SCHOOL OF SCIENCE AND TECHNOLOGY

APPLIED SCIENCE-II

BSN 2306

PHYSIOLOGY

BANGLADESH OPEN UNIVERSITY
SCHOOL OF SCIENCE AND TECHNOLOGY

APPLIED SCIENCE–II

BSN 2306

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BANGLADESH OPEN UNIVERSITY

Published by:
Publishing, Printing and Distribution Division
Bangladesh Open University, Gazipur-1705

September 2006

Computer Composed and DTP Layout by:
Md. Jakir Hossain

Cover Designed by:
Md. Monirul Islam

Printed by:
Sumi Printing Press & Packaging
9, Nilkhet, Babupura
Dhaka-1205

ISBN 98-34-4009-9

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Preface

Applied Science-II is one of the foundation courses of health science and is very important component of students in medical disciplines. B.Sc.-in-Nursing students have to learn the course very attentively for their career development. All modules for distance learners have some specificity and specialty in respect of the style or format of presentation. Here lesson begins with learning objectives and ends with exercises. Self-activities are so designed that the learner will have the base at the text and will have to work a little more for a completed answer. Important messages can easily be given the self-activity exercise that has not been totally covered in the short text. In fact learners will get the clue for further reading through the self-assessment questions. Most of the portions of the course are self-illustrating but some identified areas have been recorded for audio-visual aid. The assigned teacher will demonstrate practical portion of the course. This mark will be added at the final examination. This course has been prepared by active participation of the course development team and has been examined by the referee. In spit of it, any suggestion would be highly appreciated regarding further enrichment of the book.

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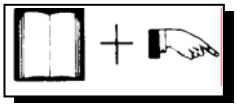
PHYSIOLOGY

Unit 1: Concepts of Physiology

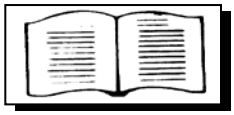
Lesson 1: Review of Basic Concepts

1.1. Learning Objectives



At the end of this lesson you will be able to-

- define of physiology and its branches
- reproduce historical perspective of physiology
- describe basic principles of physiological processes.



1.2. Definition of Physiology

Physiology is the study of the function of living organisms, animals or plants, and of the functions of their constituent tissues or cells.

Physiology is the study of the functions of living organisms, animal or plant, and of the functions of their constituent tissues or cells

Physiology may also be defined as the branch of biology that deals with internal functions of living things, including metabolism, respiration and reproduction, rather than their shape and structure.

Physiology *deals with the study of the physical and chemical processes that take place in living organisms during the performance of functions*. It is mainly concerned with life activities like reproduction, growth, metabolism, excitation, and contraction as they are carried out within the fine structures, cells, tissues, organs, and organ systems of the body.

Classification

Physiology uses many physical and chemical tools for its biological performances and hence it has been a distinct discipline from the 19th century. Till today three broad divisions are commonly described -

1. General physiology- concerned with basic processes common to all life forms.
2. Animal physiology- concerned with functional anatomy of humans and other animals, pathology and comparative studies.
3. Plant physiology- concerned with processes pertinent to plant life e.g. photosynthesis.

In addition to the above main branches there are many other working sub-branches in physiology. These are discussed sequentially in the text.

1.3. Historical Perspectives

Historical Perspective

Alexandrian physician Herophilus in about 300 BC used to study physiology by dissected body of the criminals. This is probably the earliest record for study of physiology.

Chronology of the development of the subject might be-

1. In 1616 English physician William Harvey discovered blood circulation.

2. Flemish chemist Jan Baptista vans Helmont developed the concept of gases and suggested the use of alkalis in treating digestive disturbances.

3. Italian biophysicist Giovanni Alfonso Borelli studied of animal motion.

4. Dutch microscopist Antoni van Leeuwenhoek gave the first descriptions of red blood cells and spermatozoa.

5. Italian histologist Marcello Malpighi demonstrated the existence of capillaries and studied the physiology of the kidney, liver, and spleen.

6. The English physiologist John Mayow showed that air was not a single substance but a mixture of several, not all of which were necessary for life.

7. In the 18th century, the British chemist Joseph Priestley showed that the proportion of oxygen essential for animal life is identical with the proportion of oxygen needed to support combustion. Antoine Laurent Lavoisier, the French chemist, isolated and named oxygen shortly thereafter and showed that the by-product of respiration is carbon dioxide.

8. Dutch physician Hermann Boerhaave and his pupil, the Swiss scientist Albrecht von Haller did much work for modern physiology during the 18th century. They laid the foundation for an integrated study of physiology through their criticism of the iatrochemists (scientists who believed physiology involved only chemical reactions) and the iatrophysicists (scientists who believed physiology involved only physical reactions), Haller was the first scientist to state that all living matter possesses irritability.

9. Sir Michael Foster became Professor of Practical Physiology at University College in London in 1869. He taught the first ever offered laboratory course as a regular part of instruction in medicine.

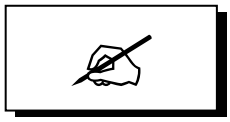
10. In the 20th century Physiology has grown as a mature science and has been able to become the parent of a number of related disciplines like biochemistry, biophysics, general physiology, and molecular biology. Many research areas like mammalian physiology have been fully exploited from a classical-organ and organ-system point of view and comparative studies in physiology is expected to continue.

11. In the 20th century extensive research work has been done on neurological advances of physiology. Lord Edgar Douglas Adrian, British Physiologist, measured and recorded electric potentials from sense organs and motor nerve fibers. Sherrington investigated the integrative action of the nervous system.

12. Later American physiologists Joseph Erlanger and Herbert Spencer Gasser demonstrated functional differences in nerve fibers and used the oscilloscope to record the variation of electrical impulses that occurs in these fibers. In fact they followed the work of Lord Edgar Douglas Adrian and Sherrington.

13. American biochemist Julius Axelrod, the Swedish physiologist Ulf von Euler, and the British physician Sir Bernard Katz demonstrated the role of specific chemicals in the transmission of nerve impulses. The importance of these investigations to such basic processes as the control of blood pressure and the mobilization of strength to meet an emergency is shown by the fact that all of the seven investigators mentioned received Nobel Prizes in physiology or medicine.

14. Still the solution of the major unsolved problems of physiology will require technical and expensive research by teams of specialized investigators. Bases of the phenomena of life yet remained to be explored.



Exercise: Reproduce the historical evolution of Physiology.

1.4. General Principles in Physiology

Moles

Mole may be defined as the molecular weight of any substance measured in gram. Molecular weight is a ratio of mass of one molecule of any substance to the mass of one-twelfth the mass of a C^{12} atom.

One milimole (mmol) is equal to 1/1000 mole, while one micromole (μmol) is equal to 1/1,000,000 mole.

E.g., 1 mol Nacl ≡ 23 g + 35.5g = 58.5g, while 1 mmol of Nacl ≡ 58.5 mg.

pH

May be defined as the negative logarithm of hydrogen ion concentration. pH of water at 25°C is 7.0. For pH less than 7.0, there is increment of [H+] where as decreases of H+ happens with high pH i.e., pH $\propto$ 1 / [H+].

Buffers

May be defined as a substance having the capacity to maintain the pH of any solution relatively constant, by binding or releasing of H^+, even after addition of considerable amount of acid or base.

Diffusion

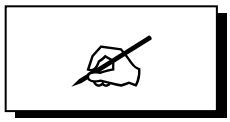
Diffusion is defined as a process by which a gas or a solute expands, along concentration gradient (higher to lower), to fill available volume because of movement of its particles. Diffusion is directly proportional to the cross-sectional area across which diffusion takes place.

Osmosis

Osmosis is defined as a process by which a solvent migrates through a semi permeable membrane to a place of greater concentration of the solute. The gradient is lower to higher, to neutralize the solvent concentration.

The pressure required for or to prevent solvent migration is called Osmotic pressure of the solution. In an ideal solution, osmotic pressure is related to temperature and volume.

One osmole (osm) is equal to the gram-molecular weight of a substance divided by the number of osmotically active particles that liberates in solution. The miliosmole (mosm) is $1/1000^{th}$ of 1 osm.



1.5.1. Exercise

1.5.1. Multiple Choice Questions

Tick (√) the correct answer

1. Physiology is the study of

   a. pathological processes
   b. drugs
   c. normal body mechanisms
   d. none of the above.

2. Diffusion is

   a. movement of solution
   b. movement of solvent
   c. movement of solute
   d. none of the above.

3. Osmosis occurs through

   a. semipermeable membrane
   b. impermeable membrane
   c. both of the above
   d. none of the above.

1.5.2. Short Questions

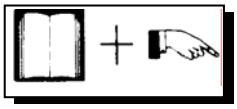
1. Define physiology.
2. Define diffusion.
3. Define osmosis.
4. Define osmotic pressure.

1.5.3. Broad Question

1. Define physiology. Describe historical perspective of physiology.

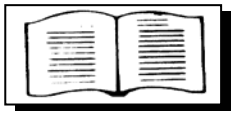
Lesson 2: Physiology of Blood-I

2.1. Learning Objectives



At the end of this lesson you will be able to-

- define blood and its functions
- reproduce composition of blood
- describe reticuloendothelial system and fate of RBC.



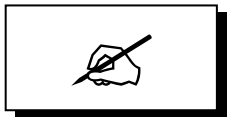
2.2. Definition of Blood

Blood is a specialized type of fluid connective tissue in which there is liquid intercellular substance known as plasma and formed elements: the red blood cells, the white blood cells and the platelets suspended in the plasma.

Functions of Blood

1. Transport oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs.
2. Transport hormones, vitamins and other essential chemicals to their site of action.
3. Convey nutrients absorbed from the intestine to the tissue cells for utilization and also remove of metabolism waste products.
4. Regulate of plasmas the colloidal osmotic pressure
5. Maintain body water balance
6. Maintenance of the acid base equilibrium
7. Regulate of the body temperature
8. Help in defensive mechanism
9. Help in coagulation of blood

Blood is a specialized type of fluid connective tissue containing plasma and formed elements



Exercise: Enumerate seven functions of blood.

2.3. Composition of Blood

Formed Elements (45%)	Plasma (55%)
1. Erythrocyte (RBC)	1. Water (91%)
2. Leukocyte (WBC)	2. Solid (8-9%)

3. Thrombocyte
   (Platelets)

a. Inorganic constituents

- Sodium
- Potassium
- Calcium
- Magnesium
- Bio-carbonate
- Chloride
- Phosphorus
- Iron

b. Organic constituents

i. Protein
- Albumin
- Globulin
- Fibrinogen

ii. Fat
- Cholesterol
- Phospholipids

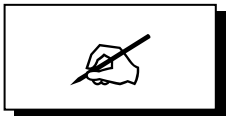
iii. Carbohydrate
- Glucose

iv. Non- protein nitrogenous part (NPN)
- Urea
- Uric acids
- Xanthine, hypoxanthine
- Creatine, creatinine
- Amino acid

v. Other substances
- Internal secretions
- Antibodies
- Various enzymes (amylase, proteases)

vi. Colouring matter

The yellow colour of plasma is due to small amounts of bilirubin, carotene and xanthophyllin.



Exercise: Write the composition of blood in tabulated form.

Erythrocyte (Red blood cell)

Formation and maturation of RBC under physiological condition is called erythropoiesis

- Manufactured in bone marrow. Life span of RBC is 120 days.
- About 7.5 μm in diameter & 2 μm thick each contains 29 pg of haemoglobin.
- Non-nucleated circular, biconcave disc with rounded thicker edges.
- Soft, flexible and can readily squeeze through narrow capillaries. Inside the cells there is a proteins and lipids framework.

Normal Red Cell Count

- Adult male: 5-5.5 million/ mm^3 of blood.
- Adult female: 4.5-4.8 million/ mm^3 of blood.
- Infant: 6-7 million / mm^3 of blood.

Site of Origin of R B C

1. Mesoblastic erythropoiesis– Embryonic life. RBC develops from the mesoderm of the yolk sac.
2. Hepatic erythropoiesis– During 2-6 month of pregnancy. RBCs are formed in the liver and spleen.
3. Myeloid erythropoiesis– After 6^{th} month of pregnancy to birth and also after birth. From bone *marrow*.

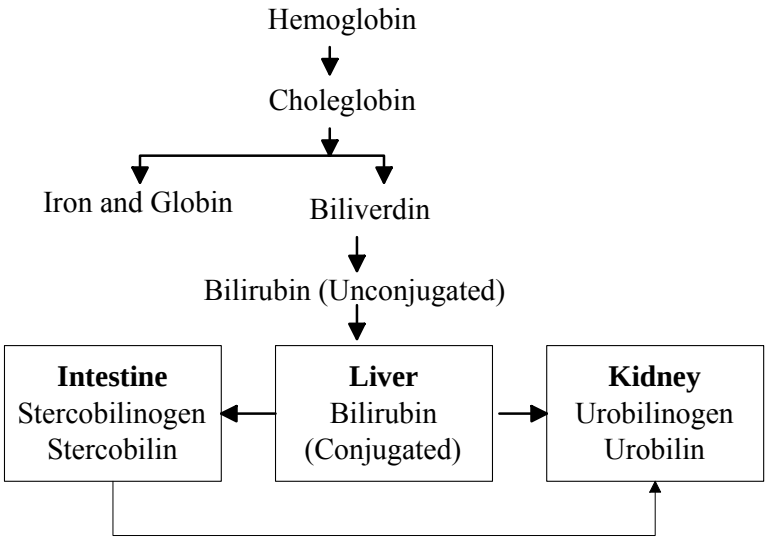
Stages of <u>Development of R B C</u>

- Stage 1 Haemocytoblast
- stage 2 Proerythroblast
- stage 3 Early normoblast
- Stage 4 Intermediate normoblast
- stage 5 Late normoblast
- Stage 6 Reticulocyte
- Stage 7 Erythrocyte.

Factors affecting for <u>Erythropoiesis</u>

- Diet
- Hypoxia
- Erythropoietin
- Hormones like
- Thyroid, Pituitary etc
- Vitamins
- Minerals.

Fate of R B C



2.4. Reticuloendothelial System

The system is applied to monocytes and macrophages located at the reticular substances of the body. The monocytes and macrophages engulf the damaged tissues, cellular debris or foreign bodies.

Components of RE System

1. Lymphocytes
2. Macrophages in spleen
3. Macrophages in bone-marrow
4. Histocytes in tissues
5. Kuffer cell in the liver.

Functions of RBC

1. RBC contains haemoglobin, which carries oxygen and carbon di oxide.
2. RBC helps to maintain acid base balance.
3. Red cells help to maintain the viscosity of blood.

Exercise: Describe item sentences about Erythrocyte.

Types of Polycythaemia

1. Primary polycythaemia rubra vera
2. Secondary polycythaemia

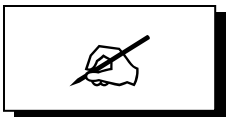
Loss/ destruction of RBC
- Haemorrhage
- Haemolysis
- Hypersplenis

   i. Hypoxia occmes in

   - High altitude
   - Cyanotic heart diseases
   - Pulmonary diseases.

Causes of Anaemia (Hb level < 13g/dl for male & 11.5 g/dl for female)

1. Severe blood uses due to any cause
2. Chronic blood uses due to nay cause
3. Deficiency of Fe^{++}, Vit.B_{12}, Folic acid, Vitamin C and Protein
4. Aplastic anaemia
5. Marrow infiltration in
   i. Leukaemia
   ii. Lymphoma
   iii. Myeloma
6. Symptomatic
   i. Chronic infection
   ii. Uraemia
   iii. Liver diseases
   iv. SLE
   v. Hypothyroidism
   vi. Hypopituitarism
   vii. Malignancy etc.



2.5. Exercise

2.5.1. Multiple Choice Questions

Tick (√) the correct answer

1. Blood is a

   a. vascular tissue
   b. connective tissue
   c. epithelial tissue
   d. none of the above.

2. Formed elements comprise

   a. 45% of blood
   b. 65% of blood
   c. 80% of blood
   d. none of the above.

3. Erythropoiesis is influenced by all the factors except

   a. vtamin B_6
   b. vitamin B_{12}
   c. folic acid
   d. vitamin A.

4. All of the following are causes anaemia except

   a. vitamin C deficiency
   b. vitamin B_{12} deficiency
   c. fat deficiency
   d. protein deficiency.

2.5.2. Short Questions

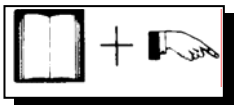
1. Enumerate inorganic composition of blood.
2. Name three important functions of blood.
3. Define reticuloendothelial system.

2.5.3. Broad Questions

1. Define blood. Describe the functions of blood.
2. Briefly describe the composition of blood? Name five buffers in human body.
3. What are the stages of erythropoiesis? Describe the fate of erythrocytes.

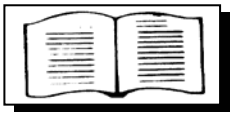
Lesson 3: Physiology of Blood-II

3.1. Learning Objectives



At the end of this lesson you will be able to-

- classify leucocytes
- reproduce properties and functions of WBC
- describe thrombocytes with functions
- describe the classification and functions of plasma proteins.



3.2. Leucocytes

Leucocytes are also called White Blood Corpuscles (WBC). Normal cunt of W B C is from 4000-11000 / mm^3. There are different types of leucocytes.

Classification

A. *Granulocytes* (Granules present in the cytoplasm): 03 types-

   i. Neutrophil (50-70%): half-life in circulation fine granules in cytoplasm neutral red is clover 06 hour; multilobular nucleus

   ii. Eosinophil (1-4%): Coarse red granules in cytoplasm

   iii. Basophil (0-2%): purple blue granules in cytoplasm.

Diapedesis : Is the process of insinuation of Neutrophil through capillary walls between endothelial cells

B. *Agranulocytes* (No granules in the cytoplasm): 02 types-

   i. Lymphocyte (20-40%)- Centrally placed nucleus rounded

   ii. Monocyte (2-10%)- Nucleus kidney shaped, eccentric in position.

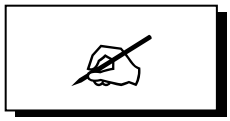
3.3. Functions of W B C

1. Phagocytosis
2. Antibody formation
3. Formation of fibroblasts
4. Secretion of heparin
5. Antihistaminic function

Properties of W B C

1. *Diapedesis*: Neutrophil can easily squeeze to pass through the minute pores of the vessel to the site of infection.

2. *Phagocytosis*: W B C can engulf the foreign particles and digest them.
3. *Amoeboid movement:* WBC can produce pseudopodia and move to the site of infection.



Exercise: Enumerate the functions of WBC.

Leukocytosis

Causes of Neutrophil Leukocytosis

1. Acute bacterial infections
2. Myeloproliferative disease
   i. Myeloid leukaemia
3. Haemorrhage especially internal
4. Tissue damage: Trauma, Burn, and Myocardial infarction etc.
5. Malignancy
6. Drugs - especially steroids.

Causes of Pancytopenia

1. Aplastic anaemia
2. Malignant lymphoma
3. Hypersplenism
4. Pernicious anaemia
5. S L E.

Causes of Neutropenia

1. Apastic anaemia
   i. Idiopathic
   ii. Cytotoxic drugs- Phenylbutazone, Chloramphenicol
2. Acute leukaemia
3. Hypersplenism
4. Idiopathic

Causes of Eosinophilia

1. Allergy or hypersensitivity to food or drugs
2. Parasites- hydatid or hookworm diseases
3. Skin diseases
   i. Scabies
   ii. Eczema
   iii. Urticaria.
4. Malignancy and Hodgkin's disease
5. Tropical pulmonary eosinophilia.

3.4. Thrombocytes (platelets)

Small granulated bodies 2-4 μm in diameter. Half-life about 4 days.

Total count 150,000 -450,000/ mm^3 of blood

- **Thrombocytosis:** Total number of platelets more than normal.
- **Thrombocytopenia:** Total number of thrombocytes is reduced in number and less than 150,000 platelets.

Tiny measles like rashes arise in the body called thrombocytopenic purpura. Platelet count below here is 50,000/ mm^3 of blood.

Functions of Blood Platelets

1. Haemostasis
2. Blood coagulation
3. Phagocytic action
4. Storage and transport.

Causes of Thrombocytopenia

1. Viral infections e.g., dengue fever
2. Idiopathic thrombocytopenic purpura
3. Pancytopenia
4. Incompatible or massive blood transfusion
5. Massive hemorrhage.
6. Disseminated intravascular coagulation.

3.5. Plasma Proteins

Total amount 5.5 to 8.8 gm/dl of blood

Classification

1. Albumin– 4.5 gm/100 ml of blood
2. Globulin– 2.5 gm/100 of blood
3. Fibrinogen- 0.3 gm/100 ml of blood.

Globulin is subdivided into α_1, α_2, β_1,β_2 and γ- globulin.

Sources of Plasma Protein

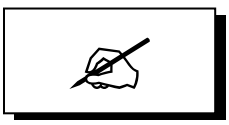
1. Diet- animal and vegetable proteins
2. Tissue proteins
   - Fixed cell proteins
   - Dispensable proteins
   - Labile proteins.

Site of Plasma Protein Production

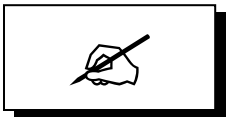
1. Albumin from the liver
2. Fibrinogen from the liver
3. Globulin- from the plasma cells.

Functions of Plasma Proteins

1. Acts as antibody to defense against infection (γ- globulin).
2. Acts as buffer (15% of the buffering capacity of blood)
3. In the transport of hormones like thyroid, cortisol etc.
4. Essential for blood coagulation
5. Maintenance of the blood colloidal osmotic pressure
6. Albumin serves as a carrier for metals, ions, fatty acids, enzymes, drugs etc.



Exercise: Mention important functions of plasma proteins.



3.6. Exercise

3.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Plasma proteins

   a. help blood coagulation
   b. originate from human left kidney
   c. carries O_2 to tissues
   d. none of the above.

2. Lymphocyte is one type of

   a. granulocyte
   b. agranulocyte
   c. thromocyte
   d. none of the above.

3. Pupura occurs when blood platelet count is

   a. more than 450,000/mm^3
   b. equal to 150,000- 450,000/mm^3
   c. less than 40,000/mm^3
   d. none of the above.

4. In dengue fever blood platelet count is

   a. increased
   b. decreased
   c. unchanged
   d. none of the above.

3.6.2. Short Questions

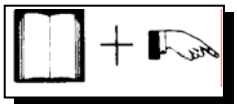
1. What do you mean by diapedesis?
2. Define phagocytosis.
3. Define purpura.
4. Enumerate the functions of blood platelet.

3.6.3. Broad Questions

1. Classify leucocytes. Describe functions of leucocytes.
2. Briefly describe the properties of WBC.
3. Classify plasma proteins.
4. What are the functions of plasma proteins?

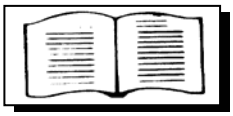
Lesson 4: Physiology of Blood-III

4.1. Learning Objectives



At the end of this lesson you will be able to-

- define blood clotting and haemostasis
- describe factors for coagulation
- reproduce mechanisms of coagulations
- describe and classify blood groups.



4.2. Haemostasis

Haemostasis may be defined as spontaneausarnest of bleeding.

Steps:

1. vasocenitriction
2. platelel plngformation
3. coagulution
4. fibrous organisection or dissolution of blood clot.

Coagulation a semisolid plug formed at the site of vascular damage

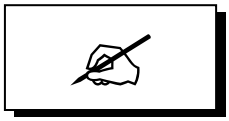
Blood does not clot in normal circulation because of the following reasons-

1. Presence of anticoagulant- heparin
2. Smooth vascular endothelium
3. Flow of blood

4.3. Coagulation factors

i. Fibrinogen
ii. Prothrombin
iii. Tissue thromboplastin
iv. Calcium
v. Labile factor
vi. (Not assigned)
vii. Stable factor
viii. Anti-haemophilic factor
ix. Christmas factor
x. Stuart factor
xi. Plasma thromboplastin antecedent

xii. Hageman factor
xiii. Fibrin stabilizing factor
xiv. Platelets.



Exercise: Enumerate the factors for haemostasis.

Local Vasoconstriction

Injured vessel faces constriction by serotonin and other vasoconstrictors liberated from platelets that adhere to the vessel wall. Vessels cut transversely can constrict but vessels cut longitudinally can not get this benefit.

Coagulation mechanism 3 steps

1. Formation of prothrombin activator
2. Prothrombin activator connects prothrombin to thrombin
3. Thrombin converted fibrinogen in to fibrin.

Pathways of formation of prothrombin activator

It is generally considered in 2 basic ways-

i. By the extrinsic pathway that begins with trauma to the vascular wall and surrounding tissues.
ii. By the intrinsic pathway that begins in the blood itself.

Extrinsic Mechanism

Step 1. Release of tissue thrombolpastin- Several factors, called tissue thromboplastin, is released by traumatized tissue. These include especially phopholipids from the membranes of the tissues and a lipoprotein complex containing an important glycoprotein that functions as a proteolytic enzyme.

Step 2. Activation of factor X– This action is promoted by factor VII and tissue thromboplastin. In the presence of tissue phospholipids, calcium ions acts enzyma tically on factor X to from activated factor X (Xa).

Step 3 Effect of activated factor X to from prothrombin activator- the activated factor X (Xa) immediately binds with the tissue phospholipids released as part of the tissue thromboplastin and also with factor V to form a complex called prothrombin activator.

Intrinsic Mechanism

Step 1 Activation of factor XII and release of phospholipids

Step 2 Activation factor XII acts enzymatically on factor XI

Step 3 Activation factors XI acts on factor IX to activate

Step 4 Activation factor X role of factor VIII

Step 5 Factor X combines ē and platelets to form prothrombin activator.

4.4. Anticlotting Mechanisms

Interaction between the platelet aggregating effect of thromboxane A_2 and the antiaggregating effect of prostacycline maintains fluidity of blood inside blood vessel.

Heparin is a naturally occurring anticoagulant, which facilitates the action of antithrombin III. Heparin forms an irreversible complex with Protamine, the highly basic protein and is used clinically to neutralize heparin. Low molecular weight heparins are used clinically because they have a longer half-life.

4.5. Blood Group

Human red cell membranes contain chemically polysaccharide antigens called agglutinogens. The presence or absence of these agglutinogens in the RBC membrane determines the blood group. A and B are called specific antigens because they carry corresponding antibody. O is called non-specific antigen, as it has no corresponding antibody.

Type A individual has A antigen, B type possesses the B antigen, AB type have both while O type have none. The antigens are complex oligosaccharides and differ in terminal sugar.

Classical blood groups are A, B, AB and O.

Other Agglutinogens

Other than ABO system, there is Rh, MN, Kell, and Kidd etc. system in body. The ‘Rh factor’ named after rhesus monkey as it was first studied in this animal. The system has not been detected in tissues except red blood cells. Rh positive means that the blood contains agglutinogen D. About 85% Caucasians and over 99% of Asians are Rh+ve.

Landsteiner's Law

"If an agglutinogen is present in the red cell membrane, the corresponding agglutinin must be absent from plasma.

2^{ND} part- If an agglutinogen is absent in the red cell membrane the corresponding agglutinin must be present in plasma."

Cell type	Serum containing α- agglutinin	Serum containing β- agglutinin	Percentage
A	+	-	41%
B	-	+	09%
AB	+	+	03%
O	-	-	47%

Blood Transfusion

The relationship of A B O blood group to the blood transfusion can be shown as below-

Plasma of Recipient	Cells of Donor			
	A	B	AB	O
A +β	-	+	+	-
B +α	+	-	+	-
AB +O	-	-	-	-
O + AB	+	+	+	-

Complications of Blood Transfusion

1. Febrile reactions due to
    a. Pyrogens
    b. Leukocyte or platelet iso-agglutinins
    c. Hypersensitivity to plasma
2. Allergic reactions
3. Circulatory overload

4. Haemolysis

   due to

   a. Blood group incompatibility
   b. Improper or long time stored of donor blood

5. Reactions due to infected stored blood
6. Disease transmission
   a. Viral hepatitis, HIV/AIDS, Cytomegalovirus, EB virus, Herpes simplex
   b. Syphilis
   c. Malaria
   d. Brucellosis
7. Thrombophlebitis
8. Air embolism
9. Transfusion siderosis
10. Complications of massive transfusion
    a. Collapse due to cold blood
    b. Excess citrate
    c. Excess ammonia from stored blood
    d. Hyperkalaemia
    e. Thrombocytopenia.

4.6. Exercise

4.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Plasma proteins

   a. help blood coagulation
   b. originate from human left kidney
   c. carrie O_2 to tissues
   d. none of the above.

2. Type A blood group contains

   a. a antigen
   b. b antigen
   c. no antigen
   d. none of the above.

3. Rh factor is named for

   a. guinea pig
   b. scientists name
   c. rhesus monkey
   d. none of the above.

4. Incompatibility in blood transfusion is caused by

   a. overt blood transfusion
   b. anaemic blood transfusion
   c. mismatched blood transfusion
   d. none of the above.

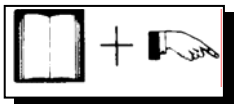
4.6.2. Short Questions

1. Enumerate important factors for coagulation.
2. Why blood does not coagulate in normal circulation?
3. Classify conventional blood groups.

4.6.3. Broad Questions

1. Describe the mechanisms of coagulation.
2. Classify blood groups.
3. Describe complications of blood transfusion.

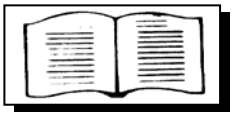
Lesson 5: Physiology of Lymph



5.1. Learning Objectives

At the end of this lesson you will be able to-

- define lymph and classify lymphatic system
- functions and formation of lymph
- describe different lymph organs in the body and functions.



5.2. Definition and Physiological Anatomy of Lymph

Lymph is an alkaline transparent, clear and colorless fluid found in the lymphatic vessels and cisterna chyli. Its composition is similar to that of blood plasma.

Lymphatic systems are endothelial tubes collecting fluids from the tissue spaces and return into the blood. Lymphatic systems carry proteins.

Parts of Lymphatic System

A. Lymph vessels or lymphatic channels

1. Lymph capillaries
    i. Larger lymph vessels
    ii. Thoracic duct
    iii. Lacteals.

B. Lymphoid tissue

1. Central lymphoid
    i. Bone marrow (B lymphocyte)
    ii. Thymus (T lymphocyte).

2. Peripheral lymphoid tissue
    i. Lymph node
    ii. Spleen
    iii. Epitheli-lymphoid tissue
    iv. Lymphoid nodules.

C. Lymphocytes.

Lymph Vessel

There are three coats in larger lymph vessels-

i. Tunica intima- endothelial cells with thin layers of fibrous tissue
ii. Tunica media- smooth muscle cells
iii. Tunica adventitia- fibrous tissue and smooth muscle cells.

5.3. Functions of Lymphatic System

i. Absorption different types of foreign bodies (e.g. bacteria, virus or microorganisms) at lymph node
ii. Production of lymphocytes- T lymphocytes kills the foreign bodies and B-lymphocytes synthesize antibodies.
iii. B lymphocyte– humeral immunity T lymphocyte– cell mediated immunity.

5.4. Formation of Lymph

Lymph is derived from interstitial fluid and flows through the lymphatic channels. Average protein concentration in the interstitial fluid of most tissues is about 02 gm/dl & protein concentration of lymph flowing from the tissues is near this value.

The protein concentration of lymph in the liver and intestine is 6 gm/dl and 3 to 4gm/dl. Two third of lymph is derived from the liver respectively intestine. The protein concentration of thoracic lymph is 3 to 5 gm/dl.

Rate of lymph flow

It is determined mainly by 2 factors-

i. Interstitial fluid pressure
ii. The degree of activity of the lymphatic pump

Lymphatic system also plays an important role in controlling-

i. The concentration of protein in the intestinal fluid
ii. The volume of interstitial fluid
iii. Interstitial fluid pressure

Increasing interstitial fluid pressure greatly increases the rate of lymph flow.

Lymph vessels are absent *in*

i. Central nervous system
ii. Splenic pulp
iii. Bone marrow
iv. Avascular structures: epidermis, hair, nails, cornea, and cartilages.

Lymph Node

In the course of lymph vessels there are small, oval or bean shaped bodies called *Lymph nodes*. Each lymph node is covered by a capsule, which consists of dense collagene fibres.

It consists of a. capsule and b. parenchyma

i. An outer cortex
ii. An inner medulla.

Functions of lymph nodes

i. Phagocytosis by macrophages
ii. Production of lymphocytes and antibodies
iii. Acts as filter of lymph.

Lymphoid Organ

Organized collections of lymphoid tissue are called lymphoid organ. These are-

i. Lymph node
ii. Spleen
iii. Thymus
iv. Tonsils.

Spleen

This is the largest lymphoid organ. It has only two efferent lymph vessels.

Functions of Spleen

i. It has phagocytic action

ii. It is an important haemopoietic organ during foetal life
iii. It has an immune response
iv. RBCs are stored in the spleen.

Thymus

A primary central organ of lymphoid system. It has two lobes. A connective tissue capsule covers each lobe of the thymus. Each lobe consists of an outer cortex and inner medulla.

Functions of Thymus

i. Production of lymphocytes
ii. Maintenance of normal concentration lymphocytes in blood.

Changes with Age

Thymus is relatively large at birth. It doubles its birth weight by puberty. Later on it is replaced by adipose tissue.

Tonsils

Composed of aggregates of incompletely encapsulated lymphoid tissues that contact with the epithelium of the initial portion of the digestive tract. According to their location, tonsils in the mouth and pharynx are called *palatine, pharyngeal or lingual* tonsils. Tonsils produce lymphocytes.

Palatine Tonsils

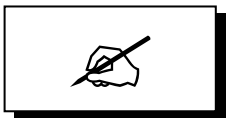
Two palatine tonsils are located in the lateral walls of the oral part of the pharynx. Participate in lymphocyte production and body protection.

Pharyngeal Tonsil

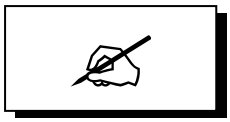
A single tonsil situated in the super posterior portion of the pharynx. It is covered columnar epithelium. Composed of mucosa and shows by diffuse lymphoid tissue and lymphatic nodules.

Lingual Tonsils

Lingual tonsils are smaller and more numerous than the others. They are situated at the base of the tongue.



Exercise: Discuss the lymphoid organs.



5.5. Exercise

5.5.1. Multiple Choice Questions

Tick (√) the correct answer

1. Lymph is the

   a. transparent colorless fluid
   b. opaque liquid
   c. fraction of blood
   d. none of the above.

2. Spleen has got

   a. phagocytic action
   b. anti-rheumatic action
   c. antimalarial action
   d. none of the above.

3. Tonsil capsule is

   a. complete
   b. incomplete
   c. distorted
   d. none of the above.

5.5.2. Short Questions

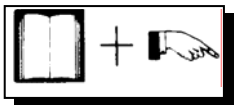
1. What are the layers of lymph vessels?
2. How lymph is formed?
3. Name lymphoid organs.
4. Classify types tonsil.

5.5.3. Broad Questions

1. Define lymph. Enumerate the parts of lymphatic system.
2. Reproduce the functions of lymphatic system.

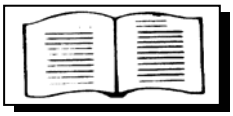
Lesson 6: Physiology of Tissue Fluid

6.1. Learning Objectives



At the end of this lesson you will be able to-

- define and discuss the role of body water
- discuss water balance in the body and its regulation
- describe different types of body fluids
- describe the difference between ECF and ICF solutes
- reproduce components of body fluid compartments.



6.2. Body Water

Body water can be referred to as the total amount of water present in the body in different forms and compartments. The total amount of water in a human body of about 70Kg weight is approximately 40 liter, averaging 57% of his total body weight. In a newborn infant this may be as high as 75% of the body weight but it progressively decreases from birth to old age. Maximum decrease occurs in the first 10 years of life.

Functions of Body Water

1. Maintains body temperature.
2. An essential constituent of all body cells.
3. A transport medium for nutrients to enter into the cells and waste products to excrete out.
4. Also a vehicle for transport of electrolytes, enzymes, hormones, vitamins micronutrients etc.
5. A medium for many body reactions.

6.3. Water Balance

The balance between water intake and water output of the body is called water balance.

Classification of water balance

1. Positive water balance-

Water intake is more than (>) water output. This means that water is retained in the body. This is called positive water balance. It occurs in the following conditions-

i. During growing Period

ii. Recovery from a disease

iii. During Pregnancy.

2. Negative water balance-

When the water output > water intake. It is called negative water balance. It occurs in the following conditions.

i. Vomiting, diarrhoea, haemorrhage

ii. Burns

iii. Starvation, Anorexia, Addison's disease, Diabetes.

Regulation of Water Balance

The following factors water balance of the body control by-

i. Temperature and humidity

ii. Electrolyte concentrations

iii. Thirst mechanism

iv. Some hormones like ADH, aldosterone etc.

Types of Body Fluid

1. Intracellular fluid (I.C.F) the amount of fluid inside the cells of the body is known as intracellular fluid. Total amount of ICF is about 25 litres.
2. Extracellular (E.C.F) the amount of fluid in the spaces outside the cells of the body is known as extracellular fluid. *Total amount of E C F is 15 litres.*

6.4. ECF is Again Subdivided into

i. Plasma

ii. Interstitial fluid

iii. Cerebrospinal fluid

iv. Intra-ocular fluid

v. Fluid of the gastro intestinal tract

vi. Fluid of the potential spaces.

Transcellular Fluid

It is that part of the extracellular fluid, which is separated from the other extracellular fluid by epithelial membrane. It measures about 2`5% and includes-

i. Fluid in the pleural, peritoneal and pericardial cavities

ii. Fluid in the GIT, respiratory tract

iii. Synovial fluid

iv. Cerebrospinal fluid

v. Intraoccular fluid.

Tissue fluid is formed from the plasma by the process

1. Diffusion- Random movement of molecules or ions from an environment of higher concentration to a lower concentration separated by the plasma membrane is called diffusion.
2. Filtration- The process of separation of undissolved particles from the liquids by passing the mixture through a membrane due to the difference of hydrostatic pressure or gravitational force across the filtering surface.

Sources of Tissue Fluid

i. Systemic Capillaries

ii. Tissue metabolism.

6.5. Different Composition of the ECF and ICFs.

Constituents	**ECF**	**ICF**
Na+	142 mEq/L	10 mEq/L
K+	5 m mEq/L	140 meq/L
Ca++	5 m Eq/L	1 m Eq/L
Mg++	3 m Eq/L	141 m Eq/L
Cl-	103 m Eq/L	< 1 mEq/L
HCO_3^-	28 m Eq/L	58 m Eq/L
Phosphates	4 m Eq/L	4 m Eq/L
SO_4^-	1 m Eq/L	10 m Eq/L
Glucose	90 mg%	75 m Eq/L
Amino acids	30 mg%	2 m Eq/L
Cholesterol	0	200
Phospholipids		
Neutral fat		
PO_2	35 mm Hg	
PCO_2		

Difference between E C F and I C F s

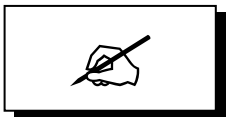
E C F	I C F
1. E C F Contains large amount of sodium chloride, bicarbonate ions, amino, acids, glucose, oxygen and fatty acids.	1. ICF contains large amounts of potassium, magnesium and phosphate ions.
2. There is less amount of protein in the ECF.	2. Large amount of protein is present in the ICF.

Causes of Fluid Loss from the Body

1. Hot weather- Maximum water is lost in sweat.
2. Heavy exercise- Exercise increases the loss of water in 2 ways.
   i. It increases the rate of respiration, which promotes increased water loss through the respiratory tract.
   ii. Exercise increases the body heat that causes loss of fluid by sweating.
3. Insensible water loss- loss of water by diffusion and by the skin evaporation from the respiratory tract.
4. Temperature- Normally, at an atmospheric temperature of about 68`F approximately 1400ml of fluid is lost in urine; 100 ml fluid is lost in sweat, 100 ml in faces. The remaining 700ml fluid lost by evaporation from the respiratory tract and Skin.

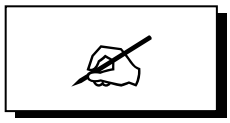
Daily Loss of Water (in ml)

	Normal temperature	**Hot weather**
Insensible loss:		
Skin	350	350
Respiratory tract	350	250
Urine	1400	1200
Sweat	100	1400
Faeces	100	100
Total	2300	3300



Exercise: Write down the differences between ECF and ICF.

Tips
Measurement of blood volume
Blood Volume = Plasma Volume x (100/ 100-0.87 haematocrit).



6.6. Exercise

6.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Average amount of water in a 70-Kg weight male is

   a. 40 Litre
   b. 70 Litre
   c. 35 Litre
   d. none of the above.

2. Water balance of body is controlled by all below except

   a. thirst mechanism
   b. kidney condition
   c. acute liver diseases
   d. temperature and humidity.

3. In ECF normally there is

   a. less amount of protein
   b. increased amount of animal protein
   c. no protein
   d. none of the above.

6.6.2. Short Questions

1. Define body fluid.
2. Write types of body fluids.
3. What are the sources of tissue fluid?
4. Enumerate causes of fluid loss from body.

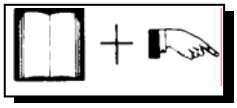
6.6.3. Broad Questions

1. Describe the physiological role of body water.
2. Classify water balance. Name five factors for regulation of human body water.
3. What are the differences between ECF and ICF?

Unit 2: Related to Respiratory and Cardiovascular System

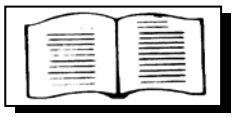
Lesson 1: Physiology Related to Respiratory System-I

1.1. Learning Objectives



At the end of this lesson you will be able to-

- define respiration and other common terms related to it
- describe the mechanisms and functions of respiration
- describe different types of respiratory muscles.



1.2. Respiration

Respiration is a physiological process by which O_2 is taken from atmosphere by the lungs to the tissues and co_2 is carried out from the tissues to the atmosphere by the lungs.

Physics of Breathing

Physics of breathing includes two sets of work forces. These are-

Respiration is a Physiological process by which O_2 is transported from atmosphere by the lungs to the tissues and co_2 is carried out from the tissues to the atmosphere by the lungs

Elastic Work

Performed by respiratory muscles by stretching the elastic tissues of the chest wall and lungs.

Some Frequently used Terms

Eupnoea– Normal breathing

Tachypnoea- Rapid breathing

Anoxia- Decreased concentration of O_2 at the tissue level

Hypoxaemia– Decreased concentration of O_2 in the blood

Hypercapnoea– Increased concentration of CO_2 in blood

Hypocapnoea– Decreased concentration of CO_2 in blood

Dyspnoea– Difficulty in breathing

Apnoea– Temporary cessation of breathing

Emphysema– Excess air in the lung tissues.

1.3. Mechanism of Respiration

i. Upward downward movement of the diaphragm.

ii. Elevation and depression of ribs.

The vertical and anteroposterior diameter of the chest cavity is increased or decreased by these two mechanisms.

Phases of Respiration

1. Inspiration (Active process) Transport of O_2 from atmosphere by the lungs to the tissues. Duration is about 2 secs.
2. Expiration (Passive process) Transport of CO_2 from the tissue to the atmosphere by the lungs. Duration is 3 secs.

Type of Respiration

1. External Respiration

Transport of O_2 from lungs the cells and carried of CO_2 from the cells to the lungs. It includes 4 steps.

a. Pulmonary ventilation- In flow and out flow of air between alveoli and atmosphere

b. Diffusion of O_2 and CO_2 between alveoli &blood

c. Transport of O_2 from the atmosphere to the cells and CO_2 from the cells to the atmosphere by the lungs

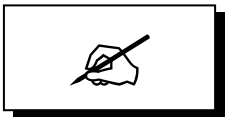
d. Regulation of respiration.

2. Internal Respiration

Utilization of O_2 and production of CO_2 by cells and the gaseous exchanges between cells and fluid medium.

Functions of Respiration

1. Gaseous exchanges
2. Regulation of PCo_2 of blood
3. Maintenance of acid base balance
4. Excretory functions
5. Haemostatic functions
6. Maintenance of temperature.



Exercise: Describe the mechanisms of respiration.

Components of Respiratory System

1. Gas exchanging organ- lungs.
2. Ventilatory pump.

- Respiratory muscles causing changes in size of thoracic cavity
- Areas of brain that controls respiration
- Tracts and nerves that connect the brain to the muscles.

Normal breathing rate is about 12-15-breaths/ minute.

Normally per breath contains 500 ml of air or 6-8 L/ min.

About 250 ml of O_2 enters the body and 200 ml of CO_2 is expired out.

Over 250 different volatile substances have been traced in expired air including traces of methane from the intestine. Sometimes alcohol and acetones are also detected in the expired air if these are present.

Functions of Nose

1. Nose is the first station for breathing mechanism.
2. Air is conditioned by the nasal conchae and septum.
3. Filtration and removal of dust particles.
4. Sense organ for taking smell.

Physiological Anatomy of Lung Bronchopulmonary Segment

Bronchopulmonary segment is an independent unit of lung tissue that is aerated by a single segmental bronchus. It is pyramidal in shape and surrounded by connective tissues. It has segmental artery, lymph vessels, and autonomic nerves. It has surgical importance to remove of a portion of the lung in diseased condition.

The Main Bronchopulmonary Segments are as Follows

Right lung	Left lung
A. Superior lobe	1. Superior lobe
– Apical	– Apical
– Posterior	– Posterior
– Anterior	– Anterior
	– Superior lingular
B. Middle lobe	– Inferior lingular
– Lateral	
– Medial	2. Inferior lobe
	– Superior
C. Inferior lobe	– Medial basal
– Superior	– Anterior basal
– Medial basal	– Lateral basal
– Anterior basal	– Posterior basal.
– Lateral basal	
– Posterior basal	

1.4. Muscles of Respiration

Muscles of Inspiration

1. The diaphragm
2. External intercostal
3. Sternocleidomastoid
4. Scaleni
5. Serratus anterior
6. Serratus posterior
7. Latissimus dorsi.

Muscles of Expiration

1. Internal intercostal
2. Rectus abdominis

3. Serratus posterior inferior
4. Transversus Abdominis.

1.5. Exercise

1.5.1. Multiple Choice Questions

Tick (√) the correct answer

1. Inspiration is an

   a. active phase
   b. passive phase
   c. sometimes active and sometimes passive
   d. none of the above.

2. Hypercapnoea means

   a. decreased CO_2 in blood
   b. increased concentration of CO_2 in air
   c. increased concentration of CO_2 in blood
   d. none of the above.

3. Rectus Abdominis is a muscle of

   a. inspiration
   b. expiration
   c. both a and b
   d. none of the above.

1.5.2. Short Questions

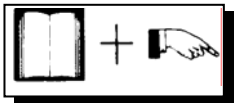
1. Define respiration.
2. Enumerate the phases of respiration.
3. What are the functions of nose?
4. Enumerate the causes of fluid loss from body.

1.5.3. Broad Questions

1. Describe the physiological bronchopulmonary segments.
2. What are the main functions of respiration?
3. Enumerate the muscles of respiration.

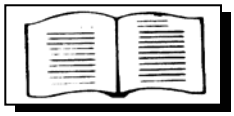
Lesson 2: Physiology Related to Respiratory System-II

2.1. Learning Objectives



At the end of this lesson you will be able to-

- define respiratory membrane
- describe layers of respiratory membrane
- define respiratory distress syndrome
- describe lung function test.



2.2. Respiratory Membrane

Respiratory membrane is the term given collectively to all membranes of the terminal portions of the lungs through which gaseous exchange occur between the alveolar air and the pulmonary blood.

Following *factors affect* the rate of gaseous exchange through the respiratory membrane-

1. The thickness of the membrane.
2. The surface area of the membrane.
3. The diffusion coefficient of the gas in the substance of the membrane.
4. The pressure difference between the two sides of the membrane.

The thickness of the respiratory membrane increases during oedema and fibrosis of the lung and decreases during emphysema, Tuberculosis.

2.3. Layers of the Respiratory Membrane

1. Fluid containing surfactant layer
2. Alveolar epithelium
3. Epithelial basement membrane
4. Interstitial space
5. Capillary basement membrane
6. Capillary endothelium.

Surfactant

Surfactant is a surface-tension-lowering agent that contains mixture of several phospholipids, proteins and ions. The phospholipid contains dipalmitoylphosp-hatidylcholine (DPPC), surfactant apoproteins and calcium ions. Dipalmitoyl lecithein is responsible for reducing the surface tension when the alveoli are small. Surfactant is produced by type-II alveolar epithelium.

Significance

1. Responsible for reducing the surface tensions of the respirators membrane.
2. Prevents the accumulation of fluid in the alveoli.
3. Prevents collapse of the lungs.

2.4. RDS

Normally the surfactant is responsible for the expansion of the lung. In newborn babies, especially in premature babies, if the surfactant secretion is decreased, lung expansion is difficult. The baby dies because of inadequate ventilation. This condition is called *hyaline membrane disease* and also known as respiratory distress syndrome. Hyaline membrane disease is more common in infants with low serum thyroid hormone levels. Maturation of the surfactant is accelerated by the presence of glucocorticoid hormones.

Compliance

Compliance is defined as the expansi-bility of the lung or chest cage as a whole with change in lung volume per unit change in airway pressure. This is expressed as $\Delta V/ \Delta P$.

Compliance

Expansibility of the lungs is called *compliance*

$C = \Delta V/ \Delta P$

Factors that cause abnormal compliance-

1. Chest deformities like kyphosis, scoliosis *decreases* chest compliance.
2. Fibrosis or oedematous conditions causes the destruction of the lung tissues resulting *decreased* lung compliance.
3. Chest muscle paralysis *reduces* the chest compliance.
4. Emphysema *increases* the compliance.

Resistance

Resistance of the lungs and chest is a dynamic measurement that can be defined, as the pressure difference required for a unit of airflow through respiratory system.

Alveolar Ventilation

The total volume of air, which enters into the alveoli and other gas exchange auas of lungs (alveolar sac, alveolar ducts and respiratory brochioles) in each minute.

Alveolar Ventilation

= Respiratory rate x (tidal volume–dead space volume)

= 12x (500-150)

= 12x350 ml=4200 ml=4.2 liter.

2.5. Lung Function Test

Pulmonary Volumes and Capacities

Pulmonary Volumes

1. Tidal volume (VT)= VT is the volume of air inspired or expired with each normal breath. Normal level is about 500ml.
2. Inspiratory reserve volume– It is the extra volume of air that can be inspired over and beyond the normal tidal volume. Its amount is about 3000 ml.
3. Expiratory reserve volume– It is the extra amount of air that can be expired by forceful expiration after the end of a normal tidal expiration. Its amount is about 1100 ml.
4. Residual volume– It is the volume of air still remaining in the lungs after the most forceful expiration. Normal level is 1200 ml.

Pulmonary Capacities

1. Inspiratory capacity– The tidal volume plus the inspiratory reserve volume. Normal value is 3500ml.
2. Functional residual capacity– The expiratory reserve volume plus the residual volume. Physiological value is 2300 ml.
3. Vital capacity–This is a maximum amount of air that a person can expel after a forceful inspiration. It is about 4600 ml.
4. Total lung capacity– Summation of the vital capacity plus the residual volume. It is about 5800 ml.

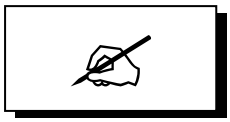
Dead Space Volume

The amount of air, which occupies the respiratory passages but do not take past in gaseous exchange is called dead space air. Normally it is about 150 ml.

Types

i. *Anatomical dead space*– The space of the respiratory passages except the space of gaseous exchange.

ii. *Physiological dead space*– The anatomical dead space with the alveolar dead space.



Exercise: Write in brief about pulmonary volumes and capacities.

2.6. Exercise

2.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Surfactant is a

   a. polysaccharide
   b. lipoprotein
   c. bacterial complex growth
   d. none of the above.

2. Vital capacity is normally

   a. 2500 ml
   b. 6.5 Litre
   c. 4600 ml
   d. none of them.

3. Dead space in respiration means

   a. part of respiratory system deprived of respiration
   b. respiration in an almost dead patient
   c. both A and B
   d. none of the above.

2.6.2. Broad Questions

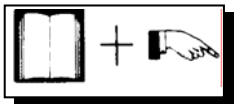
1. Describe the layers of respiratory membrane.
2. Describe the significance of surfactant?
3. What do you know about hyaline membrane disease?

2.6.3. Short Questions

1. Define respiratory membrane.
2. Define surfactant.
3. What is lung compliance?
4. Define and classify dead space volume.

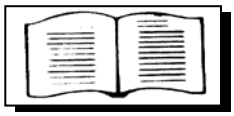
Lesson 3: Physiology Related to Respiratory System-III

3.1. Learning Objectives



At the end of this lesson you will be able to-

- describe the principle of gas transport
- write about regulation of respiration
- describe the oxygen haemoglobin dissociation curve
- describe types of hypoxia.



3.2. Transport of Gases

Diffusion of O_2 and CO_2 through the pulmonary membrane-

This has been established that O_2 'flows downhill' from air to tissues through alveoli and blood while CO_2 'flows downhill' from tissues to alveoli. The normal partial pressure of O_2 in the alveoli is 104 mm Hg while the venous blood entering the pulmonary capillary is 40 mm Hg. The initial pressure difference is 64 mm Hg that causes diffusions of O_2 through the pulmonary membrane into the blood. The hemoglobin will become completely saturated with oxygen.

PCO_2 in the venous blood flowing into the lungs is 45 mm Hg and in the alveoli is 40 mm Hg. The pressure difference is 5 mm Hg that causes CO_2 to diffuse out of the blood into the alveoli.

Transport of O_2 via the blood hemoglobin-

Oxygen delivery to a particular tissue depends upon-

Oxygen delivery to the tissue depends on-
- O_2 inhalation
- Gas exchange area of lung
- Blood flow and O_2 combination with blood

- Amount of O_2 entering the lungs
- Adequacy of pulmonary gas exchange area
- Blood flow to the tissue
- Capacity of the blood to carry O_2.

About 97% of O_2 is carried from the lungs to the tissues by combination with hemoglobin in the red blood cells. Hemoglobin has the peculiar property of combining with large quantities of O_2 when the PO_2 is high and then releasing this when the PO_2 falls.

Transport of CO_2 in the Blood

With utilization of the O_2 in the cell, large quantities of CO_2 are formed that causes increased intracellular PCO_2 is about 46 mm Hg. The PCO_2 in the arterial blood entering the tissue capillaries is only 40 mm Hg. The pressure difference makes the CO_2 diffuse rapidly into the blood. And then this CO_2 in the blood combines with water to form carbonic acid. Most of the carbonic acid immediately gets dissolved to form bicarbonate ions and hydrogen ions. The hydrogen ions then combine with haemoglobin.

3.3. Regulation of Respiration

Respiratory Center

Respiratory center is placed in the medulla oblongata and pons components of human brain and is composed of groups of neurons.

Respiratory center has three groups of nerve cells-

1. Dorsal respiratory group- It is placed in the dorsal portion of the medulla oblongata and is responsible for inspiration.

2. Ventral respiratory group- It is placed in the antero-lateral part of the medulla oblongata and is responsible for both inspiration and expiration.

3. Pneumotaxic center- It is placed posteriorly in the superior part of the pons and is responsible for the rate and pattern of breathing.

Mechanism of Regulation of Respiration

Respiration is controlled by the respiratory centers and maintained the rate and depth of respiration. A special reflex that regulates the respiratory rhythm is known as Hering-Breuer reflex. The stretch receptors of the lungs detect the reflex and then transmit the impulse to the respiratory center via the vegus nerve. It prevents the lungs over inflation or over deflation.

Control of the Alveolar Ventilation by CO_2

CO_2 is a powerful stimulus for increasing rate and depth of respiration. When PCO_2 is increased in the body respiratory centers of the brain stem are stimulated and, ventilation increases for which excess CO_2 comes out from the lungs.

Regulation of Alveolar Ventilation by Lack of O_2

Hldane Effect

Lack of oxygen stimulates special type of nerve receptors called chemoreceptors that are located in the carotid and aortic bodies. Signals are transmitted to the respiratory center to increase in alveolar ventilation.

An increase in CO_2 in the blood will cause O_2 to be displaced from the haemoglobin. On the other hand, binding of O_2 with haemoglobin tends to displace CO_2 from blood. This is known as *heldane* effect.

This result-increase in amount of O_2 delivered to the active tissues. This increase selease of O_2 due to in crease concentration of CO_2 at the tissue level is known as Boher effect.

At the tissue level the excess bicarbonate formed is released from the cell into the circulation and then chloride enters into the cell. This process is called chloride shift.

3.4. Oxy Hemoglobin Dissociation Curve

Oxy hemoglobin dissociation curve

Hemoglobin transports oxygen from the lungs to the tissues of the body. When increases PO_2 it will increasingly bind more hemoglobin. It is known as *percentage saturation of haemoglobin.* Oxygen saturation is about 97% in the arterial blood. The nature of the transport of O_2 with hemoglobin can be explained by typically a sigmoid shaped graph known as O_2 dissociation curve.

Factors affecting the oxyhaemoglobin dissociation carve-

1. PH or H^+ concentration
2. Temperature of the blood
3. CO_2 concentration
4. 2.3-diphosphoglycerate
5. Foetal haemoglobin
6. Exercise.

Periodic Breathing

1. **Cheyne-Stokes Breathing:** It is the gradual increase in depth and frequency of respiration for duration of 10 to 60 seconds. This condition may be present normally in children. It may also be present in congestive heart failure, renal failure, Hypoxia etc-
2. **Biot's Breathing:** Different types of short breathing followed by long irregular types are called biot's breathing. It is found in meningitis.

3.5. Hypoxia

Decreased concentration of oxygen at the tissue level is called hypoxia.

Causes of Hypoxia

A. Inadequate oxygen in the lungs- e.g. lack of oxygen in the atmosphere.

B. Pulmonary diseases

C. Inadequate transport of O_2

   i. Anaemia

   ii. Heart failure

   iii. Oedema.

Hypoxia

D. Inadequate O_2 utilization in the tissue

   i. Cellular enzyme poisoning

   ii. Vitamin deficiency.

Classification of Hypoxia

1. **Hypoxic Hypoxia:** The ability of utilization of oxygen is normal but the supply of oxygen is low e.g., In high altitude.
2. **Anaemic Hypoxia:** The supply of oxygen is normal but the transport vehicle (Hb) of oxygen is low e.g., Hb anemia.
3. **Histotoxic Hypoxia:** The supply of oxygen is normal but the ability of utilization of oxygen to the tissues is decreased e.g., potassium cyanide poisoning.
4. **Stagnant Hypoxia:** The supply of O_2 is normal but the tissue can not get O_2 due to inadequate blood supply to the tissues e.g., congestive caudiac failure.

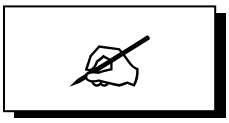
Cyanosis

It is a clinical condition characterized by the bluish dis-colouration of the skin and mucus membrane due to the presence of excess deoxygenated haemoglobin in the blood.

Site– Tongue, Nose, Lips, Ear lobules, Nail bed etc.

Types

i. Central cyanosis
ii. Peripheral cyanosis.



3.6. Exercise

3.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. About 97% of O_2 are carried to tissues by combining with

   a. polysaccharide
   b. haemoglobin
   c. plasma protein
   d. none of the above.

2. Normal PO_2 in the alveoli is

   a. 104 mmHg
   b. 10 mmHg
   c. 80 mmHg
   d. none of them.

3. O_2 dissociation curve is affected by all of the following except

   a. exercise
   b. CO_2
   c. NH_3
   d. pH.

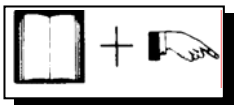
3.6.2. Short Questions

1. Write notes on-bohr effect, heldane effect in respiration.
2. Define cheyne-stokes breathing.
3. Define cyanosis. How many types of cyanosis are there?
4. Enumerate factors affecting O_2 haemoglobin dissociation curve.

3.6.3. Broad Questions

1. Describe the layers of respiratory membrane.
2. What do you know about O_2 haemoglobin dissociation curve?
3. Classify hypoxia. What are causes of hypoxia?

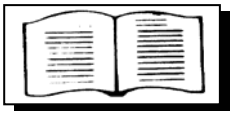
Lesson 4: Physiology of Cardiovascular System-I



4.1. Learning Objectives

At the end of this lesson you will be able to-

- describe structure of cardiac muscles
- describe the properties of cardiac muscles
- sound of the heart
- describe measurement of blood pressure.



4.2. The Heart

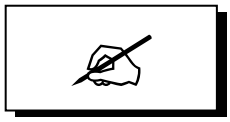
Physiologic Anatomy

Cardiovascular system includes heart and blood vessels. The normal heart rests on the diaphragm on its longitudinal axis oriented from right shoulder to left upper quadrant of the abdomen. The *base* consists of the atria and great arteries. The *apex* comprises the junction of the ventricles and the ventricular septum. The heart tilts forward on the apex, which is more easily palpated at the anterior chest wall, at the 4^{th} or 5^{th} intercostals space at about the mid-clavicular line.

The transverse and ascending aorta form the top of the cardiac while superior vena cava lines upper right margin. The right atrium provides the remaining right lateral cardiac border. Right ventricle occupies most of the inferior border while the left ventricle contributes the apex and the lower left lateral cardiac border. The left atrial appendage perches atop the left ventricle and to the side of the pulmonary artery, interjecting its auricle on the cardiac border between the left ventricle and pulmonary outflow tract. The pulmonary outflow area forms the rest of the upper left border.

The atria are separated from the ventricles by the externally encircling *coronary sulcus* (AV sulcus). The sulcus contains the *right coronary artery* after its origin from the aorta and till its descending on the posterior wall. *Left circumflex artery* runs through the sulcus from left till its ramification posteriorly. The anterior *interventricular sulcus* from cornary sulcus to apex marks the external boundary between the ventricles. It contains the *left anterior descending coronary artery* over the muscular *interventricular septum* between ventricles and continues on the apex to the posterior *interventricular sulcus* on the back of the heart. The *posterior descending coronary artery* is the branch of the *right coronary artery* or *left circumflex artery* and passes through the *posterior interventricular sulcus*.

Junction area of the coronary sulcus and the posterior interventricular sulcus at the posterior basal surface is the *crux* of the heart.



Exercise: Describe cardiac silhoutte of a normal heart.

Structure of Heart Muscle

Cardiac muscles are arranged in three forms -

i. Atrial muscle fibres

ii. Ventricular muscle fibres and

iii. Other specialized fibers for initiation and conduction of action potentials and for generating force of contraction.

Structure of Cardiac muscles

Cardiac muscle is a specialized type muscle fiber containing *contractile protein* actin and myosin and the *regulatory protein* tropomyosin and troponin. Huge numbers of mitochondria are located close to myofibrils. There are also large numbers of sarcoplasmic reticulum that serve as intercellular store of calcium.

4.3. Properties of Cardiac Muscle

1. Autor r*hythmicity*: main characteristic feature of the cardiac muscle is that it can initiate its own impulse rhythmically. The rate of rhythmicity in sino atrial node is 70-80/ min., in AV node 40-60/ min, in atrium 60/min and in ventricle 20-40/ min.

2. *Conductivity:* The heart muscles can conduct impulse throughout its span. Impulses that originate at the SA node spread over the atria and reach the AV node through the internodal fibers.

3. *Excitability and contractility*: Cardiac muscle is excitable by adequate stimuli and responds by contraction.

4. *Refractory period*: The refractory period of the heart is long and can be divided into-

    i. *Absolute refractory period*- this period extends throughout period of contraction and 1^{st} of ↓ of relaxation period

    ii. *Relative refractory period*- this period starts immediately after the absolute refractory period and involves the last 2/3 of period relaxation

4.4. Movement of the Heart

Apex beat is the outer most and most outward point where the heart can be easily palpated.

Heart Sounds

The sounds 'lub' and 'dub' results from libations produced by closure of semilunar (atrial and pulmonary) and atrioventricular (mitral and tricuspid) valves. There are also third and fourth heart sounds.

Heart Sounds

1. *First heart sound*: Caused during the onset of ventricular systole due to the vibration produced by closure of the atrioventricular valves.
2. *Second heat sound*: It occurs at the onset of diastole and is caused by the vibrations due to sudden closer of the semilunar valves in an aorta pulmonary artery.
3. *Third heart sound*: It is due to the sudden rush of atrial blood into the ventricles when the atriventricular valves open. It happens just after the second sound and coincides with the opening of the atrioventricular valves.
4. *Fourth heart sound*: It is due contraction of the atria causing rush of blood into the ventricles.

Cardiac Output

The amount of blood that is pumped out by each ventricle in one minute is called *cardiac output*. Normal value is 5-6 litre. *Cardiac index means* cardiac output/ minute/ square meter of the body surface. Average value in human is 3.3 litre.

Stroke volume means the output per ventricle per beat. Normally it is 70 ml. *Stroke volume index* means the stroke volume/ square metre of body surface. Average value is 47 ml.

Minute volume means the output per ventricle per minute. Normally it is about 5-6 liter.

Control of Cardiac Output

Depends on

i. Venous return

ii. Force of contraction

iii. Frequency of heart beat

iv. Peripheral resistance.

Factors Affecting Cardiac output

i. Fever, hyperthyroidism, excitement

ii. Hypothyroidism, haemorrhage, shock, heart failure etc.

iii. Posture, sleep etc.

iv. Muscular exercise.

Peripheral Resistance

It is the vector of obstacle forces that the flowing blood has to overcome while passing through the body vascular system. Peripheral resistance depends mainly on-

i. Velocity of blood flow

ii. Viscosity of blood

iii. Elasticity of the arterial wall

iv. Lumen of the blood vessels.

4.5. Blood Pressure

Blood pressure may be defined as the lateral pressure produced by the flowing blood on the vessel wall while passing through it.

Blood Pressure = *Cardiac output x Peripheral resistance*

Blood Pressure = Cardiac output X *Peripheral resistance.*

Lateral pressure is that pressure when the force is produced at right angles to the direction of flow at any point within a tube filled with a circulating fluid.

Types of blood pressure

1. **Systolic pressure:** maximum pressure during systole (110-140 mmHg)

2. **Diastolic pressure:** minimum pressure during diastole (60-90 mmHg)

3. **Pulse pressure:** difference between systolic and diastolic pressures (30-40mmHg)

4. **Mean pressure:** diastolic pressure plus one third of the pulse pressure (88-98mmHg).

Methods of Measurement of Blood Pressure

A. Direct Method

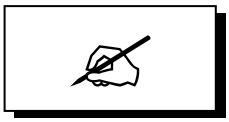
The arterial pressure can be measured when a cannula is inserted into an artery by using a mercury manometer or a calibrated gauge and an oscillograph arranged to write on a moving paper strip. End pressure is recorded by tying off of the artery beyond the cannula insertion point.

B. Palpatory Method

It is comfortable and rather supplementary to measure blood pressure by palpation before auscultation. This is an authentic procedure indeed. Systolic pressure can be measured by palpating the pulse. The arm is inflated with the cuff till disappearance of the radial pulse. The cuff is the slowly deflated to locate the first pulse beat. This is equivalent to the systolic blood pressure of the person. This is usually 2-5 mmHg lower than the record by auscultatory method.

C. Auscultatory Method

This is the routine procedure for measuring the human blood pressure. Here a mercury manometer called *Sphygmomanometer* is attached to an inflatable *Riva-Roci cuff*. The cuff is wrapped around the forearm with its lower border about 2.5 cm above the elbow joint. A *Stethoscope* is placed on the brachial artery on the lateral aspect of the lower arm. The cuff is inflated to occlude the radial artery. This is usually 20 mm Hg above the expected systolic blood pressure level as has been presumed by palpatory method. The cuff is then slowly deflated to get the first audible sound (Korotkoff sound phase I). This is the level of systolic blood pressure. With further deflation of the cuff, the sounds get louder, then gradually dull, muffled and finally disappear (Korotkoff phase-V). This best fits to the diastolic blood pressure. The sounds of korotkoff appear due to turbulent blood flow through obstructed artery and disappeared with return of laminar flow.



Exercise: Enumerate factors influencing cardiac output.

4.6. Exercise

4.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. All of the following are true for the human heart except

   a. it has four chambers
   b. apex is normally on right 6^{th} intercostals space
   c. own blood supply by coronary arteries
   d. consists of specialized type of tissue.

2. Normal cardiac output is

   a. 100 litres
   b. 7-8 litres
   c. 5-6 litres
   d. none of the above.

3. Systolic blood pressure is recorded at the

   a. korotkoff phase-I sound level
   b. korotkoff phase-IV sound level
   c. korotkoff phase-V sound level
   d. none of the above.

4.6.2. Short Questions

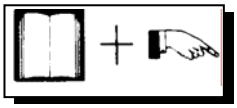
1. Define blood pressure.
2. Explain conductivity of cardiac muscles.
3. Define apex beat. What is the clinical significance of apex beat?
4. Define pulse pressure and mean pressure.

4.6.3. Broad Questions

1. Describe gross physiological anatomy of the heart.
2. What are the properties of cardiac muscles?
3. Describe how you will measure blood pressure of a person.

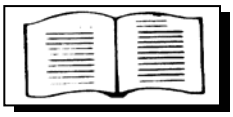
Lesson 5: Physiology of Cardiovascular System-II

5.1. Learning Objectives



At the end of this lesson you will be able to-

- describe circulation of blood
- explain cardiac cycle in phases
- describe electric activities of the heart
- describe about electrocardiography.



5.2. The Circulation

To meet tissue demand blood must be in motion, which is called circulation.

There are 2 types of circulation

1. *Systemic circulation:* The arcade of systemic circulation is like-

   Aorta → artery and arterioles capillaries → cells and tissues

   Veins and venules ← capillaries ←

   Inferior venacava → right atrium.

2. *Pulmonary circulation*-

   Right ventricle → pulmonary artery → lungs

   Left atrium ← pulmonary veins. ←

5.3. Cardiac Cycle

Cardiac Cycle

Cyclical repetition of varies changes in heart from one beat to the next is called cardiac cycle. Cardiac cycle time is the time required for one complete cardiac cycle. With normal heart rate of 75/ minute, cardiac cycle time would be (60/75) = 0.8 seconds. This would mean that every cardiac event is repeated every 0.8 sec interval.

The cardiac cycle consists of two separate phases- *diastole* (The relaxation phase) and *systole* (The contraction phase).

Ventricular Systole and Diastole Events

Ventricular systole (0.3 sec)

1. Isometric contraction phase (0.05 sec)

This is the period between the closing of the atrioventricular valves and opening of the semilunar valves. The first sound occurs at the onset of ventricular systole. It is caused by the sudden closure of the atrio-ventricular valves due to sharp rise of intraventricular pressure. The semilunar valve opens a little later.

2. Ejection phase (0.25 sec)

a. Maximum ejection phase (0.11sec)

b. Reduced ejection phase (0.14 sec)

In the ejection phase the semilunar valves open and the ejection phase starts. During this period blood is expelled from the ventricles in to the systemic aorta and to the right atrium then to the pulmonary trunk. In the first part of this period (0.11 sec), the out flow is very rapid. Hence it is known as the maximum ejection period. In the last part (0.14 sec) the rate of outflow slows down. Hence it is called the reduced ejection period.

Ventricular Diastole (0.5 sec)

i. Protodiastolic phase (0.04 sec)

It is the short Interval between the onset of diastole and the closure of the semilunar valves.

ii. Isometric relaxation period (0.08): It is the interval between closure of the semilunar valves and opening of the atrioventricular valves.

3. Filling Phase

a. First rapid filling phase (0.113 sec):

At the end of isometric relaxation period, the atrioventricular valves open. Blood rushes into the ventricles and ventricular filling begins. This first part of this period is known as the first rapid filling phase.

b. Slow feeling phase (0.16 sec)

The rate of inflow from the atria will be gradually slower. This period is called slow filling phase.

c. Last rapid filling phase (0.1sec)

The last part this period is rapid because the ventricular diastole is overlapped by the atrial systole.

Exercise: Describe main changes during ventricular systole.

5.4. Electrical Activity of the Heart

Cardiac muscles have the property of automaticity, i.e. these can discharge spontaneous electric impulses of their own. Different parts of the heart discharge impulses at different and individualized frequency and pace. They also have the special conducting electrical system for conveying impulses through myocardium. The conductive system is composed of the modified cardiac muscles having fewer striations and indistinct boundaries. Components of the specialized conductive system are -

- Sinoatrial (SA) node
- Internodal atrial pathways
- Atrioventricular (AV) node
- Bundle of His and its branches
- Purkinje system.

Cardiac Pacemaker

SA node is located at the junction of the superior vena cava and the right atrium. It discharges most frequently; depolarization from here spreads to other parts of the myocardium before their own depolarization. Hence it is called the normal *cardiac pacemaker*. Number of impulses discharged from the SA node is normally the heartbeat. The AV node is located at the right posterior portion of the interatrial septum. Impulses generated at the SA node pass through the atrial pathways to the AV node. Three bundles of atrial fibers containing Purkinje type fibers connect and conduct these impulses between SA node and AV node. Atrial myocytes are also supposed to have contribution for this conduction. Impulses from AV node pass to the bundle of His. This leaves a *left bundle branch* at the top of the interventricular septum and continues as the *right bundle branch*.

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In human heart, ventricular muscle depolarization starts at the left side of the interventricular septum and spreads first to the right across mid portion of the septum. Chronologically and sequentially posterobasal portion of the left ventricle, the pulmonary conus and the uppermost portion of the septum depolarize lastly.

5.5. Electrocardiogram

The electrocardiogram (ECG or EKG) is defined as the graphic representation of the electric potential differences produced in association with the cardiac cycle. Generation and conduction of impulse produces weak electrical current that spreads throughout the body. ECG is recorded by setting electrodes on the surface of the body at various positions. These electrodes are connected to a decoder equipment to come out as a graph.

In this apparatus upright deflection indicates positive potential while negative potential is represented by downward deflection.

Usage of ECG

ECG is particularly used for diagnosis and treatment of many clinical presentations like

1. Ischaemic heart diseases (Coronary Heart Disease)
2. Hypertrophic diseases of the heart
3. Arrhythmias
4. Electrolyte effect on heart
5. Pericarditis
6. Drug effects on heart
7. Effect of systemic diseases on heart.

ECG

ECG is a good laboratory test for identifying heart diseases. But it cannot be the sole determining factor in every cases of heart disease treatment. A patient with organic cardiac lesion may have non-significant ECG evidence for the disease. The treating physician must always correlate clinical findings to interpret ECG. Placement of the leads properly in right place is the primary pre-requisite that is asked for.

ECG Record

ECG recording principles are based on the physical properties of action potentials and also the laws of electricity conduction. Since the body fluids are good conductors, ECG is done by using an *active* or *exploring* electrode connected to an indifferent electrode at zero potential (*Unipolar recording*) or by using two active electrodes (*Bipolar recording*).

In a normal ECG, P wave is formed by atrial depolarization, while the QRS complex, ventricular depolarization and the ST segment and T wave by ventricular repolarization. The U wave is found occasionally due to slow repolarization of the papillary muscles.

Bipolar Leads

Bipolar chest leads were used previously. Presently bipolar limb leads are used routinely. They are also called standard limb leads. The bipolar standard leads (I, II, III) are recorded by connecting electrodes to left arm

(LA), right arm (RA) and left leg (LL). A ground lead (*Black cord usually)* is also connected to the right leg (RL).

Lead I = LA - RA

Lead II = LL - RA

Lead III = LL - LA

(Lead II = Lead I + Lead III)

Unipolar Leads

Unipolar leads comprise extremity leads (VR, VL, and VF), precordial (chest) leads (V), esophageal leads (E) etc. The unipolar limb leads in frontal plane bears a mathematical relationship with bipolar limb leads. The chest leads that record potentials in the horizontal plane are not influenced by 'indifferent' potentials of the bipolar limb leads.

With minor technical modification of the equipment, amplitude of deflections of VR, VL, and VF is increased by 50%. These leads are called augmented unipolar extremity leads and are designated aVR, aVL, aVF.

American Heart Association prescribes position of the chest leads as follows-

V_1 : Right sternal border at *fourth* intercostal space

V_2 : Left sternal border at *fourth* intercostal space

V_3 : Mid point in line between V_2 and V_4

V_4 : Left midclavicular line at *fifth* intercostals space

Normal ECG

V_5 : Left anterior axillary line (Same horizontal plane as V_4)

V_6 : Left midaxillary line (Same horizontal plane as V_4)

V_7 : Left posterior axillary line (Same horizontal plane as V_4)

V_8 : Left posterior scapular line (Same horizontal plane as V_4)

V_9 : Left border of spine (Same horizontal plane as V_4)

V_{3R-9R} : Right side of chest location same as left side

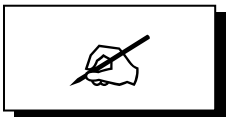
$3V_{1-9}$: Left sided but leads are set one space higher

$3V_{3R-9R}$: Right sided leads one space higher

VE : Taken over ensiform cartilage.

Routine ECG consists of 12-leads- I, II, III, aVR, aVL, aVF, $V_{1-6.}$
Oesophageal lead is taken by passing a lead into the oesophagus by a nasal catheter.

Unipolar intracardiac lead is introduced into the heart through a cardiac catheter. This is of much use for arrhythmia monitoring specially during any invasive cardiac manipulation is attempted.



5.6. Exercise

5.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. ECG is the study of

   a. cardiac cycle
   b. brain condition
   c. cardiac potential differences
   d. none of the above.

2. Cardiac Pacemaker is

   a. sinoatrial node
   b. atrioventricular node
   c. bundle of his
   d. none of the above.

3. Normally the cardiac cycle time is

   a. 5 minutes
   b. 0.8 sec
   c. 10 sec
   d. none of the above.

5.6.2. Short Questions

1. What are types of the circulation?
2. Define ECG.
3. What is intracardiac lead ECG? What are the uses of it?
4. Define augmented unipolar leads.

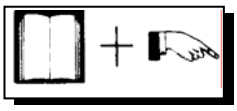
5.6.3. Broad Questions

1. Define cardiac cycle. Describe in brief a normal cardiac cycle.
2. Describe position of the leads for a 12 lead normal ECG.

Unit 3: Gastro-intestinal and Excretory System

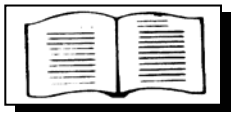
Lesson 1: Physiology of Gastro-Intestinal System-I

1.1. Learning Objectives



At the end of this lesson you will be able to-

- define digestion and mention the purpose of digestion
- describe components of GI system
- rewrite hormones of GI tract
- describe movement of Gastro intestinal tract.



1.2. The Gastrointestinal System

Gastrointestinal system is supposed to be the portal for digestion and also for absorption. It contains alimentary tract and some accessories or appendages. Alimentary canal extends from oral cavity and extends up to the anus. Combination of action of individual units makes the system workable.

Digestion is a physiological process by which complex food materials are broken down mechanically and chemically in the gastrointestinal tract to be converted into absorbable forms. It happens principally at the small intestine.

1.3. Components of Gastrointestinal System

Alimentary Tract

1. Mouth
2. Tongue
3. Pharynx
4. Oesophagus
5. Stomach
6. Small intestine
   a. Duodenum
   b. Jejunum
   c. Ileum
7. Large intestine
   a. Caecum

   b. Ascending colon
   c. Transverse colon
   d. Descending colon
   e. Sigmoid colon
8. Rectum
9. Anal canal.

Alimentary Tract Associated Organs

1. Salivary glands

Alimentary Tract
- Organs
- Secretions
- Functions
- Importance

- Parotid gland
- Submandibular gland
- Sublingual gland.

2. Liver
3. Pancreas
4. Gall bladder.

Importance of the Gastrointestinal Tract

1. The movement of food by peristalsis (propulsive movement)
2. Secretions of the digestive juice through the tract
3. Digestion of the foods by the digestive juice
4. Absorption of the digestive and other essential products.

Purpose of Digestion of Food

1. Create energy to the body for activity
2. For the growth of the body.
3. For the repair of wear and tear.

1.4. Hormones of GI Tract

1. Gastrin
2. Secretin
3. Pancreozymin
4. Cholecystokinin
5. Enterogastrone
6. Pancreatic Polypeptide

7. Motiline
8. Villikinine
9. Gastric inhibitory polypeptide (GIP)
10. Vasoactive intestinal polypeptide (VIP).

Juices from the Alimentary Tract

1. Salivary juice
2. Gastric juice
3. Pancreatic juice
4. Intestinal juice.

1. Salivary Juice

The salivary juice is secreted from the salivary glands. Salivary glands are parotid, submandibular and submaxillary. Daily secretion of salivary juice is about 1400-1600 ml.

Composition of Salivary Juice

Salivary Glands

1. Ptyaline
2. Mucin
3. Calcium
4. Sodium
5. Bicarbonate
6. Potassium
7. Chloride
8. Water.

Functions of Salivary Juice

1. Food particles are lubricated by the salivary juice
2. Easily deglutition of the food materials by the juice
3. It also responsible for destroying different types of bacteria.

Mechanism of Saliva Secretion

The salivary nuclei in the brain stem control the saliva secretion. These can be stimulated either by nerve impulses from the mouth when food is eaten or by psychic stimuli from the cerebral Cortex.

Xerostomia means dryness of the mouth due to the compete cessation of salivary secretion.

Causes

1. Anxiety
2. High temperature
3. Some drugs like antihistamine antidepressant etc.
4. Diabetic ketoacidosis
5. Dehydration.

Hyposalivation or Scanty Salivation

Causes

1. Dehydration
2. X-ray radiation
3. Drugs/ operation.

Hypersalivation or Plenty Salivation

Causes

1. Pregnant woman
2. Mouth and tongue ulcers
3. Carcinoma of the tongue
4. Gastric ulcer.

Sialolithiasis: Stone present in salivary duct is called sialolithiasis.

2. Gastric Juice Secretion

The gastric glands secrete the gastric juice. Daily secretion is about 1100-1500 ml. The gastric glands are-

1. Cardiac glands- contain rnucous secreting cells
2. Glands of the body and fundus of stomach
   a. Mucus cells- secrete mucus and pepsinogen
   b. Chief or peptic cells-secrete pepsinogen (large amount), gastric renin
   c. Parietal cells-secrete Hcl and intrinsic factor
   d. Entero-chromaffin cell- secrete gastrin and serotonin
3. Pyloric glands-mucus neck cell secretes mucin and gastrin.

Gastric Juice

Composition of Gastric Juice

1. Mucin
2. Pepsin
3. Hydrochloric acid
4. Intrinsic factor
5. Sodium
6. Potassium
7. Calcium
8. Chlorine.

Functions of Gastric Juice

1. Digests protein up to the stage of peptone by enzyme pepsin ē HCL
2. Fat is digested by gastric lipase
3. Gastric HCL is also acts as an antiseptic
4. Gastric HCL causes hydrolysis of all the food materials.
5. Toxic substances are excreted through gastric juice.

Factors Affecting Gastric Juice Secretion

1. Anxiety, tension, emotion
2. Quantity of drinks
3. Nature of food staff
4. Intake of acids/ alkalis
5. Hormones
6. Electrolyte
7. Drugs
8. Vitamins.

Factors increasing gastric juice secretions	Factors inhibiting gastric juice secretion
1. Taste, smell, sight of food 2. Insulin- decreasing blood sugar level.	1. Anxiety, tension, emotion. 2. Excess fat in the duodenum.

3. Pancreatic Juice

Daily secretion is about 800-1500 ml.

Composition

1. Proteolytic enzyme-Trypsin, Chymotrypsin, RNAase, DNAase carboxypoly-peptidase.
2. Pancreatic amylase.
3. Lipase, Phospholipase.

Functions of Pancreatic Juice

1. Digestion of major food items like carbohydrate, protein and fat.
2. Neutralize equal volume of gastric juice.
3. Breaking of RNA and DNA into nucleotides.

4. Intestinal Juice (succus intericus)

It is secreted by the brunner's gland and crypts of leiberkun.

Composition

1. Proteolytic enzyme-Nuclease, Nucleotidase, Nucleosidase, Erepsion.
2. Carbohydrate splitting enzyme
   i) Sucrase ii) Maltase iii) Lactase, iv) Lsomaltase
3. Fat splitting enzyme- Lipase.

Functions of Intestinal Juice

1. Digestion of fats, proteins and carbohydrates
2. Protection of intestinal mucosa
3. Assistance for absorption of vitamin B_{12}
4. Maintenance of water balance.

Exercise: Describe gastrointestinal secretions with function.

1.5. Movement of Gastro-Intestinal Tract

Two special types of movement are present in the gastrointestinal tract-

1. The propulsive movement that propel food materials forward along the tract. The propulsive movement is known as peristalsis that occurs in all smooth muscle tubes.
2. The mixing movement that keep mixing the content of the intestine. The mixing movements promote mixing of the food in all parts of the gastrointestinal tract with the gastrointestinal secretions.

1.6. Exercise

1.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Digestion principally occurs at the

   a. stomach
   b. small Intestine
   c. rectum and sigmoid colon
   d. none of the above.

2. Sight of food

   a. increase gastric juice secretion
   b. decrease gastric juice secretion
   c. neutralizes gastric pH
   d. none of the above.

3. Pepsin is secreted in

   a. gastric juice
   b. intestinal juice
   c. pancreatic juice
   d. none of the above.

1.6.2. Short Questions

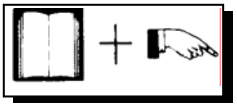
1. Define digestion.
2. Name the salivary glands.
3. What are the functions of pancreatic juice?
4. Write down the composition of pancreatic juice.

1.6.3. Broad Questions

1. Enumerate components of gastrointestinal system.
2. What are the hormones of GI tract?
3. Write down the composition and functions of gastric juice.

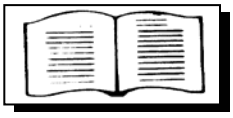
Lesson 2: Physiology of Gastro-intestinal System-II

2.1. Learning Objectives



At the end of this lesson you will be able to-

- describe functions of liver and liver function tests
- describe composition and functions of bile
- describe functions of gallbladder
- describe physiological anatomy of pancreas.



2.2. The Hepatobiliary System

Liver is the largest gland in human bears. It is composed of a spongy mass of wedge-shaped lobes. It has many metabolic and secretory functions. Bile is a digestive fluid secreted by liver that metabolizes proteins, fats and carbohydrates.

Functions of Liver

1. Secretes bile and excretes through faces
2. Excretion of steroid hormones
3. Glycogenesis i.e., conversion of glucose into glycogen
4. Stores glycogen, vitamins, and other substances
5. Synthesizes proteins
6. Synthesizes factors for blood coagulation
7. Synthesizes cholesterol and lipoproteins e.g. VLDL, HDL, LDL
8. Removes wastes and toxic matter from the blood
9. Destroys old red blood calls
10. Phagocytosis for foreign particles by kupffer cells.

Liver Function Tests

A. Routine Biochemistry

1. Determinations of prothrambin time
2. Estimation of total protein, albumin, globulin, fibrinogen
3. Serum bilirubin (Total, direct and indirect)
4. SGPT and SGOT

5. Alkaline phosphatase
6. Gamma glutemyl transpeptidase
7. Lactate dehydrogenase (LDH)
8. Choline esterase.

B. Additional Blood Investigations

1. Antimitochondrial antibody
2. Antinuclear antibody
3. Serum Immunoglobulins
4. ∝-fetoprotein
5. ∝-artitrypsin
6. Serum copper and ceruloplasmin.

C. Stool and Urine Examination

i. Routine examination for urobilinogen in both stool and urine

ii. Faecal fat analysis

The liver is neatly and closely connected with both the intestine and the gallbladder to perform many of its varied functions. Portal vein carries venous blood from the intestine to the liver to be processed before returning to the heart. A duct system carries bile from liver to the common bile duct to be emptied into the duodenum. It is also connected with the gallbladder for storage and subsequent release of bile.

Bile

Bile is also called Gall. It is a greenish yellow secretion produced in the liver and is passed to the gallbladder for concentration, storage, or transport into the duodenum. It assists in fat digestion in the duodenum. Bile is secreted without pause from hepatocytes into the common bile duct and gallbladder. It is usually concentrated to about 5 to 18 times in the gallbladder. Quantity of bile secretion into the duodenum is controlled by the hormone secretin, gastrin, and cholecystokinin and also by the vagus nerve. Normally liver produces about 250 to 1,000 ml. of bile (before concentration) per day.

2.3. Composition of Bile

Bile is composed of *bile acids and salts, cholesterol, pigments, water, and electrolytes* that keep the total solution slightly acidic (a pH of about 5 to 6). Bile salts comprise salts of four different kinds of free bile acids (Cholic, deoxycholic, chenodeoxycholic, and lithocholic acids).

All of these acids in turn may be conjugated with glycine or taurine to form more complex acids and salts. Bile salts and acids can be synthesized from cholesterol or extracted from the bloodstream by the liver. These pass into the intestine from the liver and act as detergents to emulsify fat and reduce the surface tension on fat droplets. These are then prepared for the action of pancreatic and intestinal fat-splitting enzymes.

Functions of Bile

1. Helps in the digestion and absorption of fat.
2. Bile salts increase peristalsis and thereby assist in defecation.
3. Bile salts help in the absorption of lipid soluble Vitamin A, D, E and K.
4. Helps to maintain pH for enzymic actin in intestine.

2.4. Gallbladder

Gallbladder

Gall bladder is a membranous muscular sac attached to the liver very closely. It is also present in many vertebrates. Its primary function is to store and concentrate bile. Some animals have a gallbladder that does not concentrate fluids well. These animals have usually a continuous flow of bile into the intestine. In animals without a gallbladder, such as horses, rats, and pigeons, bile comes directly from the liver.

In human being it is situated at underneath the liver. The gallbladder is a pear-shaped, expandable organ with a capacity of about 1.7 fluid ounces (50 ml). The inner surface of the gallbladder wall is lined with mucous membrane similar to that of the small intestine. Cells of the mucous membrane perform the function of absorption. Each cell surface has hundreds of microscopic projections called microvilli that increase the area of fluid absorption. The absorption of water and inorganic salts from the bile by the mucous-membrane cells leaves the stored bile about 5 to 18 times more concentrated than when it was produced in the liver.

Ruggero oddi was a 19th century Italian physician

Contraction of the muscle wall in the gallbladder is stimulated by the vagus nerve of the parasympathetic system and by the hormone cholecystokinin, which is produced in the upper portions of the intestine. Contraction of the gallbladder results in the discharge of bile through the bile duct into the duodenum. The human bile duct is composed of three branches-

1. Hepatic duct
2. Cystic duct, and
3. Common duct.

These structures are arranged into the shape of the letter Y. The lower segment is the *common bile duct*. It terminates in the duodenal wall of the small intestine. A constriction at the end of the common duct is called the sphincter of Oddi. This sphincter regulates the flow of bile into the duodenum. The upper right branch is the hepatic duct leads to the liver where bile is produced. The upper left branch, the cystic duct, passes to the gallbladder, where bile is stored.

Bile flows from the two lobes of the liver into the hepatic and common ducts. If food is present in the small intestine, the bile will continue directly into the duodenum. If the small intestine is empty, the sphincter of Oddi is closed, and bile flowing down the common duct accumulates and is forced back up the tube until it reaches the open cystic duct. It flows into the cystic duct and gallbladder, where it is stored and concentrated until needed. When food enters the duodenum, sphincter of the common duct opens, the gallbladder contracts, and bile enters the duodenum to aid in the digestion of fats.

The gallbladder is commonly a subject to many disorders, particularly the formation of solid deposits called gallstones. Despite its activity, it can be surgically removed without serious effect.

Functions of Gall Bladder

1. Storage of bile
2. Excretion of cholesterol
3. Concentrate bile many times
4. Absorptions of inorganic salts.

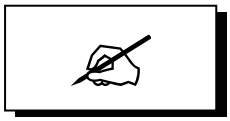
2.5. Pancreas

Pancreas

Pancreas is a vital organ for human body physiology. It weighs about 90 and 120 grams. It is a narrow but long glandular organ that is situated transversely across the upper abdomen in the space behind the posterior peritoneum. Its bulbous like head lies against the inner curve of the C-shaped loop formed by the curve of the second portion of the duodenum. The body and tail of the pancreas rise upward and leftward from the head, lying behind the stomach and the spleen. The midportion of the body lies against the vertebral column, the abdominal aorta, and the inferior vena cava.

The pancreas is both an *exocrine* (ductal) and *endocrine* (ductless) gland. Acinar and ductal tissue arise from multiple sites along the primordial epithelial buds, and islet cell tissue arises from other sites. These two separate tissues mix with one another during early fetal life,

but each retains its own distinctive character, acinar tissue being linked to the ductal system, and islet tissue having no ductal connections. Distinctly separate islet and acinar tissue are detectable microscopically by the 19th week of intrauterine life.



2.6. Exercise

2.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Toxic waste are detoxified by

   a. stomach
   b. small Intestine
   c. liver
   d. none of the above.

2. Emulsification of fat is done by

   a. bile salts
   b. lactase
   c. pepsin
   d. none of the above.

3. Cholesterol is synthesized mainly in

   a. gastric juice
   b. liver hepatocytes
   c. pancreatic juice
   d. none of the above.

2.6.2. Short Questions

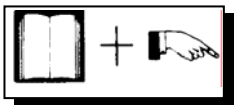
1. What is bile?
2. Name the bile salts.
3. What are the types of cells in pancreas?
4. Write down the composition of bile.

2.6.3. Broad Questions

1. Describe the physiological anatomy of hepatobiliary system.
2. What are the functions of liver?
3. Write down some important liver function tests.

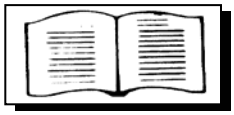
Lesson 3: Physiology of Excretory System-I

3.1. Learning Objectives



At the end of this lesson you will be able to-

- describe components and structure of excretory system
- describe functions of kidneys
- describe regulatory functions of kidneys.



3.2. The Excretory System

Parts of urinary system -
1. Kidneys- 2
2. Ureters –2
3. Urinary bladder
4. Urethra

Human excretory system in many respects resembles those of other mammalian species, but it has its own unique structural and functional characteristics. The terms excretory and urinary emphasize the eliminatory function of the system. In human being excretory system includes organ system that includes the kidneys, ureters, bladder and urethra.

The kidneys are primarily designed for urine production. But the kidneys both secrete and actively retain within the body certain substances that are similarly critical to survival like those that are eliminated. Other parts are designed for the passage, storage, and voiding of urine.

Anatomical Position

Human excretory system is composed of two *kidneys*, which control the electrolyte composition of the blood and eliminate dissolved waste products and excess amounts of other substances from the blood. These substances are excreted in the urine, which passes from the kidneys to the bladder by way of two thin muscular tubes called the *ureters*. The *Urinary bladder* is a sac that holds the urine until it is eliminated through the urethra.

The kidneys are reddish brown, bean-shaped, paired organs, concave on one long side and convex on the opposite. They are located in the abdominal cavity but outside the peritoneum on either side of the vertebral column against the back wall between the levels of the 12th thoracic and 3rd lumbar vertebrae.

The long axes of the kidneys are aligned with that of the body, but the upper end of each kidney (pole) is tilted slightly inward toward the vertebral column. Hilus is a deep vertical cleft situated at the middle of the medial concave border and leads to a cavity within the kidney called *renal sinus*. The hilus is the point of entry and exit for renal *arteries and veins*, *lymphatic vessels, nerves* and enlarged upper extension of the *ureters*.

Kidney Consists of 2 Parts

1. O*uter cortex*- Reddish in appearance due to sufficient blood supply-

i. Glomerular capillary plexus
ii. Peritubular capillary plexus
iii. Proximal convoluted tubules
iv. Distal convoluted tubules
v. Collecting tubules
vi. Juxtra glomerular apparatus.

2. Inner medulla- Pale colours due to less blood supply. It contains -

i. Loop of henle
ii. Vasa recta
iii. Inner collecting tubule.

Nephron

It is the structural and functional unit of kidney. It has two parts- *glomerulus and renal tubules*. It consists of -

i. Glomerular capillary
ii. Bowman's capsule
iii. Proximal convoluted tubule
iv. Descending limb of loop of henle
v. Ascending limb of loop of henle
vi. Distal convoluted tubule
vii. Collecting tubule.

The renal arteries arise from the abdominal aorta, one on each side, at a point opposite the upper border of the second lumbar vertebra. Each artery gives off small branches to the adrenal gland and ureter close to the renal hilus before branching into anterior and posterior divisions. The large veins carrying blood from the kidneys usually lie in front of the corresponding arteries and join the inferior vena cava almost at right angles. The left vein is longer than the right vein because the inferior vena cava lies closer to the right kidney.

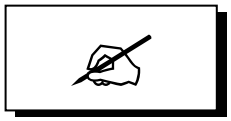
The kidneys are supplied with sympathetic and parasympathetic nerves of the autonomic nervous system.

General Function of the Kidney

The kidneys help to maintain a constant internal environment despite a wide range of changes in the external environment. General functions of kidney are designated to maintain human health with water and salts conserved, wastes excreted in concentrated form, and the blood or the tissue fluids strictly regulated for volume, chemical composition, and osmotic pressure. Arterial pressure drives water and salts to be filtered from the blood through the capillaries of the glomerulus into the lumen of the nephron. Then water and the essential electrolytes of the body are reabsorbed into the blood. The remaining filtrate is drained off as urine.

3.3. Functions of Kidneys

1. Regulation of water balance
2. Regulation of electrolyte balance
3. Regulation of acid base balance
4. Excretion of waste products
5. Regulation of osmotic pressure
6. Regulation of blood pressure
7. Absorption of vital plasma constituents such as glucose, amino acids, phosphates, bicarbonates and proteins
8. Formation of ammonia and secretion of erythropoietin



Exercise: Describe parts of kidney.

3.4. Regulatory Physiology of Kidneys

Regulatory functions of kidney

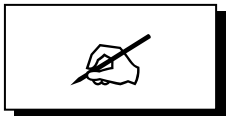
Kidneys regulate essential and interrelated properties of the tissues like *water content, acid-base balance, and osmotic pressure*. Thus electrolyte and water equilibrium is maintained. Body malfunction rapidly develops leading to sickness electronic or death if the kidneys fail to maintain a balance between quantities of water and the quantities of such as calcium, potassium, sodium, phosphorus, and sulfate in solution. Kidney maintains concentrations of *mineral ions* such as sodium, *crystalloids* such as glucose, and *wastes* such as urea within narrow normal limits. The removal of both kidneys causes urinary constituents to accumulate in the blood (uraemia). Uraemia results in death in untreated cases. If blood

contains an abnormal constituent in solution or an excess of normal constituents including water and salts, the kidneys excrete these until normal composition is restored. Only kidneys eliminate the end products wastes of protein metabolism.

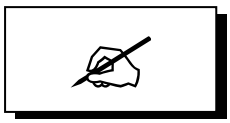
Liver and other organs detoxify or modify the wastes. Kidneys transfer them to the urine in the form in which they are produced in other parts of the body. They do not themselves modify the waste products that they excrete. But there is exception over here. Kidneys can manufacture ammonia.

The kidney also eliminates drugs, toxic agents or their metabolites. The kidneys eliminate the unwanted end products of metabolism such as urea but limit the loss of valuable substances, such as glucose. The kidneys remove excess of hydrogen ions produced from the normally acid-forming diet and manufacture ammonia to remove these ions in the urine as ammonium salts. Thus it maintains the acid-base equilibrium.

The kidney needs a relatively huge amount of blood supply to carry out its multidimensional functions. About 1,200 milliliters of blood is processed in the kidneys per minute. This equals about 1,800 liters (about 475 gallons) per day. This is about 400 times the total blood volume and roughly one-fourth the volume pumped each day by the heart. About 170 liters (45 gallons) of water are filtered from the bloodstream into the renal tubules every 24 hours. Greater part of this water (About 168.5 liters) is reabsorbed with salts dissolved in it by the cells lining the tubules. This is returned to the blood thereafter. The total glomerular filtrate in 24 hours is no less than 50–60 times the volume of blood plasma in the entire body. An average man eliminates only 1.5 liters of water in a 24-hour period. This contains the waste products of metabolism, but the actual volume varies with fluid intake and occupational and environmental factors. With vigorous sweating it may fall to 500 ml per day and with a large water intake it may rise to three liters or six times more. The kidney can vary its reabsorption of water to compensate for changes in plasma volume resulting from dehydration or over hydration.



Exercise: Describe regulatory mechanisms of the kidneys.



3.5. Exercise

3.5.1. Multiple Choice Questions

Tick (√) the correct answer

1. Main functions of kidney includes all except

   a. regulation of water balance
   b. production of globulin
   c. regulation of electrolyte balance
   d. excretion of toxic material and wastes.

2. Normally renal medulla appears pale, due to

   a. deoxygenation procedures
   b. excess fat contents
   c. poor blood supply
   d. none of the above.

3. Removal of the kidneys results in

   a. uraemia
   b. polycythaemia
   c. reduced platelet counts in peripheral blood
   d. none of the above.

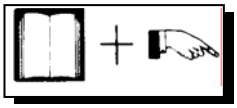
3.5.2. Short Questions

1. Describe the functions of kidney.
2. What is nephron? Explain the components of a nephron.
3. Describe renal vascular and nerve supply.

3.5.3. Broad Questions

1. Describe gross physiological anatomy of the excretory system.
2. Describe the regulatory functions of kidneys.

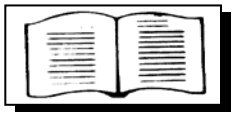
Lesson 4: Physiology of Excretory System-II



4.1. Learning Objectives

At the end of this lesson you will be able to-

- define glomerulus and describe components of filtration
- describe the mechanism of formation of urine
- describe acid base balance and acidification of urine.



4.2. Renal Blood Flow

The average flow of blood through the both kidneys is about 1200 ml/min. Entire plasma volume of the body is filtered by the kidney 60 times/ day. Renal corpuscles are important components for discussion on blood flow through kidney. These are small and rounded in shape and composed of 2 parts- Glomerulus and Bowman's capsule.

Glomerulus consists of compact tuft of interconnected capillary loops, glomerular capillaries, and a hollow balloon like capsule called the Bowman's capsule. The capillary tuft protrudes into Bowman's capsule. This resembles a closed fist invaginated into a balloon with a potential space between two protruding layers. *Glomerular membrane* is the membrane in which the fluids are passed from glomerular capillary to bowman's capsule. It is the part of glomerular capillaries.

Layers of glomerular membrane (Filtration barrier)

i. Endothelial Layer

ii. Basement membrane

iii. A layer of epithelial cells.

Factors affecting GFR

Glomerular Filtration is defined as filtration of plasmalike fluid through the glomerular capillaries into the renal tubules. The fluid that filters through glomerulus is called *glomerular filtrate*. Glomerular filtrate is `essentially protein-free`.

*Glomerular Filtration Rate (*GFR) is defined as the quantity of glomerular filtrate in all the nephrons of the both kidneys in one minute. It is about 125ml/min.

Factors Affecting GFR

- Glomerular surface area due to relaxation of mesangial cells: ∝

- Increased arterial pressure dearness GFR: ∝
- Glomerular capillary pressure is (60 mm Hg): ∝
- Colloidal osmotic pressure (32 mm Hg): 1/∝
- Bowman's capsular pressure (18 mm Hg): 1/ ∝
- Increased renal blood flow: ∝
- Sympathetic stimulation: ∝.

Renal Fraction

The amount of blood pumped out from the left ventricly to pass through the both kidneys in one minute is called renal fraction.

Total cardiac output is about 5600 ml/min.

Renal fraction = (1200x100) ÷ 5600 = 21 %

Range- 12-30%.

Plasma Clearance

The volume of plasma (in ml) that contains the constituent excreted through the kidney in each minute is known as plasma clearance.

Plasma clearance (Cx) =

Concentration of substance in urine (Ux) x volume in urine (ml/ min) (V)
Concentration of substance in plasma in ml (Px).

Plasma Load

Mechanism of urine formation

The total amount of the substance, which is present in the plasma passes through the kidneys in each minute, is known as plasma load.

Plasma load of glucose is 125mg/min.

Reabsorption and secretion in the renal tubules

Reabsorbed Substances

Na^+, K^+, Ca^+, $+Mg^+$, +glucose, amino acid, vitamins, Cl^- HCO_3^- SO_4^- NO_3^- PO_4^- Urea etc.

Secretary Substances

K^+, H^+, ammonia, creatinine etc.

4.3. Mechanism of Formation of Urine

Urine is formed by 3 processes

1. Filtration
2. Reabsorption
3. Secretion

1. Filtration

Filtration occurs in the glomerulus. The glomerulus is composed of numerous capillary blood vessels. It has afferent and efferent blood vessels.

Filtration pressure =

Glememlar capillary hydrostatic pressure- (Colloidal osmotic pressure + capsular pressure)

In the glomerulus

Hydrostatic pressure is 60 mm Hg

Colloidal osmotic pressure is 32 mm Hg

Capsular pressure is 18 mm Hg

So filtration pressure = 60 - (32 + 18) = 10 mmHg.

2. Reabsorption

Reabsorption occurs in the tubules.

a. *Proximal tubule* is responsible for about 65% reabsorption. Glucose, amino acids, acetoacetic acid, proteins, sodium, potassium, water and other electrolyte etc. are reabsorbed in the proximal tubules.
b. *Loops of Henle.* The *descending loop of Henle* is permeable to water while the *ascending loop of Henle* is permeable to sodium but not to water.
c. *Distal convoluted tubules* are normally impermeable to water, but become permeable by the action of anti-diuretic hormone (ADH).
d. C*ollecting tubules* are permeable to water due to the action of ADH.

3. Secretion

Secretion occurs in the tubules. Hydrogen ion is secreted at the proximal convoluted tubules, distal convoluted tubules and collecting tubules. Potassium ion is secreted at the distal convoluted tubules and creatinine from the proximal convoluted tubules.

4.4. Regulation of Acid Base Balance

Acid base balance actually means hydrogen ion concentration regulation in the body fluids. Kidneys balance hydrogen ion concentration by the following ways:

Hydrogen ion is secreted into tubular fluid from the tubular epithelium. This ion fills up loss of acid from the extra cellular fluids. The bicarbonate ions are filtered in to the tubules from the glomerulus and fill up the loss of alkali.

Acidification of Urine

The mechanism by which slightly alkaline glomerular filtrate is converted into acidic urine is called acidification of urine. There are three buffer systems these helps in this acidification.

Acidification of urine

1. Bicarbonate (HCO_3) buffer
2. Phosphate (HPO_4)
3. Ammonia (NH_3).

1. Bicarbonate (HCO_3) Buffers

HCO_3 in the body fluid buffer system is the major buffer system. When hydrogen ion is added to blood, as it passes through the tissues, it increases hydrogen ion concentration. So, concentration of H_2CO_3 increases. This H_2CO_3 dissociates by carbonic anhydrase to form CO_2 & H_2O. The CO_2 diffuses in the tubular cells and HCO_3 is then reabsorbed.

2. Phosphate (HPO_4) Buffers

The phosphate buffer system (HPO_4/ H_2PO_4) is important to maintain the intracellular fluid of red blood cells. The hydrogen ion is secreted from the proximal, distal and collecting duct. So hydrogen concentration is increased in the tubules. Dibasic phosphate is converted into monobasic phosphate by the action of hydrogen ion concentration with the phosphate buffer. This is acidic in nature and occurs in distal and collecting tubules.

3. Ammonia (NH_3) Buffers

It is also an important buffer system. The NH_3 is *secreted* in the proximal, distal and collecting tubules. It is converted into NH4 following its reaction with hydrogen ion. Chloride is added to it to form NH_4Cl in the urine and readjust the urine acidic in nature.

Exercise: Describe acid base regulation by the kidneys.

Acidosis

Normal blood pH is 7.4. Acidosis occurs when arterial pH is below 7.4. In other words, relative increase of acid content is called acidosis there are 2 types of acidosis-

1. *Respiratory acidosis* results from high PCO_2.
2. *Metabolic acidosis* results from abnormal retention of fixed acids that are buffered by HCO_3. It occurs due to the failure of kidney to excrete the waste products from the body.

Alkalosis

When arterial pH is above 7.4, the state is called alkalosis. In other words, relative increase of alkali in the body fluid with respect to the acid content is called alkalosis. There are 2 types of alkalosis.

a. Respiratory alkalosis results from low PCO_2 due to excessive loss of CO_2 (e.g. hyperventilation).
b. Metabolic alkalosis results from excessive loss of hydrogen (e.g. loss of HCl from vomiting or excessive intake or retention of bases like $NaHCO_3$).

Effects of Acidosis and Alkalosis

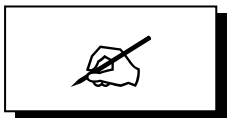
In acidosis patient develops disorientation, mental confusion and comatose due to the depression of central nervous system. In alkalosis patients develop tonic spasm of the muscles (Tetany) due to the excitability of the nervous system.

Hormones Acting on Kidney

Sl. No.	Hormones	Functions
01.	Aldosterone angiotensin-II	1. Increases the reabsorption of Sodium 2. Increases the secretion of Potassium
02.	Anti diuretic hormone	3. Helps in reabsorption of water
03.	Parathormone	4. Increases the reabsorption of Calcium ion

Kidney Function Tests

1. *Physical and chemical analysis of urine*
2. *Blood analysis* – Blood Urea, Creatinine, Electrolytes, Calcium, Phosphate, Uric acid.
3. *Renal clearance test*- Creatinine clearance test (For GFR), paraminohippuric acid clearance (as a measure of plasma flow through the kidneys), Urea clearance.
   i. Volume of 24 hour urine output (UTV)
   ii. Urinary protein for 24 hour (UTP)
   iii. Dipstix (Protein, Blood, Glucose, Urobilinogen)
   iv. Specific gravity of urine
   v. Urine pH.



4.5. Exercise

4.5.1. Multiple Choice Questions

Tick (√) the correct answer

1. Normally GFR is

   a. 100 L/hr
   b. 125 ml/min
   c. 6 L/ day
   d. none of the above.

2. Glucose and amino acids are reabsorbed in

   a. collecting tubules
   b. distal tubules
   c. proximal tubules
   d. none of the above.

3. Ascending loop of Henle is normally

   a. permeable to sodium but not to water
   b. permeable to both sodium and water
   c. permeable to water but not to sodium
   d. none of the above.

4.5.2. Short Questions

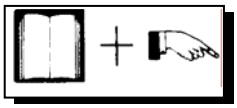
1. Define glomerular filtration rate.
2. What are the layers of the filtration barrier?
3. Define plasma clearance. What is acidosis?
4. Enumerate the name of hormones acting on kidneys.

4.5.3. Broad Questions

1. Describe the mechanism of action of urine formation by the kidneys.
2. Describe the regulatory mechanism of acid base balance of kidneys.
3. Enumerate some common renal function tests.

Unit 4: Endocrine and Reproductive System

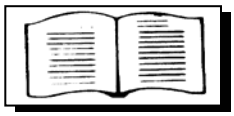
Lesson 1: Physiology of Endocrine System



1.1. Learning Objectives

At the end of this lesson you will be able to-

- define endocrine system and also hormone
- classify hormones from different points of view
- describe general mechanism of action of hormone
- describe hormones of different endocrine glands.



1.2. The Endocrine System

Endocrinology deals with the regulation of hormones synthesized by cellar a group of cells without duct system into the circulation and usually acts on remote sites. Endocrine System is defined as a group of specialized organs and body tissues that produce, store, and secrete chemical substances known as hormones. *Hormone* is a chemical substance synthesized in trace a cell or a group of cells amounts by and acts as a messenger to regulate the functions of another tissue or organ. Hormones transfer informations and instructions from one set of cells to another as the body's chemical messengers.

Hormones control various functions of body tissues, regulate metabolism and contribute to body growth or development. It also supports conception procedures and other reproductive functions.

1.3. Classification of Hormone

A. Classification on the basis of *site of action*-

i. Local hormone: Acetylcholine, cholecystokinin, secretin

ii. General hormone: Growth hormone, ACTH, thyroid hormones etc.

B. Classification on the basis of chemical nature-

i. Protein and peptides hormone: Adenocorticotropin hormone, FSH, Growth hormone.

ii. Vasopresin, oxytoin etc.

iii. Aminoacid derivatives: Thyroxine, tri-iodo thyronine, epinephrine, norepinephrin.

iv. Steroid hormone: Cortisol, aldosterone, testosterone etc.

1.4. General Mechanism of Hormonal Action

Hormone first interacts with the *receptor*, a specific protein of target cells. This interaction triggers a response. Receptor has 2 sites -

i. *Binding site* that recognizes and binds to a specific hormones; and

ii. *Effector site* that initiates cellular responses to the hormone.

Mechanism of action of hormones

Protein hormones bind to receptors on the membrane of their target cells. Some membrane receptors have enzymatic activity and are coupled to an enzyme via a protein. Thyroid and steroid hormones bind to intracellular receptors.

Basically, when the hormone bind to its membrane receptor, G proteins (found in the cell membrane will stimulate or inhibit cyclic AMP. This will stimulate cyclic GMP to activate diacylglycerol and inositol triphosphate or alter k+ or Ca++ channels.

Glucagon is produced in the pancreas but also in the wall of the gastrointestinal tract. It raises glucose levels in the blood when the body needs extra energy

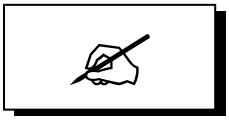
In many cases G protein activation causes protein phosphorylation. There are several known protein kinases (e.g. protein kinase A, protein kinase c etc.) regulated by hormones. Activity of some phosphatases changes with dephosphorylation. Some become more catalytically active depending upon the enzyme. So this is another place where hormones control cell function.

Lastly, some genes have regulatory sites for some of the intracellular second messengers e.g. cAMP. Thus, hormones that bind to membrane receptors activate or inactivate enzymes by second messenger signal transducers and alter transcription rates of specific genes.

1.5. Components of the Endocrine System

Hypothalamus, pituitary, thyroid, parathyroid, adrenal, pineal body, and reproductive glands—the ovary and testis are the primary glands that make up the human endocrine system. The Pituitary Gland is also called the master gland, secretes hormones that control the activity of other endocrine glands and regulate various biological processes. Its secretions include growth hormone, thyroid stimulating hormone, antidiuretic hormone, and prolactin etc. The hypothalamus, coordinator of the endocrine system, (Found deep within the brain) directly controls the pituitary gland.

The pancreas is also considered part of the endocrine system. In addition, some non-endocrine organs like brain, heart, lungs, kidneys, liver, thymus, skin, and placenta are known to actively secrete hormones. Most of the body cells can either produce or convert hormones, and some secrete hormones. Still then, the endocrine glands are specialized for hormone production from simple chemical substances.



Exercise: Describe the components of endocrine system.

Hypothalamus: Important releasing and inhibitory hormones.

Sl.No.	Name of Hormone	Function in Brief
01.	Corticotrophin releasing hormone	Potent stimulator of cAMP synthesis and also ACTH secretion.
02.	Thyroid stimulating hormone releasing hormone	Controls TSH secretion. Also a neurotransmitter.
03.	Gonadotropin releasing hormone	Stimulates release of both FSH and LH.
04.	Growth hormone releasing hormone	Stimulates secretion of growth hormone.
05.	Somatostatin or Growth hormone inhibitory hormone	Suppresses secretion of GH. Inhibits gastrointestinal motility
06.	Prolactin inhibitory hormone	Inhibits prolactin secretion.

Growth Hormone

Growth Hormone

In the pituitary somatotrops constitute 40 percent of the gland. These are predominantly located at the lateral lobes and secrete between one and two milligrams of growth hormones (GH; also called somatotropin) per day. Growth hormone stimulates growth, not only of bone but also essentially of all the body tissues. Biochemically to say, growth hormone simultaneously *stimulates protein synthesis* in tissues and enhances the *breakdown of fat* to provide the energy for the stimulated growth. Growth hormone is also an *insulin antagonist* and, in many individuals, can lead to elevated sugar levels in the blood and may cause diabetes mellitus.

While GH may act on tissues directly, much of its effect is mediated by way of *stimulating the liver* and other tissues to manufacture and release

secondary hormones, called *somatomedins*, which partly mimic the action of insulin. During childhood, somatomedin levels in the serum rise progressively with age, with an accelerated increase occurring at the time of the growth spurt of puberty, followed by a reduction to adult levels.

Growth hormone secretion is stimulated by *growth hormone releasing hormone* (GHRH; also known as somatocrinin) and is inhibited by *somatostatin*. There are prominent daily fluctuations in growth hormone secretion in normal individuals, with the largest increase occurring shortly after the onset of sleep. Again, this increase is most pronounced at the time of puberty. Growth hormone levels in the serum are elevated in individuals with tumours that produce growth hormone, and its levels are unresponsive to stimulation in states of malnutrition.

Functions of Growth Hormone

i. Transport of some amino acids through cell membranes.
ii. Activates RNA translation process to cause increased formation of proteins by the ribosomes.
iii. Increases the rate of DNA transcription to increase the amount of mRNA.
iv. Increases the replication of DNA that causes increased reproduction of the cell.
v. Decreases the rate of breakdown of proteins in the cells. Thus growth hormone has a potent effect to enhance all aspects of protein synthesis and stores in the cell body.

I. Thyroid Hormone

Functions of Thyroid Hormone

a. Promote growth and development of brain during fontal life and for first few years of life
b. Increase the rate of activity and metabolism of body cells
c. Increase breakdown of cellular foodstuff
d. Increase rate of synthesis of proteins
e. Increase the active transport of ions through membranes specially Sodium potassium pump
f. Assist in glucose metabolism
g. Affects fat mobilization and β- oxidation of fatty acids
h. Increase heart rate

Thyroid Hormone

i. Affects appetite, food intake, gastric juice secretion and also motility of the gastrointestinal tract

j. Affects growth and differentiation of organs like breast, bone marrow and teeth etc.

II. Parathyroid Hormone

Parathormene

This hormone is a single chain polypeptide of 84 amino acids. This is secreted by four parathyroid glands situated behind the lobes of thyroid. Pituitary hormones do not influence these glands, rather they respond to changes in serum ionized calcium concentration.

Functions of Parathyroid Hormones

1. Regulates calcium absorption and excretion by interaction with vitamin D and its metabolites
2. Promotes calcium reabsorption from renal tubules and bone
3. Causes increased calcium absorption from food
4. Causes enhanced mobilization of calcium from bone
5. Plays a central role in regulating calcium homeostasis
6. Stimulates osteolysis of bone returning calcium from bone to extracellular fluid
7. Increased osteoclastic activity, extensive bone remodeling and osteoblastic repair with prolonged exposure

III. Adrenocortical Hormones

Histologically *adrenal cortex* is divided into three structural zones-

- Zona Glomerulosa
- Zona Fasciculata
- Zona Reticularis.

But physiologically these layers act as two functional units to produce corticosteroid in response to humoral stimuli. *Adrenal medulla* acts as a component of sympathetic nervous system to secrete catecholamines.

Hormones (Principal) of Adrenal Cortex

Adrenocortical Hormone

1. Mineralocorticoids
2. Glucocoticoids
3. Androgens.

Functions of adrenal cortex hormones

1. Mineralocorticoids

i. Electrolyte balance
ii. Retention of sodium in distal nephron, sweat ducts colon etc.
iii. Potassium excretion.

2. Glucocorticoids

i. Regulation of blood pressure
ii. Regulation of carbohydrate metabolism
iii. Increased protein catabolism
iv. Immunomodulation.

3. Androgens

i. Serve as a precursor of testosterone

4. Catecholamines

i. Modulate vascular tone
ii. Increase heart rate
iii. Antagonize insulin action.

IV. Insulin and Glucagons

Hormones from islets of langerhans

1. Insulin from β-cells
2. Glucagon from α-cells
3. Somatostatin from δ-cells.

Actions of Insulin

Protein Metabolism

Actions of Insulin

1. Protein synthesis
2. Amino acid transport
3. Protein degradation.

Carbohydrate Metabolism

1. Glucose transport
2. Glucose phosphorylation
3. Glycogenesis
4. Glycolysis
5. Gluconeogenesis
6. Glycogenolysis

Lipid Metabolism

1. Fatty acid synthesis in liver
2. Lipoproteinlipase activity
3. Triglyceride synthesis
4. Fatty acid oxidation
5. Lipolysis

Electrolytes

1. Cellular potassium uptake

Functions of Glucagon

1. In liver-

- ♦ Stimulates glycogenolysis,
- ♦ Stimulates gluconeogenesis
- ♦ Stimulates ketogenesis.

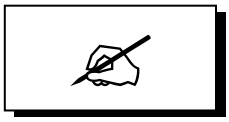
Functions of Glucagon

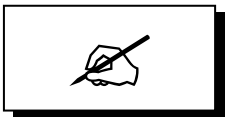
2. In muscle and adipose tissue-

- ♦ Promotes lipolysis of triglycerides
- ♦ Promotes lysosomal breakdown of protein.

3. Acts with glucocorticoids to-

- ♦ Raise blood sugar
- ♦ Promote energy substrate mobilization
- ♦ Shift muscle metabolism to fatty acids and ketogenesis.





Exercise: Enumerate the functions of adrenal hormones.

1.6. Exercise

1.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. Hormones are typically synthesized in-

   a. mostly in exocrine and rarely in endocrine glands
   b. endocrine glands solely
   c. equally both in exocrine and endocrine glands
   d. none of the above.

2. Glucagon-

   a. has no effect on blood sugar level
   b. reduces blood sugar level
   c. raise blood sugar level
   d. none of the above.

3. Main function of mineralocorticoids is to-

   a. maintain body electrolyte balance
   b. stimulate development of human genital system
   c. modulate vascular tone of the body
   d. none of the above.

1.6.2. Short Questions

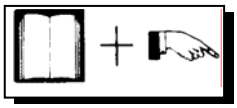
1. Define hormones. Define endocrine system.
2. What are the functions of growth hormones?
3. What are the functions of parathyroid hormones?
4. What are the functions of glucagon?

1.6.3. Broad Questions

1. Classify hormones.
2. Describe the general mechanism of hormone actions.
3. Write the functions of Insulin in human body.

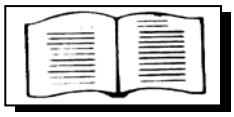
Lesson 2: Physiology of Reproductive System

2.1. Learning Objectives



At the end of this lesson you will be able to-

- define reproductive system
- describe physiology of male and female sex organs
- describe structure and functions of uterus
- describe hormones from different endocrine glands.



2.2. The Reproductive System

Reproductive System means group of body organs that are necessary for or that are accessory to the reproductive processes. *Reproduction* is the process by which an individual give rises to of spring or creation of a similar structure or situation. The basic units of sexual reproduction are the male and female germ cells. This lesson has scope to discuss about the organs within which the germ cells of animals mature and are stored, the organs through which they are transported in the process of producing a new individual, and accessory glandular organs.

Gonads

Male gonads (Testes) are organs that contain germ cells to produce male gametes or spermatozoa. *Female gametes (Ovaries)* are organs that contain germ cells to develop eggs or ova later on. In most vertebrates, individuals bear either testes or ovaries, but not both sets of organs. With sexual maturity the size of gonads increases because of the great number of germ cells produced at that time. Many germ cells are also produced during breeding seasons so that many animals have a seasonal increase in size of the gonads. During the breeding season of fish, the ovaries increase in size until they constitute about one-quarter to one-third of the total body weight.

2.3. Physiology of Male Sex Organs

Male Sex Organs

The reproductive physiology of the male human is largely external by anatomy. Sperms are produced at puberty within seminiferous tubules of the testicles. For healthy development and survival of sperms, their temperature needs to be kept slightly below body temperature. External location of the scrotum maintains it. Till maturity sperms are stored for one to three weeks into the *epididymis*, a long, coiled tube, after migrating from the testicles. The erectile organ, *penis*, is responsible for excretion of urine and transfer of sperm through a long duct called the *vas deferens* into the female vagina. Sperm leave the body in semen, a fluid produced by the seminal vesicles.

A. Primary Sex Organs in Male: Testes

Testis is the male gonad, two in number situated in the scrotum and produces spermatozoa & steroid hormone- testosterone. The seminiferous tubules of the testes produce sperm and interstitial cells of Leydig produce testosterone.

Functions of Testis

a. *Exocrine* (external secretion of a gland): spermatogenesis (the formation of mature functional spermatozoa).

b. *Endocrine* (ductless gland secretion): production of testosterone.

Semen is a thick and viscid fluid discharged from the male urethra at the time of sexual excitement. Characteristic of semen:

Colour	**:**	White
Volume	**:**	2-5 ml/ ejaculation
pH	**:**	7.8~ 8
Sperm count	**:**	60-150 million/ ml
Composition	**:**	*Fructose, phosphorylcholine, ascorbic acid, prostaglandins, falvins, citric acid, spermin, cholesterol, phospholipids, fibrinolysin, fibrinogen, phosphate, bicarbonate etc.*

B. Accessory Male Sex Organs

1. Penis with scrotum
2. Prostate
3. Urethra
4. Seminal vesicle
5. Epididymis
6. Vas deference
7. Ejaculatory duct
8. Bulbo-Urethral gland.

Secondary Sex Characters in Male

- Pubic hair

- Axillary hair
- Voice change.

Physiology of Female Sex Organs

Female Sex Organs

The specialized structured pelvic bone supports female reproductive organs and the foetus in utero. Female gonads comprise two *ovaries* to produce mature eggs. *Fallopian tubes* are appendages of uterus leading towards the ovaries. *Oviducts* are the sites of fertilization. The *uterus* is a muscular organ with an expandable neck. The neck is called the *cervix.* The uterus fosters the developing fetus finally to leave body after maturity through the vagina, or birth canal.

A. Primary Sex Organs in Female: Ovaries

Two almonds shaped bodies that produce the reproductive cell *ovum* and some hormones like oestrogen and progesterone. It is situated at *fossa ovarica* on either side of the pelvic cavity. It has two parts-

1. *The outer cortex* containing germinal epithelium, stroma, tunica albicans, follicles, corpus luteum, interstitial cells.
2. *The inner medulla* containing a stroma of connective tissue containing nerves, blood vessels, lymphatic smooth muscle fibers.

2.4. Functions of Ovary

1. Responsible for the production of ova.
2. Also responsible for the production of oestrogen secreted by the graafian follicle and progesterone secreted by the corpus luteum.

Hormones of Ovary

1. Oestrogen
2. Progesterone
3. Androgen.

Functions of 0estrogen

1. Causes increase in size of female genital organs
2. Marked proliferation of endometrium with its glands
3. Enhancement of ciliary activities to facilitate fertilization
4. Proliferation of glandular cells of breast and adult shape of it

5. Rapid bone growth after puberty
6. Feminine type of fat deposition in the body
7. Cause sodium retention and maintain body hoemostasis.

Functions of Progesterone

1. Prepares the uterus for implantation of the fertilized ovum
2. Reduces frequency of uterine contraction to prevent expulsion of fertilized ovum
3. Promotes secretary changes in mucosa of fallopian tube to nourish the fertilized ovum
4. Promotes breast development and making it secretary.

B. Accessory Female Sex Organs

1. External genitalia
2. Vagina
3. Uterus
4. Uterine tube.

Uterus and Ovulation

Uterus: Muscular, hollow organ of the female reproductive system to contain the embryo and foetus for a certain period of time. It has outer serous (Perimetrium), middle muscular (Myometrium) and inner mucous (Endometrium) coat.

Ovulation: Discharge of ovum from the mature graafian follicle of the ovary due to the action of luteinizing hormone. It occurs 10-18 days after the end of the last menstruation.

6.5. Function of Follicle Stimulating Hormone

1. It is responsible for the increasing sufficient number of granulosa cells of the graafian follicle.
2. The weight of the graafian follicle is increased by the FSH.

Function of Luteinizing Hormone

1. L H is responsible for ovulation
2. L H forms corpus luteum.

Secondary Sex Characters in Female

1. Menstruation
2. Breast enlargement
3. Voice change
4. Pubic and axillary hair.

Puberty: Period in life at which members of both sexes become functionally capable of reproduction. Boys: 13-15 year, girls: 9-16 years.

Gametogenesis: The process in which the germ cells of both male and female undergo a number of changes for fertilization.

Spermatogenesis: The process of formation of mature functional spermatozoa.

Hormonal Factors for Regulation of Spermatogenesis

Hormonal factors for regulation of spermatogenesis

1. **Testosterone:** Interstitial cells of Leydig in testicles produce this steroid hormone. It is also produced by the human adrenal cortex. It helps to promote the growth of sexual characteristics. It is responsible for normal sexual behavior. It causes occurrence of erections.
2. **Luteinizing Hormone:** Secreted by anterior pituitary gland and stimulates the development of the corpus luteum.
3. **Follicle Stimulating Hormone:** Secreted by anterior pituitary gland. It is responsible for the growth of the follicle in the ovary and mature sperm in the testes.
4. **Estrogen:** Responsible for the development of sexual characteristics and for cyclic charges in the endothelia of the vagina and the endothelium of the uterus.

Androgen: Is a steroid hormone producing or stimulating the development of male characteristics.

Prostatic Fluid: does the prostatic gland secrete a thin, milky alkaline fluid. It is composed of citric acid, calcium, and acid phosphate, a clotting enzyme and a profibrinolysin.

Function of Prostatic Fluid

1. Prostatic fluid is the part of semen.
2. The acidity of the vaginal fluid is neutralized by the prostatic fluid because of is alkalinity.

Sterility: Inability of reproductive capacity.

Impotency: Inability of the male to maintain erection.

Menstruation: The blood mixed fluid that is discharged from the uterus within a specified period of time is called menstruation. Amount of discharge is 10 – 130 ml/ cycle. Normally the period lasts for 3-7 days after every 27 to 28 days on average. From 14 ± 4 days of menstruation the period is supposed to be a danger period when conception is possible.

Composition of Menstrual Blood

Menstruation and menstrual cycle

1. Dead endometrium
2. Blood
3. Unfertilized ovum.

Menstrual Cycle: Recurrent every monthly changes in the uterus and other sex organs.

It has 03 phases-

1. Proliferative phase– Stimulated by oestrogen. Endometrium becomes thick and vascular. Duration is 10 days.
2. Secretory phase- stimulated by oestrogen and progesterone from corpus luteum. Endometrium becomes more thitk and tortuous. Duration is 14 days.
3. Bleeding or menstrual phase- Bleeding starts in this period. Duration is 1- 4 days.

Menstrual blood does not clot because of-

1. Absence of clotting factors
2. Menstrual blood contains plasmin that prevents coagulation.

Common Phenomena of Menstruation

Menarche: Onset of menstruation. Usually starts at 9- to 14 years of age.

Menopause: Ceasation of menstruation. Commonly occurs at the age of 45 to 55 years.

Amenorrhoea: Absence of menstruation.

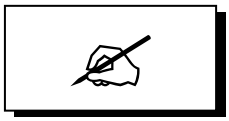
Dysmenorrhoea: Painful menstruation.

Symptoms

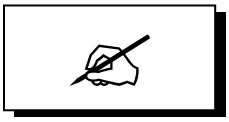
1. Ankle oedema
2. Puffiness of the face
3. Hypertension
4. Albuminuria.

Pre- Eclamptic Toxaemia: Combination of any two of the

1. Ankle oedema
2. Hypertension
3. Albuminuria.



Exercise: Describe the components of Female reproductive system.



2.6. Exercise

2.6.1. Multiple Choice Questions

Tick (√) the correct answer

1. In testes interstitial cells of leydig produces-

   a. ∝- tocoferol
   b. testosterone
   c. aldosterone
   d. none of the above.

2. pH of semen is normally-

   a. 10
   b. 3.7-5.8
   c. 7.8-8.
   d. none of the above

3. PET is determined by all of the following except-

   a. bell's palsy
   b. hypertension
   c. ankle oedema
   d. albuminuria.

2.6.2. Short Questions

1. Define Reproductive system. Define eclampsia.
2. What are the functions of placenta?
3. What are the functions of testes?
4. What are the functions of oestrogen and progesterone?

2.6.3. Broad Questions

1. Describe the components of male and female sex organs.
2. Write a short note on semen.
3. Write the hormonal factors for spermatogenesis.