveys

There are two main steps involved

1. Planning the survey
2. Administering the survey

Planning the survey

For a survey plan to succeed, the following principles must be put into consideration;

Review of existing information: involves determination of the nutritional and health status, socio-economic background, food security, cultural issues, geographical location, population and settlement patterns. This information helps one to understand the actual nutrition problem, define appropriate objectives and plan for sufficient equipment and develop an appropriate survey schedule.

Identification of survey goals and objectives: these will help in ensuring that effective outcome of the survey results is achieved. They help to inform the survey coordinator on why the nutrition survey is being conducted and the types of information needed and how this information will be used.

Identification of survey indicators: these indicators will form a range of variables for the survey. The most commonly used indicators include anthropometric indicators, mortality data, morbidity data, infant feeding, care practices and household food consumption patterns.

Selection of survey methodology: this points towards the type of survey design to be used, whether the survey will focus on households or target population only.

Selection of survey sample: sample is a proportion of a total population which is very useful when dealing with a very large target population. Different sampling methods can also be applied to get the representative sample, depending on the goals and objectives of the survey. These include;

- Simple random sampling
- Systematic random sampling
- Stratified sampling
- Two-stage Cluster sampling

The sample size is determined by the expected prevalence of the characteristics to be measured and the desired degree of precision in the estimated. Nutrition surveys require different sample sizes necessitating different types of sampling techniques so as to collect anthropometric, clinical and biochemical data. A sample method for calculation sample size is as follows;

$$n = \frac{k \times t^2 \times (1-p) \times p}{\gamma^2}$$

n= sample size

k= design effect- for simple random sample, use 1

t= confidence interval (1.96 for 95% confidence interval)

p= estimated prevalence of malnutrition

γ= precision

Nutrition survey designs should be constructed by the nutritionists and statistician together. The data collection tools that can be used in nutrition surveys include questionnaires, interviews

Identification of the types of personnel, equipment and resources required for carrying out nutrition survey

Agreement on roles and responsibilities of partners whereby all measures should be put in place to ensure all representatives of each sector represented is involved in the survey

Preparation of activity schedule: a detailed time and activity schedule which are to be completed within the set time frame and cost.

Development of data coaction instruments: these are resources that will be used to collect data and may include; questionnaires, interview schedules, focus group discussion guides and observation checklists

Pretesting of data collection instruments

Administering the survey

This step will involve translating the plans into actions as follows;

- Logistical arrangements
- Survey team selection
- Training research personnel
- Supervision of survey process
- Actual data collection activities
- Selection of appropriate data processing methods and ensuring quality control procedures

Data analysis: done using appropriate statistical tools. Data entry and clustering should be done then cleaned, analysed and interpreted. Different software can be used to analyse nutrition surveys and examples include; NutriSurvey, Epi-Info software. The most preferred is NutriSurvey because of its convenience in analysing anthropometric and mortality data. However, it lacks capability to analyse other data in the survey like morbidity, feeding practices among others hence Epi Info can be used to cover such.

Interpretation of data: this should be done by comparing the actual findings per indicator against a standard reference like the cut-off points in anthropometry.

Report writing

Discussion on the survey findings and recommendations

Dissemination of survey findings to the partners, mostly capturing;

Demographics:

- Number of children (categorised in gender)
- Age and age group distributions
- New arrivals (non-regular members)

Nutrition status

Median/mean weight-for-height and height-for-age z-scores

- % severe, moderate and global acute malnutrition (total, age, sex)

- % severe, moderate and global chronic malnutrition (total, age, sex, new arrival status)
- % edema and angular stomatitis

Programme coverage

- % currently enrolled in SFP/TFP and % below -2 z-scores who are not enrolled in SFP/TFP
- % that received vitamin A supplement within last 6 months, last 1 year, last 2 years, last 3 years, last 4 years and % never received vitamin A supplement

Number referred to SFP/TFP during survey

Once the nutrition survey is completed, there is need to follow up with stakeholders on how to use nutrition data generated from survey;

Implement nutrition survey recommendations continue monitoring and evaluation of the situation.

18.3.6.3 Self-assessment

1. Define the following terms

    A. Surveillance

    B. Nutrition survey

    C. Growth monitoring

2. Which of the following is a weakness of repeated small scale surveys?

    A. very high costs of implementation

    B. Frequent lack of contextual information

    C. limited scope for data disaggregation which may not be sufficient to allow targeting of particular population groups

    D. The exclusion of some population groups

3. Which one of the following is not a principal user of nutrition surveillance systems information?

    A. Households

    B. Government departments

    C. Research Institutions

    D. Regulatory, advisory and professional bodies

4. ________________ a series of questions and facilitated discussion in a meeting open to all community members. The interviewer follows a carefully prepared questionnaire.

   A. Mini survey

   B. Direct observation

   C. Community group review

   D. Focus group discussion

5. Explain the importance of nutrition surveillance

6. Describe the methods used in nutrition surveillance

7. You are the dietician working at Kakuma refugee camp. One of your key duties is to conduct nutrition surveillance among the populations. Answer the folloing questions in light of this

8. How are nutrition surveillance activities initiated?

9. Identify the sources of surveillance data

10. Highlight the principle users of nutrition surveillance systems information

11. Outline the objectives of nutrition survey

12. Discuss the various types of nutrition surveys, citing their advantages and disadvantages

13. Discuss the steps followed when conducting nutrition surveys

18.3.6.4 Tools, equipment, supplies and resources

Computers with internet

Library and resource Centre

WHO guidelines

MOH policies and guidelines

Skills lab

LCDs, video clips, charts and other teaching aids

Stationery

Invited expert

18.3.6.5 References

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