MSH 13

தமிழ்நாடு திறந்தநிலைப் பல்கலைக்கழகம்

TAMILNADU OPEN UNIVERSITY

SCHOOL OF MANAGEMENT STUDIES

HUMAN ANATOMY, PHYSIOLOGY AND MEDICAL TERMINOLOGY

M.B.A (HOSPITAL ADMINISTRATION)

I SEMESTER

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HUMAN ANATOMY, PHYSIOLOGY AND MEDICAL TERMINOLOGY

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SYLLABUS

MSH 13 HUMAN ANATOMY, PHYSIOLOGY AND MEDICAL TERMINOLOGY

BLOCK 1: HUMAN ANATOMY AND PHYSIOLOGY

1.1 Digestive System
1.2 Respiratory System
1.3 Circulatory System
1.4 Central Nervous System
1.5 Muscular Skeletal System
1.6 Reproductive System
1.7 Excretory System
1.8 Endocrine Glands
1.9 Special Senses

BLOCK 2: MEDICAL TERMINOLOGY

2.1 Reasons for using medical terms
2.2 Glossary of medical terms: major diseases and medical specialities

BLOCK 3: ROOTS, PREFIXES, SUFFIXES, ABBREVIATIONS AND SYMBOLS

3.1 Common roots: element referring to, usage and definition
3.2 Common prefixes and suffixes
3.3 Common abbreviations: departments, time, general healthcare, routes of medication and laboratory
3.4 Symbols

BLOCK 4: ILLNESS

4.1 Defining Illness: Direct and indirect causes
4.2 Classification and description of disease

BLOCK 5: INFECTION CONTROL

5.1 Medical asepsis, Nosocomial infection and communicable diseases
5.2 Reservoir, carrier and mode of transmission
5.3 Infection control measures
5.4 Sterilisation and aseptic techniques
5.5 Infection control committee: purpose, composition and terms of reference

TEXTBOOKS

1. John V. Basmajian and Charles E. Slonecker, **Grant's Method of Anatomy: A Clinical Problem-solving Approach** (BI Waverly Pvt. Ltd., New Delhi) ISBN 81-7431-033-9

2.Roger Watson, **Anatomy and Physiology for Nurses** (Prism Books Pvt. Ltd., Bangalore)

REFERENCES

3.William F. Ganong, **Review of Medical Physiology** (McGraw Hill, Boston) ISBN 007-144040-

4.**Stedman's Medical Dictionary** (Williams & Winlkins, Baltimore) ISBN 0-683-07922-0

5.K. Park, **Textbook of Preventive and Social Medicine** (M/S Banarsidas Bhanot Publishers, Jabalpur)

Unit P.1

HUMAN PHYSIOLOGY

Structure
Overview
Learning Objectives
P.1.1 Digestive System
1.1.2 Secretions of Gastro Intestinal Tract
1.1.2 Movements of Gastro intestinal Tract
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1.4.7 The Cerebellum
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1.4.9 Electroencephalogram (EEG) and Sleep
1.4.10The Basal Ganglia
1.4.11The Hypothalamus
1.4.12Higher Functions of the Nervous System
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P.1.8 Endocrine Glands
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1.8.3 Parathyroid Gland
1.8.4 The Adrenal Cortex
1.8.5 The Adrenal Medulla
1.8.6 Endocrine Pancreas
P.1.9 Special Senses
1.9.1 Vision
1.9.2 Audition
1.9.3 Olfaction
1.9.4 Gustation
Summary
Keywords
Review Questions
Suggested Readings

OVERVIEW

In the previous unit, A birds eye-view of Human Anatomy was explained. This unit focuses on Human Physiology. Human Physiology is the science of the mechanical, physical, and biochemical functions of humans in good health, their organs, and the cells of which they are composed.

LEARNING OBJECTIVES

After completing this unit, you should be able to explain the various systems of Human Physiology in detail. This includes

- Digestive system
- Circulatory System
- Musculo Skeletal System
- Excretory System
- Endocrine Glands and
- Reproductive System
- Special Senses
- Respiratory System
- Central Nervous System

P.1.1 DIGESTIVE SYSTEM

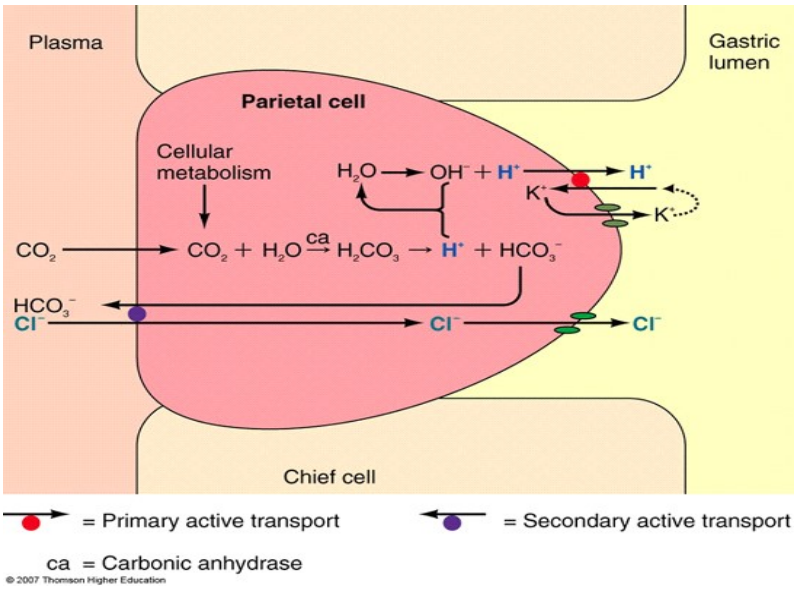
1.1.1 SECRETIONS OF GASTRO INTESTINAL TRACT

Salivary Secretion : It is the secretion from the salivary glands and is called saliva. 1500 ml of saliva is secreted per day. It contains substances that have various functions.

- Mucins, glycoproteins present in saliva lubricates the food and protects the oral muscosa.
- Lingual lipase digests fat and salivary α amylase digests carbohydrates.
- It contains IgA, lysozyme, lactoferrin which kills the bacteria.
- Saliva facilitates swallowing, keeps the mouth moist and serves as solvent for molecules that stimulate taste buds.

Gastric Secretion

It is the secretion from the glands present in the stomach and is called as gastric juice. Hcl produced by parietal cells kills the germs entering with food and activates pepsinogen that is produced by the chief cells. Pepsin, the active form of pepsinogen helps in the digestion of proteins. Intrinsic factor produced by the parietal cells helps in the absorption of Vitamin B_{12}. Mucin produced by the mucous cells prevents the damage of the stomach wall by the acid.



Bile : Bile is produced in the liver and is stored in the Gall Bladder. Bile salts keep the hydrophobic substances like cholesterol in aqueous solution by forming micelles. They are essential to emulsify the lipids present in the food. Bile salts are also responsible for absorption of fat soluble Vitamins A,D,E.

Pancreatic Secretion : The exocrine pancreas is a racemose gland and has secretory units called acini. The acinar cells produces the pancreatic juice. The various enzymes present in the pancreatic juice helps in the digestion of food.

Small Intestinal Secretion (Succus entericus) : It is produced by the goblet cells present in the crypts of Liberkuhn. The enzymes are present on the brush border of the enterocytes and helps in the digestion of food.

Large Intestinal Secretion

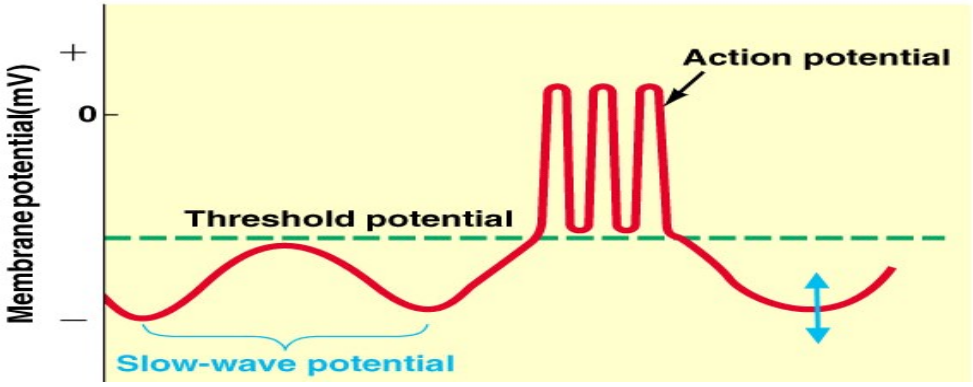
Goblet cells secretes mucus which forms a protective, lubricant layer. Vitamin K is also synthesized.

1.1.2 MOVEMENTS OF GASTRO INTESTINAL TRACT

Movements are produced due to the contraction of smooth muscles in the wall of the gut.

Basic Electrical Rhythm : Smooth muscles of gut show some electrical activities even if there is no contraction. Resting membrane potential changes between – 60 mv to – 50 mv which produces this BER.

Spike Potential : These are the action potentials and are followed by the contraction of smooth muscle. They are due to the entry of Na^+ & Ca^{2+} ions.

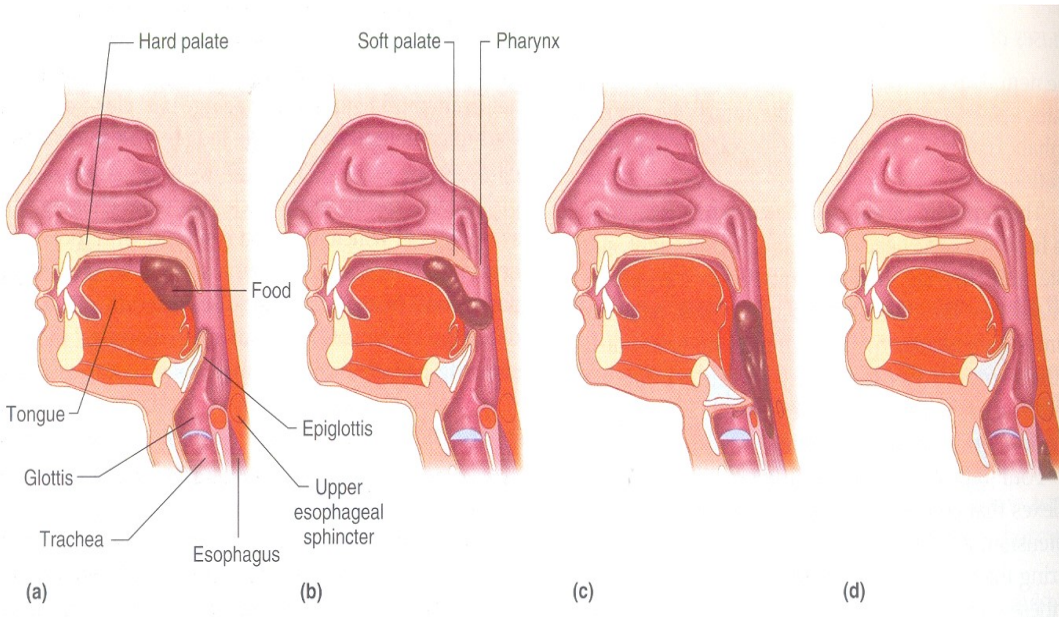


a. Mastication : It is the process by which the food taken in the mouth is crushed into smaller particles by the grinding action of the teeth. It makes the food suitable for swallowing.

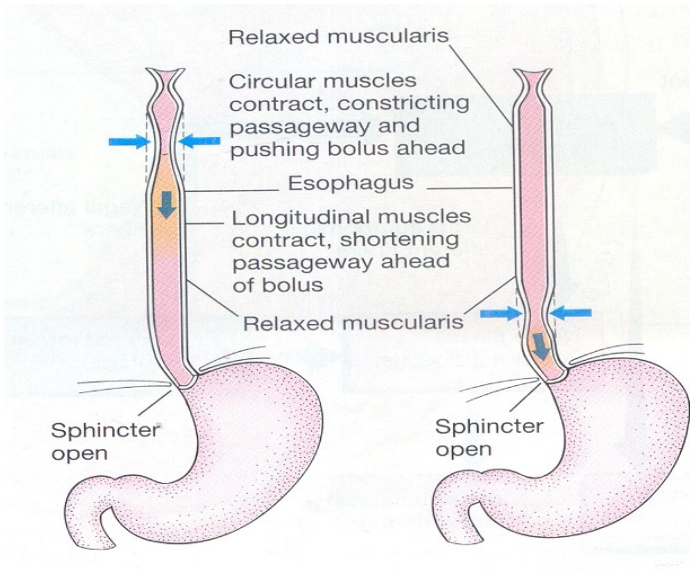
b. Deglutition : Deglutition is the process by which the food is passed into stomach from the oral cavity.

(i) Buccal Phase *:* Food in the mouth after mastication and mixing with saliva is converted into bolus and passes over back of tongue. During this phase, the nasopharynx is shut off to prevent the regurgitation through nose.

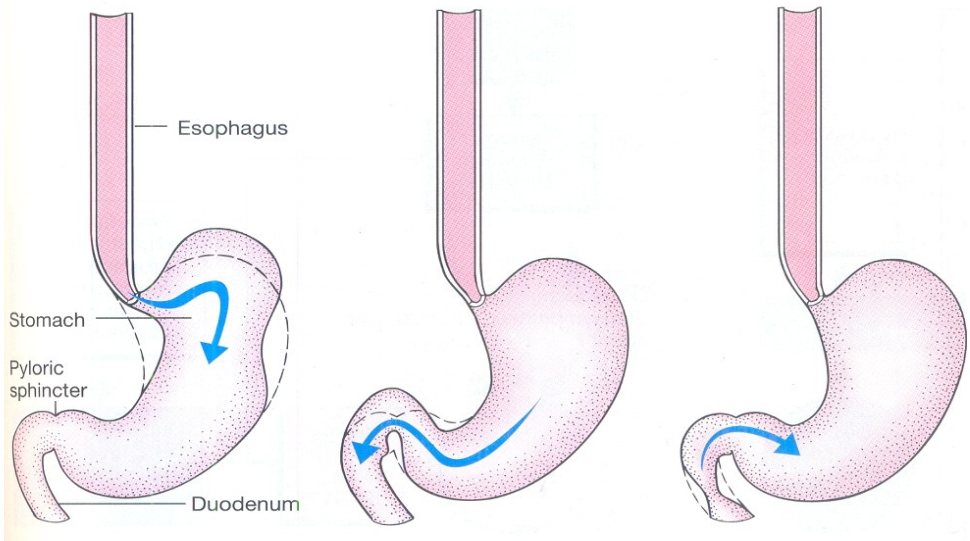
(ii) Pharyngeal Phase *:* The bolus is pushed backwards towards esophagus over the epiglottis which lies horizontally on the closed laryngeal opening. Now the upper esophageal sphincter relaxes and the bolus enters esophagus. During this phase, respiration remains stopped.



(ii) Esophageal Phase : When the food is in the esophagus the upper esophageal sphincter contracts and is called as primary peristalsis. Due to the stretch of the bolus the secondary peristalitic wave starts and the bolus is carried down to stomach.

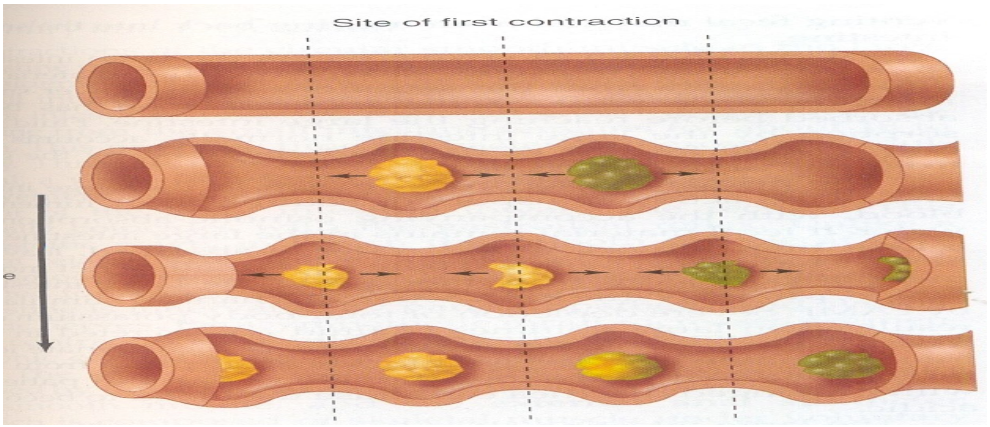


c*. Movements in the Stomach :* As soon as the food enters the stomach, the peristaltic movement starts in the form of small indentation on the wall. It soon encircles the mid part of stomach in the form of a ring which then proceeds like a wave towards the pylorus and pushes the food into the small intestine.



d. Movements in Small Intestine:

i) Segmentation Contractions : When a portion of small intestine becomes distended with chyme, the stretching of the intestinal wall elicits localized concentric contractions spaced at intervals along the intestine. This mixes the chyme with the digestive juices.



ii) Peristalisis : It is a propulsive movement. Presence of chyme in the intestine stretches its wall. A contractile ring begins on the oral side of the distended segment and moves towards the distended segment, pushing the intestinal contents in the anal direction. This is called as the Law of GUT.

e. Movements of Large Intestine*:*

***i*) Haustrations** : Mixing Movements

Large circular constrictions occur and at the same time the longitudinal muscle of the colon also contracts. These combined contractions of the circular and longtitudinal strips of muscle cause the unstimulated portions of the intestine to bulge into bag like sacs called haustrations

ii) Mass Movements : Propulsive Movements

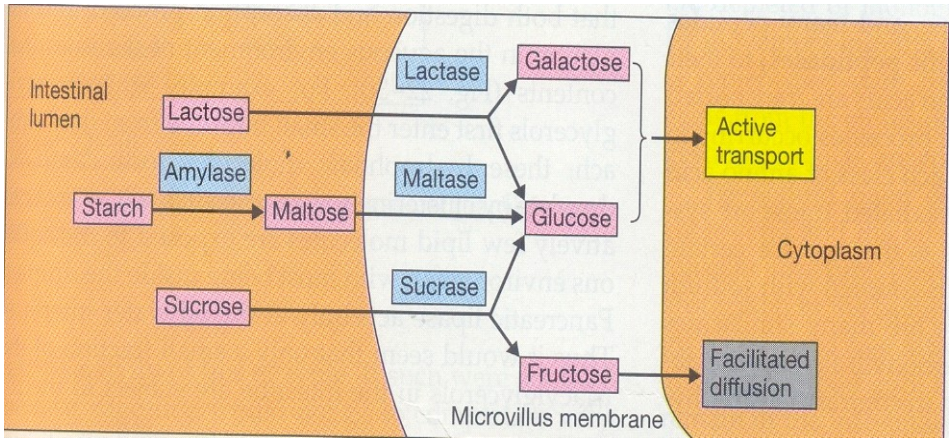
It is a modified type of peristalsis and occurs only 1-3 times a day and forces the mass of feces into the rectum.

iii) Defaecation : It is the process by which feces is expelled to the exterior. It is affected mainly by spinal reflexes, but is influenced by complex voluntary acts.

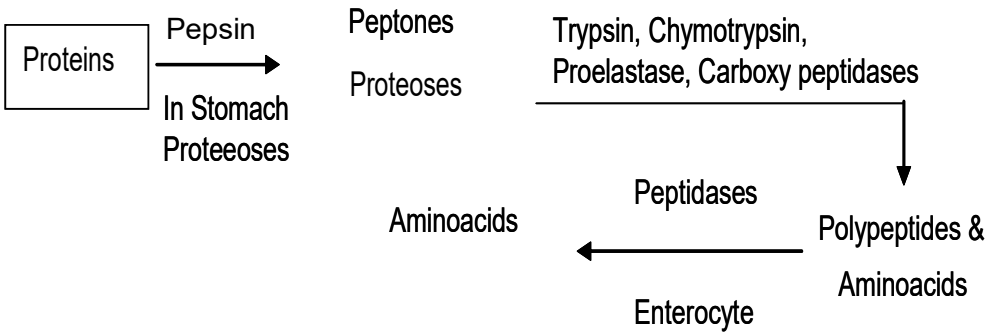
1.1.3 DIGESTION AND ABSORPTION

Digestion of Carbohydrates : Carbohydrate digestion starts with salivary α amylase which hydrolyses starch into maltose, isomaltose, α limit dextrins. In the small intestine the pancreatic amylase hydrolyses all the carbohydrates into maltose, maltotriose and α Limit dextrins. The final digestion occurs in the brush border of enterocytes and the final products of digestion are monosaccharides (glucose, fructose, galactose)

Absorption of Carbohydrates : Glucose and galactose are absorbed by secondary active transport mechanism along with the sodium ions. Fructose is absorbed by facilitated diffusion.



Digestion of Proteins : Dietary proteins are long chains of aminoacids connected by peptide linkages. In the mouth there is no digestion of proteins.



Absorption of Proteins **:** The products of protein digestion are small peptides and aminoacids which are absorbed by secondary active transport in small intestine.

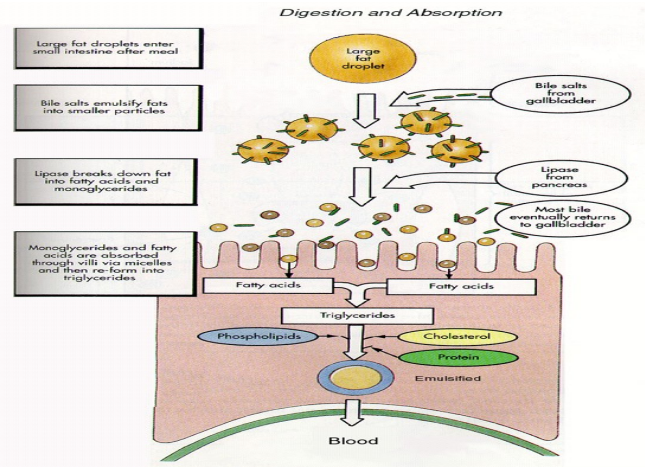
Digestion of Fats **:** The most abundant fats of the diet are neutral fats known as triglycerides, each molecule of which is composed of glycerol nucleus and three fatty acids. A small amount of triglyceride is digested in the stomach by lingual lipase secreted by lingual glands in the mouth. In the intestine, the fat globules are broken down into small sizes so that water soluble digestive enzymes can act on globule surfaces. This process is called as emulsification of fat. Bile and agitation of food in the stomach helps in emulsification.

$$\text{Fat} \xrightarrow{\text{Bile \& Agitation}} \text{Emulsified fat}$$

$$\text{Emulsified fat} \xrightarrow[\text{Intestine}]{\text{Pancreatic lipase}} \text{Falty acids, 2-monoglycerides}$$

Bile salts when in high concentration forms micelles which are cylindrical globules with 20-40 molecules of bile salts and 3-6 nm in size. The sterol nuclei of bile salt in the micelle aggregate and encompass the fat digestates forming a small fat globule in the middle of the micelle. The bile salt micelles act as a transport medium to carry monoglycerides and free fatty acids to the brush border of the intestinal epithelial cells.

Absorption of Fat **:** Lipids from the micelle are released at the brush border. The products of lipid digestion diffuse down the concentration gradient into the enterocytes. After entry into the enterocytes the small chain fatty acids upto 10-12 carbon atoms pass to the blood and larger fatty acids more than 10 – 12 carbon atoms are re-synthesized into triglycerides. Now triglycerides, cholesterol and phospholipids are coated by protein and is known as chylomicron. These chylomicrons enter into the lymphatics.



1.1.4 LIVER

Liver is the largest chemical factory of the body and has got various functions. They are

(i) Synthetic function

Bilesalts, Proteins, blood coagulation factors, lipids, glycogen, glucose and vitamins are synthesized in the liver.

(ii) Liver inactivates many drugs like sulfonamides, penicillin, erythromycin.

(iii) Helps in the metabolism of ethanol.

(iv) Deactivation of various hormones occurs in liver.

(v) Excretion of bile pigments, cholesterol

(vi) Storage function – Vitamins – A, B_{12}, D, iron in the form of ferritin are stored in the liver.

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Digestion and absorption of fat
2. Digestion and absorption of carbohydrates

Short Notes: (3 X 5 = 15)

1. Deglutition
2. Functions of saliva
3. Movements of small intestine
4. Functions of liver

P.1.2 RESPIRATORY SYSTEM

Respiration includes two processes ; external respiration which is the absorption of O_2 and removal of CO_2 from the body and internal respiration which is the utilization of O_2 and production of CO_2 by cells and the gaseous exchanges between the cells and their fluid medium.

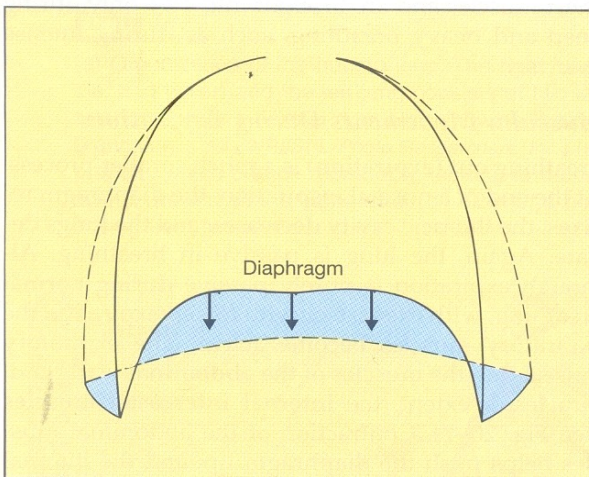
At rest a normal human breathes 12-15 times a minute. 250 ml of O_2 enters the body and 200 ml of CO_2 is excreted.

I.2.1 MECHANICS OF RESPIRATION

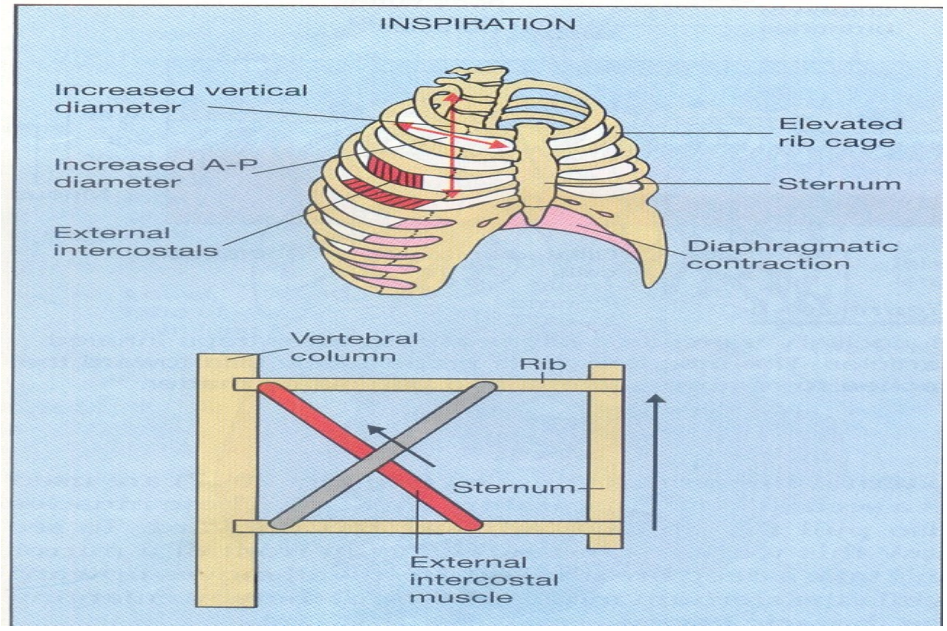
The process by which the air is taken in and given out by the living body is called as mechanism of respiration.

I) RESPIRATORY MUSCLES

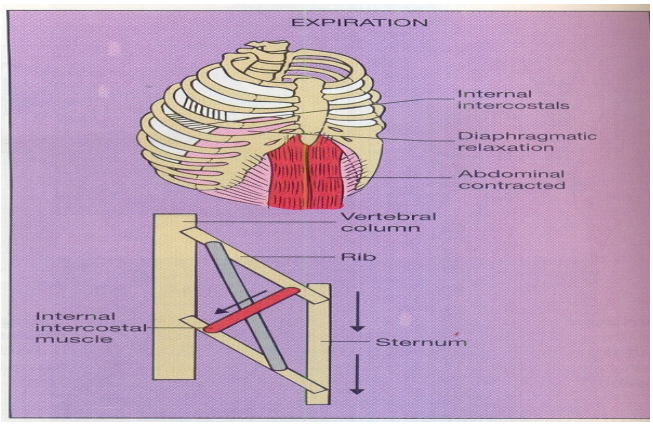
Muscles of inspiration : Diaphragm is attached to the bony boundaries of chest cavity. When it contracts, the vertical diameter of the chest cavity is increased.



When the external intercostal muscle contracts there is outward and upward movement of the ribs in the middle (bucket handle movement) and this increases the transverse diameter of the chest. Anterior down sloping ends of the ribs are also raised (pump handle movement) & sternum is pushed forward. It increases the anteroposterior diameter of the chest. Accessory muscles of respiration are scalene, sternomastoids in the neck that helps to elevate the thoracic cage during deep labored respiration.

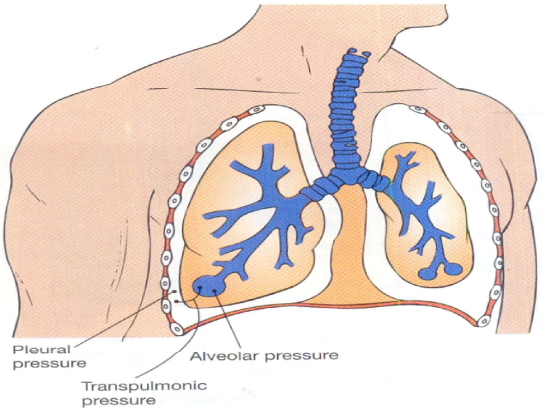


Muscles of expiration : Contraction of internal intercostals and the muscles of anterior abdominal wall helps in expiration.



II) PRESSURES INVOLVED IN RESPIRATION

The intrapleural pressure at the base of the lungs is normally – 2.5 mm Hg. This pressure at the start of inspiration decreases to -6 mm Hg. This causes the lungs to be pulled into a more expanded position. The pressure in the airway becomes negative and air flows into the lungs. At the end of the inspiration the pressure in the airway becomes slightly positive and air flows out of the lungs. The pressure of air inside the lung alveoli called as alveolar pressure becomes -1cm of water during inspiration and pulls the air into the lungs and becomes +1cm of water during expiration and pushes the air outside during expiration.



III) LUNG VOLUMES AND CAPACITIES

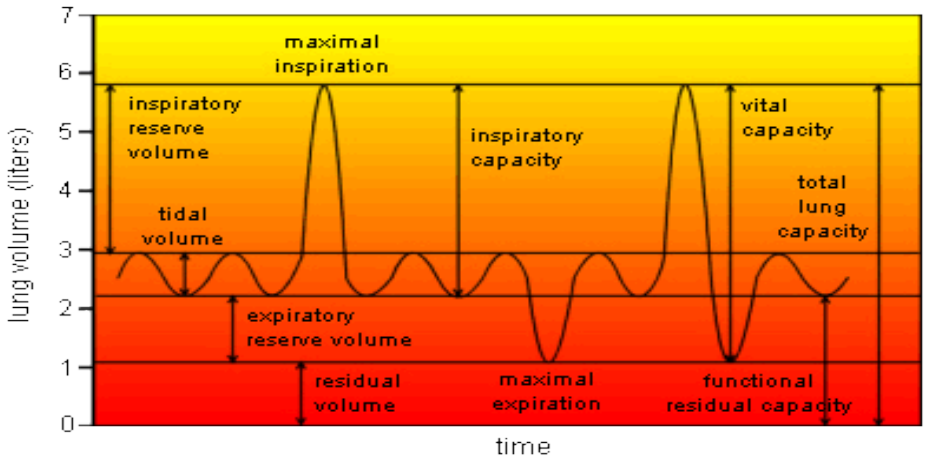
The amount of air that moves into the lungs with each inspiration or that moves out with each expiration is called the tidal volume (500 ml). The air inspired with a maximal inspiratory effort in excess of tidal volume is the inspiratory

reserve volume (3000 ml). The volume expelled by an active expiratory effort after passive expiration in the expiratory reserve volume (1100 ml). The air left in the lungs after the maximum expiratory effort is the residual volume (1200 ml).

Inspiratory capacity = TV + IRV =3500 ml

Functional residual capacity = ERV + RV = 2300 ml

The vital capacity is the largest amount of air that can be expired after a maximal inspiratory effort (4600 ml). The total lung capacity is the maximum volume to which the lungs can be expanded with greatest possible effort (5800 ml).



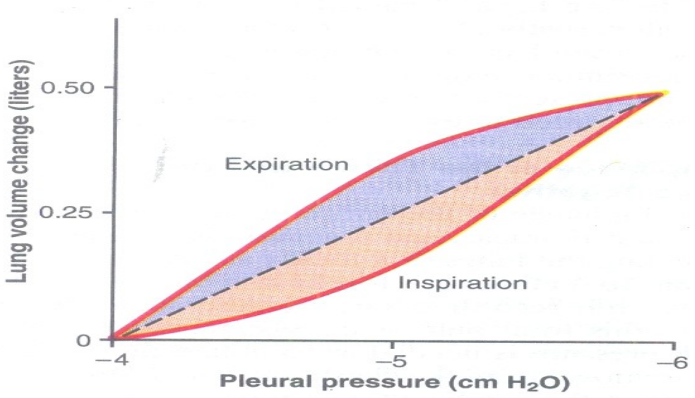
The amount of air inspired per minute is the pulmonary ventilation and is normally 6 L. The total volume of new air entering the alveoli is the alveolar ventilation and is 4.2 L/min

IV) COMPLIANCE OF THE LUNG & CHEST WALL

The extent to which the lungs can expand for each unit increase in transpulmonary pressure is called their compliance. The total compliance of both the lungs is 200 ml of air per centimeter of water. The characteristics of compliance diagram is determined by

(a) Elastic forces of the lung which is mainly due to the elastin and collagen fibers.

(b) Elastic forces caused by surface tension of the fluid that lines the inside walls of the alveoli.



When the alveoli are small they will collapse if the surface tension is high. So the surface tension is normally kept low by a fluid called as surfactant that is produced by type II alveolar epithelial cells. The components of the surfactant is dipalmitoylphosphatidylcholine, surfactant apoproteins, calcium ions.

Surfactant is important at birth. After birth the infant makes strong respiratory movements and the lungs expand. Surfactant keeps them from collapsing again. Surfactant deficiency causes Infant Respiratory Distress Syndrome - IRDS

1.2.2 GAS EXCHANGE IN THE LUNGS

The respiratory unit is composed of a respiratory bronchiole, alveolar ducts, atria and alveoli.

Each alveolus is 0.2 mm in diameter.

Respiratory Membrane : This is the membrane across which the gas exchange occurs between the alveolar air and the pulmonary blood. The layers of the respiratory membrane are

(1) A layer of fluid lining the alveolus

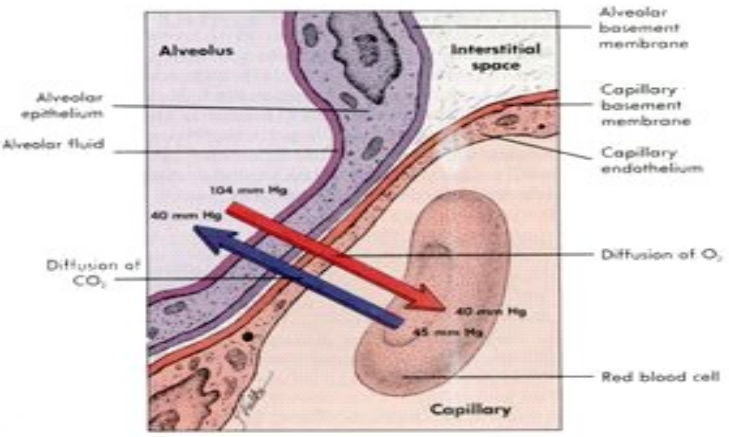
(2) The alveolar epithelium

(3) An epithelial basement membrane

(4) Interstinal space between the alveolar epithelium and the capillary mem brane

(5) A capillary basement membrane

(6) The capillary endothelial membrane



FACTORS THAT AFFECT THE RATE OF GAS DIFFUSION ARE

- ***Thickness of the respiratory membrane***: Certain pulmonary diseases like fibrosis which increases the thickness of the membrane, decreases the diffusion.
- ***Surface area of the membrane***: When diseases like emphysema decrease the surface area of the membrane, the diffusion decreases.
- ***The diffusion co-efficient*** for the transfer of gas through the respiratory membrane depends on gas's solubility in the membrane and inversely on the square root of the gas's molecular weight.
- ***Pressure difference of the gas across the respiratory membrane.***

Ventilation/perfusion ratio *:* The ratio of pulmonary ventilation to pulmonary blood flow for the whole lung at rest is 0.8.

1.2.3 GAS TRANSPORT BETWEEN THE LUNGS & THE TISSUES

OXYGEN TRANSPORT

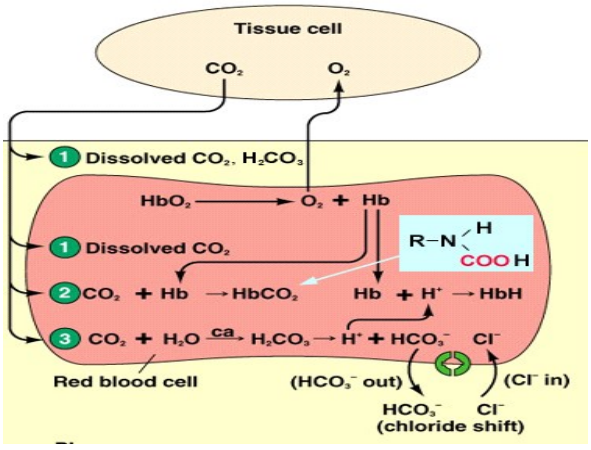
Reaction of Hemoglobin & Oxygen : Hemoglobin is a protein made up of four subunits, each of which contains a heme moiety attached to a polypeptide chain. Heme contains atom of ferrous iron. Each of the four iron atoms can bind reversibly with one O_2 molecule called as oxygenation. The curve relating the percentage saturation carrying power of haemoglobin to the partial pressure of O_2 (PO_2) has a sigmoid shape and is called as oxygen – hemoglobin dissociation curve.

Factors affecting the affinity of hemoglobin for oxygen : Each gram of Haemoglobin can bind with 1.34 ml of O_2. Hemoglobin in 100 ml of blood can combine with 20 ml of oxygen. A rise in temperature, fall in pH, rise in 2,3, DPG shifts the curve to the right. This causes O_2 to be released to the tissues. A fall in the temperature, rise in pH and fetal Hb shifts the curve to the left. Here the quantity of oxygen that binds with hemoglobin becomes increased, thus allowing greater oxygen transport to tissues. The decrease in O_2 affinity of hemoglobin when the pH of blood falls is called as Bohr Effect.

CARBON DIOXIDE TRANSPORT

An average of 4 ml of CO_2 is transported from the tissues to the lungs in each 100 ml of blood. 70% is transported in the form of bicarbonate ion, 23% in combination with hemoglobin and plasma protein known as carbaminohemoglobin and 7% in the dissolved state.

Chloride shift **:** The rise in bicarbonate (HCO_3^-) content of red cells is much greater than that in plasma as the blood passes through capillaries. So 70% of HCO_3^- formed in red cells enters the plasma. The excess HCO_3^- leaves the red cells in exchange for chloride ions. This exchange is called as chloride shift.



Since deoxygenated hemoglobin binds more H^+ than oxyhemoglobin and forms carbamino compounds more readily venous blood can carry more CO_2 than arterial blood. This is called as Haldane effect.

In the tissue capillaries, Haldane effect causes increased pickup of carbondioxide because of oxygen removal from hemoglobin and in the lungs it causes increased release of CO_2 because of O_2 pick up by hemoglobin. Due to the Haldane effect, carbondioxide dissociation curve shifts and this doubles the amount of carbondioxide released from the blood in lungs and doubles the pick up of carbondioxide in tissues.

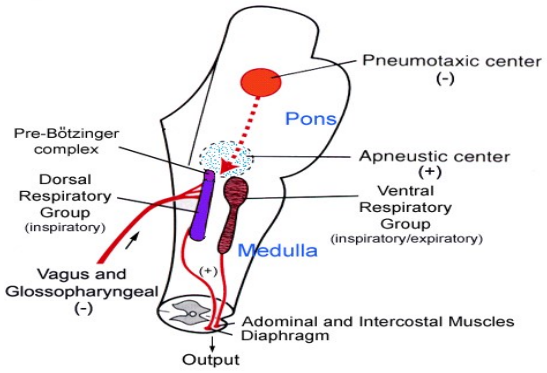
1.2.4 REGULATION OF RESPIRATION

The nervous system normally adjusts the rate of alveolar ventilation almost exactly to the demands of body so that the oxygen pressure (PO_2) and Carbondioxide pressure (PCO_2) in the arterial blood are hardly altered even during exercise and other types of respiratory stress.

NEURAL CONTROL OF BREATHING

The respiratory center is composed of several groups of neurons located bilaterally in medulla oblongata and Pons.

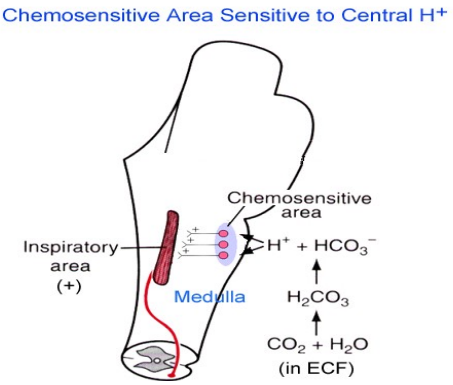
- ***Dorsal Respiratory group of Neurons*** **:** The basic rhythm of respiration is mainly generated by this group of neurons. The inspiratory signal is a ramp signal which increases steadily in a ramp manner for 2 seconds and ceases abruptly for next 3 seconds.
- ***Ventral respiratory group of Neurons :*** They have both expiratory and inspiratory neurons. They remain inactive during normal quiet respiration. When the respiratory drive becomes greater than normal, respiratory signals spill over into the ventral respiratory neurons and they then contribute to the respiratory drive.
- ***The pneumotaxic center :*** It is located in upper pons and transmits signals to the inspiratory area. It limits the duration of Inspiration and increases the respiratory rate.
- ***Apneustic center*** : Under few conditions this center sends signals to the dorsal respiratory group of neurons to prevent or retard the switch off of the inspiratory ramp signal.



Located in the muscular portions of bronchi & bronchioles are stretch receptors that transmit signals through vagi into the dorsal respiratory group of neurons when lungs become overstretched. This switches off the inspiratory ramp and stops further inspiration. This is called the Hering – Breuer inflation reflex. It is not activated until the tidal volume increases to 1.5 litres.

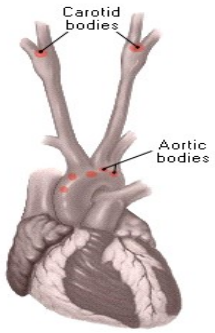
CHEMICAL CONTROL OF RESPIRATION

Chemoreceptors in the brain stem : Chemosensitive area is located bilaterally beneath the ventral surface of the medulla. These neurons are excited by CO_2 and hydrogen ions. This in turn excites the other portions of the respiratory center.



Peripheral chemoreceptor system : They are present in the carotid bodies located at the bifurcation of common carotid arteries and supplied by glossopharyngeal nerve. The aortic bodies are located along the arch of aorta and supplied by vagi.

The glomus cells present in these bodies are excited by hypoxia and in turn stimulate the nerve endings. An increase in CO_2 or hydrogen ion concentration also excites the chemo receptors.



Periodic Breathing : Cheyne stokes breathing: It is characterized by slowly waxing and waning respiration, occurring over and over again about every 40 – 60 seconds.

Hypoxia : Hypoxia is O_2 deficiency at the tissue level. It is divided into four types.

- Hypoxic hypoxia: In this condition the PO_2 of arterial blood is reduced. Eg: High altitude, pulmonary fibrosis.
- Anemic hypoxia: The amount of hemoglobin available to carry O_2 is reduced. Eg: Anemia, Carbon monoxide poisoning.
- Stagnant or ischemic hypoxia: Blood flow to the tissue is so low that adequate O_2 is not delivered to it. Eg: Shock.
- Histotoxic hypoxia: The amount of O_2 delivered to the tissue is adequate but, because of the action of a toxic agent, the tissue cells cannot make use of the O_2 supplied to them. Eg: Cyanide poisoning.

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Describe in detail the mechanics of respiration
2. Describe in detail neural regulation of respiration
3. Describe in detail chemical regulation of respiration

Short Notes: (3 X 5 = 15)

1. Hypoxia
2. Gas exchange
3. O_2 transport
4. CO_2 transport

P.1.3 CIRCULATORY SYSTEM

1.3.1 CARDIAC MUSCLE

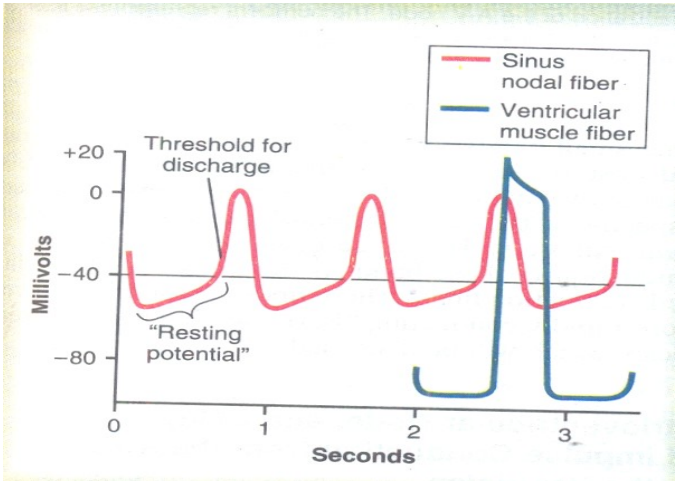
The muscular walls of heart are composed of a branching network of muscle fibers. They are 10 – 20 µm wide and 50 -100 µm long. Each bundle is organized into a series of repeating subunits called sarcomere. It is composed of thick and thin filaments. The molecular structure of actin and myosin resembles that of skeletal muscle. The myocardial cells are connected to one another by intercalated discs which serve as low-resistance bridges for rapid transmission of impulse.

1.3.2 PROPERTIES OF CARDIAC MUSCLE

ELECTRICAL PROPERTIES

i) Action potential in cardiac muscle : The RMP is about -90mV. Stimulation produces a propagated action potential. It consists of depolarization (Na^+ influx), plateau phase (Ca^{2+} influx) and repolarisation (K^+ efflux) phases. In cardiac muscle, the repolarisation time decreases as the cardiac rate increases.

ii) Pacemaker potential : Sino atrial node (SA node) is the pacemaker of the heart where the cardiac impulse originates. The resting membrane potential of these fibres is -55 to -60mv. In these cells the membrane potential after each impulse declines to the firing level. This pre potential triggers the next impulse. Pre potential is due to decrease in K^+ efflux opening of calcium channels and slow sodium calcium channel opening leads to influx of sodium and calcium ions which produces depolarization.



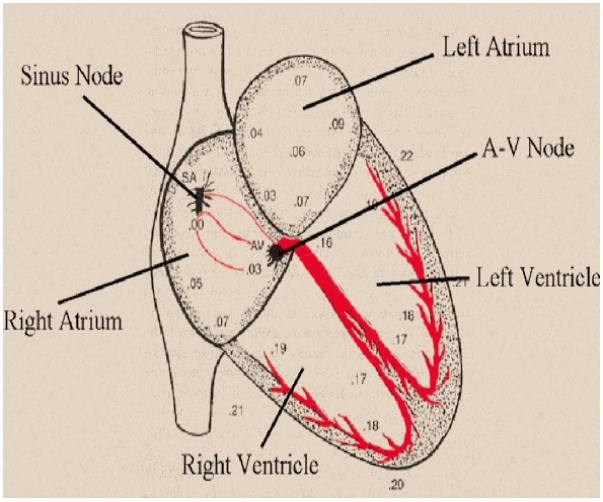
MECHANICAL PROPERTIES

i) Molecular basis of contraction : It is same as that of skeletal muscle. Most of the Ca^{2++} needed for muscle activation is released from ECF and sarcoplasmic reticulum. The Ca^{2+} produces muscle contraction. The tropomyosin is anchored to actin and when Ca^{2+} is bound to troponin, the tropomyosin undergoes a conformational change uncovering the active sites and allowing myosin filaments to form bonds with actin filaments. Following contraction, Ca^{2+} is rapidly reaccumulated causing relaxation (Ca^{2+} -Mg^{2+} ATPase)

ii) Refractory period : It is the period during which a normal cardiac impulse cannot re-excite an already excited area of cardiac muscle. This is absolute refractory period and for ventricle it is normally 0.25 – 0.30 seconds. There is an additional relative refractory period of 0.05 seconds during which the muscle is more difficult than normal to excite.

Conduction

Cardiac impulse is generated in the SA node and passes to the AV node by the internodal fibres. From here they travel through the bundle of His to purkinje fibres. Purkinje fibres transmit the impulses rapidly at the velocity of 1.5 – 4 m/sec. The impulses reach the endocardial surface and then travel to the epicardial surface.



1.3.3 ELECTRO CARDIOGRAM (ECG)

When the cardiac impulse passes through the heart, electrical current spreads from the heart into the adjacent tissues and to the surface of the body. The record of these potential fluctuations is the electrocardiogram. The ECG can be recorded by using an active electrode connected to an indifferent electrode at zero potential (unipolar recording) or by using two active electrodes (bipolar recording).

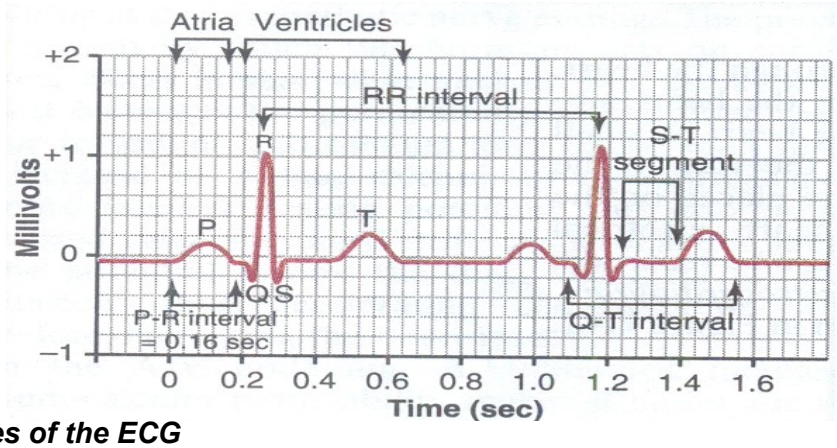
Bipolar leads

Standard limb leads – lead I, lead II, lead III

Unipolar leads

Precordial chest leads – V_1, V_2, V_3, V_4, V_5, V_6

Augmented limb leads – avR, aVL, aVF.



Waves of the ECG

P wave – atrial depolarization

QRS complex – ventricular depolarization

T wave – ventricular repolarization

P-R interval – The time between beginning of p wave and beginning of QRS complex. Normal value 0.12 – 0.20 seconds.

Q – T interval – Beginning of Q wave to the end of T wave. Normal value – 0.35 seconds.

1.3.4 CARDIAC CYCLE

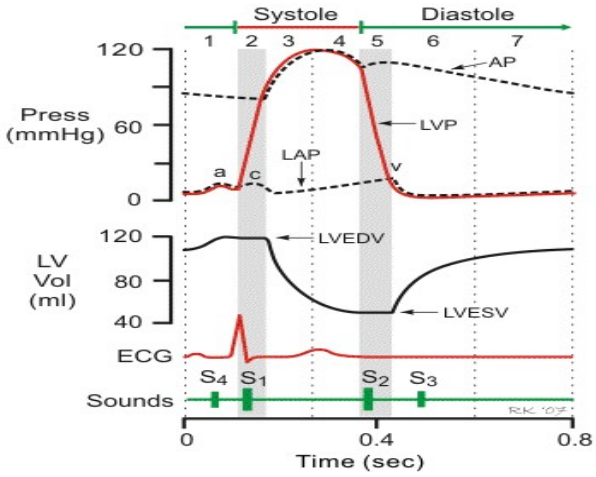
The cardiac events that occur from the beginning of one heart beat to the beginning of the next is called as the cardiac cycle. The normal duration is 0.8

seconds. The cardiac cycle consists of a period of relaxation called *diastole* during which heart fills with blood followed by a period of contraction called *systole*. Blood normally flows continually from the great veins into atria.

(i) Function of atria as pumps **:** When the pressure changes in the atria is recorded there are three major pressure elevations are noted in the curve 'a' wave caused by atrial contraction, 'c' wave is due to the backflow of blood into atria at the onset of ventricular contraction. 'v' wave is due to slow flow of blood into atria from veins.

(ii) Function of ventricle as pumps : At the start of ventricular systole, the mitral and tricuspid (AV) valves close. The ventricular pressure increases abruptly. Already the semilunar valves are closed. It takes a few seconds for the ventricle to build up sufficient pressure to push the aortic and pulmonary (semilunar) valves to open. Therefore during this period contraction is occurring but no emptying and is called as *isovolumetric contraction.*

When the left ventricular pressure rises above 80 mmHg it opens the semi lunar valves and blood is pushed into the aorta and this phase is the period of *ejection.* At the end of systole, ventricles start relaxing and all the valves are closed, intraventricular pressure starts decreasing. This period is called as i*sovolumetric relaxation.*



(iii) Heart Sounds : First sound is due to the closure of mitral and tricuspid valves. Second sound is due to the closure of aortic and pulmonary valves.

Third sound is due to the rapid ventricular filling and fourth sound due to the atrial systole. First and second heart sounds can be heard with stethoscope, third and fourth heart sounds can be recorded with phonocardiogram.

1.3.5 CARDIAC OUTPUT

The amount of blood pumped out of each ventricle per beat is the stroke volume and is 70 ml in an resting man. The output of the heart per unit time is the cardiac output and is 5L/min in the adult.

Factors maintaining cardiac output

(i) Systemic factors

Venous return – Flow of blood from veins into the heart.

Peripheral resistance – Pressure load against which the heart has to pump the blood.

(ii) Cardiac factors

Force of contraction of the heart

Frequency of the heart rate – increase or decrease in the heart rate affects the cardiac output. Normal heart rate is 70 beats /min.

Cardiac output can be measured by direct Fick method and the indicator dilution method.

iii) Starling's law of the heart

Energy of contraction is proportional to the initial length of the cardiac muscle fiber.

1.3.6 BLOOD PRESSURE

The blood pressure is defined as the lateral pressure exerted by the contained blood on the walls of the arteries. The maximum pressure corresponds to ventricular systole and is known as systolic pressure 90 -120 mm Hg. The minimum pressure coincides with diastole and hence is known as diastolic pressure 60 – 80 mm Hg. The difference between the diastolic and systolic pressure is the pulse pressure.

MEASUREMENT OF BLOOD PRESSURE

Blood pressure is measured by using an instrument known as sphygmomanometer. After tying the cuff, on auscultation over the brachial artery distal to the cuff, certain sounds are heard on gradual deflation of the cuff. These sounds are called as korotkow's sounds. Beginning of the sound is taken as the index of systolic pressure and the disappearance of the sound is taken as diastolic pressure.

REGULATION OF BLOOD PRESSURE

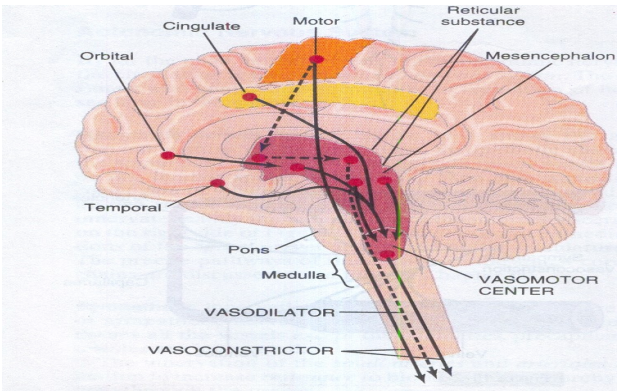
Rapid control of arterial pressure

a) Vasomotor center *:* Located bilaterally in the reticular substance of the medulla and lower third of pons is vasomotor center. This center transmits parasympathetic impulses through the vagus nerves and sympathetic impulses to all the blood vessels. This center has a vasoconstrictor area, vasodilator area and a sensory area.

The vasoconstrictor area sends impulses continuously and these impulses normally maintain a partial state of contraction in the blood vessels called vasomotor tone. When there is a need, the nervous control has the capability to cause rapid increase in arterial pressure. They occur by the following mechanisms.

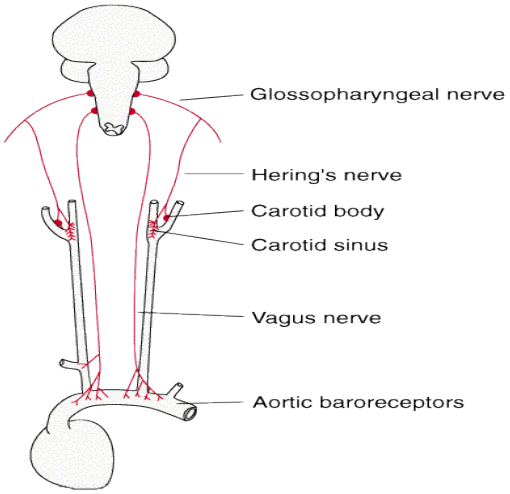
- All the arterioles of the body are constricted
- Veins are constricted
- Heart is stimulated and cardiac pumping is enhanced.

The impulses come to the vasomotor center from the higher centers like cerebral cortex, hypothalamus.



b) Baroreceptors : They are stretch receptors present in the carotid sinus and aortic arch. The carotid sinus is a small dilation of the internal carotid artery just above the bifurcation of common carotid artery and is supplied by the glossopharyngeal nerve. Aortic receptors are found in the wall of arch of aorta and is supplied by the vagus nerve.

When the pressure increases, the baroreceptors are stimulated and signals enter tractus solitarius of medulla. They inhibit the vasoconstrictor center and excite the vagal parasympathetic center. The net effect is vasodilation of veins and arterioles, decreased heart rate and strength of contraction. So excitation of baroreceptors causes the arterial pressure to decrease.



c) Chemoreceptor reflex : Carotid and aortic bodies are the chemoreceptors present near the baroreceptors. Fall in BP decreases the PO_2 and increases PCO_2 to the chemoreceptors and causes stimulation of vasomotor centre and respiratory center. The final effect is increased in heart rate, increased blood Pressure and increase in rate and depth of respiration.

d) Atrial and pulmonary Artery reflex *:* Both atria and pulmonary artery have stretch receptors called low pressure receptors. Stretch of the atria causes reflex dilation of afferent arterioles in the kidneys and secretion of atrial natriuretic peptide that causes of fluid in the urine.

e) Central Nervous system ischemic response *:* When the blood flow to the vasomoter centre becomes decreased severely, the neurons in the vasomotor center itself becomes strongly excited. There is elevation of the arterial pressure and it is known as CNS ischemic response.

Long term regulation of blood pressure

a) Aldosterone system : Decrease in the arterial pressure decreases the tissue perfusion that stimulates adrenal cortex to produce aldosterone. Increased aldosterone causes water and electrolyte retention and increases the blood pressure.

b) Renin – angiotensin system *:* Decrease in arterial pressure produces renal ischemia and secretion of renin from juxtaglomerular apparatus. Renin converts angiotensinogen in the plasma into Angiotensin I. Angiotensin I is converted into Angiotensin II by converting enzyme. Angiotensin II causes water and electrolyte retention by acting on the kidneys and increases the blood pressure. It directly acts on the blood vessel and causes vasoconstriction and increases in blood pressure.

Hypertension is a sustained elevation of the systemic arterial pressure. A person is said to have hypertension when the mean arterial pressure is greater than upper range of the normal. A mean arterial pressure greater than 110 mmHg is considered as hypertension. This level occurs when the diastolic blood pressure is greater than 90 mmHg and the systolic pressure is greater than 136 mmHg.

1.3.7 CORONARY CIRCULATION

The heart is supplied by two coronary arteries right and left arising from the root of the ascending aorta. Normal coronary blood flow of both the arteries is 250 ml/min. O_2 consumption of the myocardium is very high. Coronary blood flow fluctuates with each cardiac cycle. It increases during diastole and decreases systole called phasic coronary flow.

Coronary blood flow can be measured by using kety method or Nitrous Oxide technique, Radio nuclide utilization technique and coronary angiography.

CLINICAL ACTIVITY FOR HUMAN PHYSIOLOGY

ACTIVITY A

CLINICAL MEASUREMENT OF RADIAL PULSE AND BLOOD PRESSURE.

Aim: To clinically examine the peripheral arterial pulse (pressure pulse) of a subject.

Principle: Duration of ventricular systole of cardiac cycle, blood is ejected into the distended aorta causing sudden dilatation of aorta (to accommodate output of blood) transmitted in the form of a wave throughout the arterial system which is felt as the “peripheral pressure pulse”.

Apparatus required: A watch with a centre second.

Procedure: The subject is asked to sit comfortably. Right forearm of the subject is held in semiprone position with wrist slightly flexed. The radial pulse of the subject is palpated over the radial artery on the anterior aspect of the wrist with the tips of index middle and ring fingers. The proximal finger controls the flow of blood, middle finger feels the pulse wave and distal finger prevents regurgitation of blood. The following points are noted:

i) Rate (number of pulsations felt in one minute)

ii) Rhythm

iii) Volume (amplitude)

iv) Character

v) Condition of arterial wall – artery is emptied by compression and its walls palpated by rolling between the fingers and the underlying bone.

vi) Radio femoral delay – the radial and femoral pulses are palpated at the same time and compared. Normally, they will occur at the same time and there will be no radio-femoral

vii) Equality of pulse wave on both sides of the body-radial pulse of the other arm is similarly examined.

Observation:

Name Age: Sex:

Rate : /min

Rhythm :

Volume :

Character :

Condition of vessel wall

Equality of pulse on two sides.

Radio-femoral delay:

II. Note the pulse rate three times and obtain the mean rate/minute.

Ask the subject to stand. Note the pulse rate for 15 sec (to be expressed as pulse rate per minute by multiplying with 4) every 30 second, till it becomes steady.

Pulse rate

Pulse rate average

Supine position

Standing:

Immediate (time)

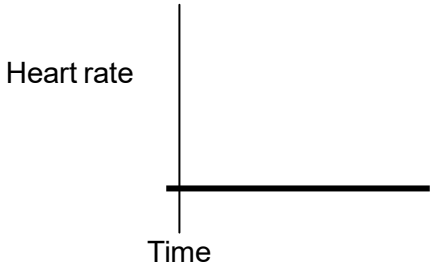
After 30 sec

After 1 minute

After $1^{1/2}$ minute

After 2 minute

Plot the changes in heart rate against time



Discussion:

Pulse (pressure pulse) is defined as rhythmic dilatation (alternate expansion and contraction) of arterial wall due to pressure changes created by intermittent ejection of blood from heart during ventricular systole into the already full aorta and transmitted as wave through blood column and arterial system to the periphery causing expansion of arterial walls. Velocity of pulse wave is (5-7 meters/sec) 6 time rapid than velocity of blood flow and depends on 1. Elasticity of arterial wall. 2. Inertia of blood 3. Stroke volume and cardiac output.

Any superficial artery is inspected and palpated to study the pulse. Radial artery – easily accessible and palpable because of its superficial position against the lower and of radius.

Bronchial artery: Palpated by thumb placed on its course in front of the elbow.

Carotid artery: thumb is placed adjacent to trachea in the lower part of the neck and gently pressed until carotid pulsations is felt.

Femoral artery – palpated by thumb placed on mid point between anterior superior iliac spine and pubic tubercle.

Popliteal artery palpated in popliteal fossa

Dorsalis pedis artery: palpated on the dorsal aspect of foot, on the proximal aspect of 1st interosseous space.

Posterior tibial artery: palpated 1cm behind the medial malleolus of tibia.

Normal pulse rate of an adult is 60 – 80/minute. Average 72/min.

Normal heart rate is pulse rate.

Tachycardia is pulse rate more than 100/minute

Bradycardia is pulse rate less than 60/minute

<u>Physiological causes of tachycardia</u>

i) Age: In new born infants pulse rate is high 140/minute
Pulse rate decreases as the child grows reaching normal adult rate by 20 years of age.

ii) Sex: In females pulse rate is faster than in males during menstruation and menopause.

iii) Emotion, excitement and exercise

iv) Increase in environmental temperature

v) After meals

vi) Diurnal variation pulse rate is higher in the evenings.

Pathological causes of tachycardia:

Fever

Thyrotoxicosis

Cardiac failure, paroxysmal – tachycardia

Haemorrhage, shock

Anaemia

Physiological causes of bradycardia:

Athelets due to increase in vagal tone, sleep

Pathological causes of bradycardia

Hypothyroidism

Hypothermia

Raised intracranial tension

Heart block

Rhythm:

Normal pulse is regular in rhythm (i.e) each successive pulse comes at equal intervals of time.

If the rhythm is irregular it may be regularly irregular.

Second degree heart block

Irregularly irregular

e.g Atrial fibrillation – extra systoles

Pulse deficit: Difference between the heart rate and pulse rate is more than 10. E.g Atrial fibrillation.

Sinus arrhythmia – common in children pulse rate goes up during inspiration large amount of blood is pumped into left atrium due to squeezing action of lungs, stroke volume of left ventricle increases, baroreceptors are stimulated causing reflex slowing of heart rate.

Pulsus paradoxus: pulse goes up during expiration and falls down during inspiration. E.g Pericardial effusion, bronchial asthma.

Volume is the amplitude of expansible movement of vessel wall during transmission of pulse wave through it. It measures the amount of blood flowing with every heart beat and is directly related to stroke volume due to, left ventricular contraction. Volume is constant from beat to beat.

Volume is moderate in normal healthy individuals; large volume is characteristic of hyperkinetic circulatory state.

e.g Volume increases in athletes, exercise, excitement. Fever anaemia, thyrotoxicosis, aortic incompetence.

Small volume in characteristic of low cardiac output. E.g Arteriosclerosis cardiac failure, shock haemorrhage.

Abnormal pulse is characteristic of certain diseases.

Collapsing pulse (water hammer or corrigan's pulse). Aortic incompetence valves cannot close or open completely – during systole due to increase stroke volume aorta gets filled up rapidly followed by regurgitation of blood into the left ventricle causing a sudden rise in pressure followed by an equally sudden fall of pressure pulse wave respectively. Collapsing pulse occurs in any condition where the pulse pressure is high with normally elastic arterial wall. E.g Anaemia, hypertension, AV fistula, thyrotoxicosis.

Condition of arterial wall: Arterial wall of a healthy individual is palpable, soft elastic in young people. In old people, arteries are tortuous and thickened due to arteriosclerosis cord like and hence easily palpable.

Pulses of both sides of the body should be equal. Inequality suggests:

Abnormally placed artery

Contraction of aorta

Obstruction to vessels by atheroma, thrombus or embolism

Pressure by lymphnodes

Diminished or absence of blood flow due to local diseases of arteries.

The radial pulse of a healthy adult has a rate of 70/mt. Regular rhythm, moderate volume not collapsing arterial wall is not thickened or tortuous and equally felt on both sides.

REVIEW QUESTIONS

1. Define “Peripheral pulse”.
2. Explain the mechanism causing “peripheral pulse wave”
3. Name the different arteries where the peripheral pulse is felt.
4. Why is the radial artery selected to study the pulse?
5. What are the features of the pulse to be looked for when feeling the pulse?
6. Describe the pulse of a healthy person.
7. What is the signification of clinical examination of the pulse?
8. What is bradycardia and tachycardia? Examine the physiological and pathological conditions causing them.
9. What is the velocity of pulse wave? What are factors which determine the velocity of pulse wave?
10. What is (a) sinus arrhythmia (b) pulse deficit
11. Why are arteries easily palpable in old people?

ACTIVITY B BLOOD PRESSURE

Aim: 1. To record the blood pressure of a subject by indirect methods.

a. Palpatory method b. Auscultatory method

2. To determine the effect of posture and exercise on blood pressure

Principle: Blood pressure is indirectly measured by balancing the pressure of blood in brachial artery, against the pressure of air in an inflatable rubber cuff surrounding the brachial artery which is measured by a Hg manometer. The pressure is then gradually released. The pressure recorded when the blood starts flowing through the artery is systolic pressure while the pressure recorded when the pressure in the cuff is equal to the pressure in the artery is diastolic pressure.

A. Sphygmomanometer: Sphygmomanometer is the instrument used to measure the blood pressure in human beings consists of an inflatable rubber cuff for applying extra arterial pressure, an Hg manometer (Consists of a tube containing Hg at the base, either limb has graduations from '0' to 100 mm each graduation corresponding to 2 mg Hg) to record the pressure applied, a bulb for inflating the cuff, a valve for deflating the cuff and rubber tubing connects the bulb to the cuff and from the cuff to the manometer.

Procedure: The subject is asked to sit comfortably and calmly. Left arm is placed to be at the level of the heart. The Sphygmomanometer is vertically fixed for level of Hg to at zero mm. Cuff of Sphygmomanometer is tied around the left arm of the subject across the brachial artery with lower border of the cuff about 1" proximal to the cubital fossa, so that cuff compresses sufficient length of the artery when inflated. Pulsations of the brachial artery is felt on the inner side of the biceps at the elbow (L). Radial pulse is felt at the anterior aspect of lower end of left forearm.

Palpatory method: With one hand feeling the radial pulse, cuff is inflated to raise the pressure in the Sphygmomanometer till the radial pulse is obliterated. The pressure is further raised by another 20-30 . Hg above the point disappearance of pulse , cuff is deflated slowly to allow slow and steady fall of pressure . The reading of the manometer when the pulsation in the radial artery just reappears indicates the systolic pressure. Now all the pressure in the cuff is released, till the Hg column shows zero reading.

Disadvantages: The systolic pressure recorded is not very accurate but acts as a control over the reading got by auscultatory method. The diastolic pressure cannot be recorded by this method.

Ausculatory method: Brachial artery is felt in the cubital fossa. Diaphragm of the stethoscope is placed on the brachial pulse. The cuff is inflated to about 30 mm Hg. above the value of systolic pressure got by the palpatory method. The cuff is then slowly deflated. As the pressure of the air in the cuff coincides with systolic pressure turbulence in blood flow through the compressed artery

into the distal segment occurs, producing a faint tapping sound. Reading of the manometer at this sound corresponds to systolic pressure. As the pressure in the cuff is progressively lowered the sound undergoes a series of changes in quality and intensity known as "Sounds of Korotkow". Five phases of sounds are heard in succession.

Phase I: Sudden appearance of a clear faint tapping sound, indicates systolic pressure, Persists upto succeeding fall of pressure of 15-20 mm Hg.

Phase II: Murmer during next 15-20 mm Hg. Fall in pressure.

Phase III: Clear, loud gong sound, during next 15-20 mm Hg. Fall in pressure.

Phase IV: Muffled sound lasting through next 5-6 mm Hg. Fall in pressure.

Phase V: All sounds disappear – corresponds to diastolic pressure.

The pressure in the cuff is released till the reading in the manometer is zero. The blood pressure is recorded in the standing and lying down positions by the palpatory and auscultatory methods. The blood pressure is recorded after asking the subject to exercise (moderate) for 5 min. After practicing recording of systolic and diastolic pressure for a number of times, proceed to examine the effect of change of posture and exercise on the blood pressure.

Effect of posture:

Record the blood pressure in a subject with the manometer cuff already wrapped around his arm after the rest in supine position for about 10 min. Take three recording and calculate the average.

The subject is asked to stand up. As soon as he stands – one student should keep on recording the blood pressure repeatedly till it comes to normal. Another student notes these pressure reading and corresponding the time (Zero time = the moment the subject stands up)-

Tabulate the changes in the systolic and diastolic blood pressure versus time in the following manner.

Postural changes in blood pressure:

Posture	Systolic	Diastolic	Palpatory	Mean
Lying supine				
Standing time				

Plot the blood pressure readings against time graphically

Effect of Exercise on Blood Pressure:

Record the resting blood pressure and resting heart rate in supine position. Perform the exercise as in a Harvard step test or in a bicycle ergometer for a fixed period of time.

Immediately after the completion of exercise the subject lies supine and blood pressure recording starts immediately and repeated continuously till it comes to normal. The recording of the blood pressure is done by one student. Simultaneously another student keeps on noting the blood pressure reading and the corresponding time. A third student measures the pulse rate of the subject from immediately after exercise till it comes to normal. The results are plotted in the same manner as in posture experiment.

Exercise effect on blood pressure

	S.P	D.P	P.P	M.P
Resting B.P.				
After exercise				
Time				

Exercise effect on heart rate

Resting H.R.			
After exercise			
Time			

Plot the heart rate and blood pressure change graphically against time.

Precautions:

1. There should be no leakage of air in the Sphygmomanometer

2. Hg. Column of the manometer should show a reading of zero mm Hg. Before using the apparatus.

3. The subject should be in a state of physical and mental rest.

4. The arm should be relaxed. If the muscles are contracted reading will be inaccurated.

5. After exercise the BP reading should be taken within 3 min. Since after this BP will return to normal.

Note: The cuff should be sufficiently long to cover more than ½ the girth of the limb (diameter of the cuff should be 20% wider than the diameter of the arm) with a breadth of ½ its length.

Inference: Whether the systolic, diastolic, pulse, pressure and mean pressure are within physiological limits.

Result: Blood pressure + Systolic / Distolic pressure = mm Hg.

Pulse pressure = mm Hg.

Mean pressure = mm Hg.

Discussion:

Blood pressure is defined as the lateral pressure exerted by blood column on the vessel wall during its flow.

BP depends upon the systolic force of contraction of the heart, cardiac output, peripheral resistance (frictional resistance offered by the circulatory system to blood flow). BP when measured has two readings systolic and diastolic. Systolic pressure is the maximum work done by the heart and the pressure which the arterial walls have to withstand.

Normal Value 100-140 mm Hg.

Systolic pressure fluctuates due to number of physiological factors heart rate, stroke volume, blood volume, Velocity and viscosity of blood and increases in old age due to arteriosclerosis.

Diastolic pressure is the minimum pressure recorded during diastole of heart is on index of peripheral resistance which the heart has to overcome depends on diameter of the lumen of blood vessels.

Normal value 60-90 mm Hg.

Diastolic pressure remains within a limited range and hence variation is of greater clinical significance.

Pulse pressure is the difference between systolic and diastolic pressures varies directly with stroke volume.

Normal value 30-60 mm Hg. (average 40 mm Hg). In adult ratio of systolic : Diastolic : Pulse Pressure = 3 : 2 : 1

Mean pressure is the average arterial pressure throughout the cardiac cycle = Diastolic Pressure + 1/3 Pulse pressure

Physiological variation of BP:

1. Age: BP increases from infancy to adolescence to reach adult.
2. Sex: Both systolic and diastolic pressures are lower by 5 mm of Hg. in females, than males. BP raises after menopause.
3. Build: Systolic pressure is high in obese people.
4. Exercise: After heavy exercise systolic pressure increases upto 180 mm Hg.
5. Posture: On assuming a standing posture after lying down. There is a tendency of the BP to fall in the head and upper part of the body. The baroreceptor mechanism quickly brings the pressure towards normal value. Actual changes are variable.
6. Sleep: Systolic pressure is less by 15-20 mm Hg.
7. Ingestion of meals: Systolic pressure increases due to increased cardiac output.
8. Emotional excitement: Systolic pressure rises.
9. Diurinal variation: BP highest in afternoon and lowest in the morning.
10. Respiration: With normal respiratory rate BP decreases during inspiration.
11. Right of left limb: Systolic pressure in right arm in 20-30 mm Hg. Higher than in left arm.
12. Low BP: is found in normal people without any obvious cause.

Pathological variation: Under basal state constantly elevated systolic pressure more than 150 mm Hg. Diastolic pressure more than 90 mm Hg. is known as hypertension.

Causes: Essential hypertension in old people

Secondary hypertension

Renal disease – Pyelonephritis

Toxaemia of pregnancy

Arteriosclerosis, atherosclerosis

Hyperthyroidism

Increased intra cranial tension

Adrenal tumour – Phenochromocytoma

Under basal state persistent systolic pressure is less than 100 mm Hg. Diastolic pressure is less than 50 mm Hg. is known as hypothesion.

Causes: Surgical shock, myocardial infarction, hypothyroidism adrenal insufficiency.

Normal function of BP is to maintain sufficient pressure head to keep blood circulating and provide a motive force of filtration at capillary bed to effect nutrition to tissues, formation of urine, lymph etc.

Auscultatory (silent) gap: Korotkow's sounds appears normally at systolic pressure and disappear at diastolic pressure, but sometimes these sounds disappear between phase I and II for a brief period of 40 mm Hg. Range causing underestimation of systolic pressure. Silent gap is encountered in conditions associated with wide pulse pressure. As a routine systolic pressure should be recorded first by palpatory method and followed by auscultatory method.

REVIEW QUESTIONS

1. What are the methods by which BP is recorded in human beings?
2. What are the principle involved in recording of BP?
3. Define: a. Blood pressure
   b. Systolic pressure
   c. Mean pressure
   d. Diastolic pressure
   e. Pulse pressure

   What are their normal values and significance?

4. What are the factors which affect BP?
5. What are the physiological variations of BP?
6. What is hypertension? Name few conditions causing it?
7. What is hypotension? Name few conditions causing it?
8. Of the two pressures, systolic and diastolic which is more important? Why?
9. What is auscultatory gap? How is it important?
10. What is the disadvantage of palpatory method of recording the BP?

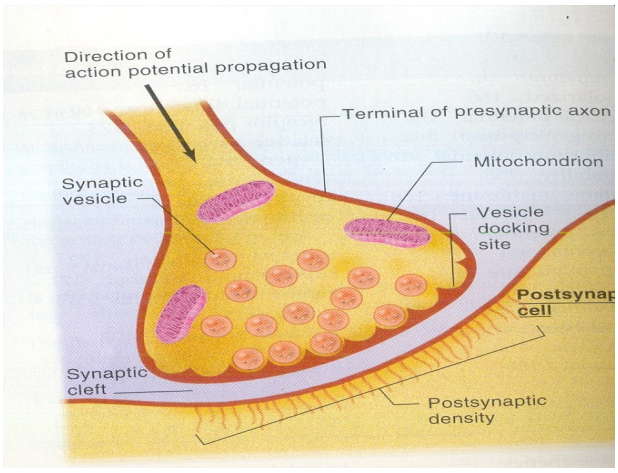
P.1.4 CENTRAL NERVOUS SYSTEM

The basic structural and functional unit of the nervous system is the neuron. It consists of central nervous system and peripheral nervous system. The part of the nervous system which occupies the central axis of the body is called central nervous system. It comprises the brain and spinal cord. The part of the nervous system which lies outside the CNS containing nerve fibers is called peripheral nervous system.

1.4.1 THE SYNAPSE

It is the junctional region between the two neurons, where information from one neuron is relayed to another neuron. There are 3 types of synapses viz., (i) axodendritic (ii) axosomatic (iii) axoaxonic synapses.

Structure of synaptic junction



SYNAPTIC TRANSMISSION

The sequence of events are

1) When the axon is stimulated it develops an action potential (AP).
2) The AP travels down the axon and reaches the pre synaptic membrane
3) The synaptic vesicles now rupture and the neurotransmitter is released.
4) In the post synaptic membrane, the neurotransmitter combine with the receptors, and produces synaptic potential which can be of two types.

(a) Excitatory post synaptic potential (EPSP)

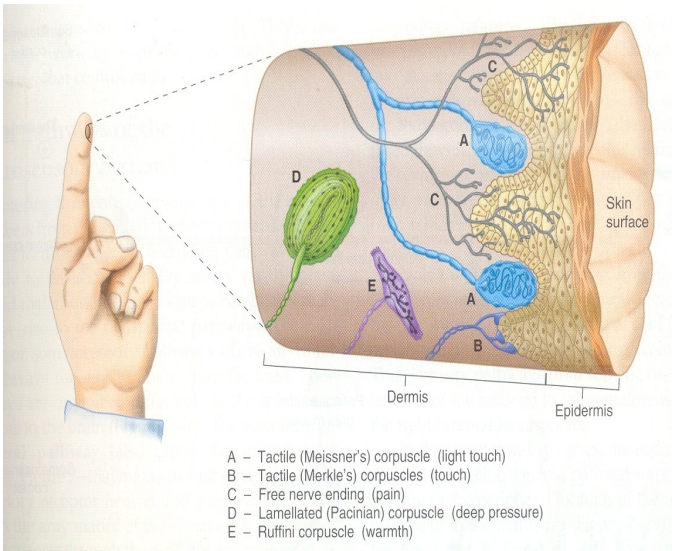
(b) Inhibitory postsynaptic potential (IPSP)

5) When EPSP has sufficient strength, AP is developed.

1.4.2 THE RECEPTORS

Receptor is a specialized, modified sensory nerve ending which undergoes depolarization in response to a specific stimulus and in turn sends information to the CNS. It acts as a transducer that converts various forms of energy in the environment into electrical energy in the neuron. Eg., Merkel's disc, Meissner's corpuscles, Ruffini's end organs, Krause's end bulb, Free nerve endings, Pacinian corpuscles.

Structure of receptors



Specificity of the response : Normally a receptor is stimulated most easily when subjected to stimulation; other modes of stimulation are almost ineffective. When a receptor is adequately stimulated it develops a non propagated current which is called generator potential. When it becomes strong, an action potential develops in the nerve fiber and now the nerve can said to be the conducting impulse.

1.4.3 REFLEXES

Reflex is an involuntary response to a stimulus which depends on integrity of reflex pathway. The reflex arc consist of:

a) The receptor
b) The afferent nerve
c) The center
d) The efferent nerve
e) The effector organ

Clinical classification reflexes

1. Superficial reflexes
2. Deep reflexes
3. Visceral reflexes
4. Pathological reflexes

1.4.4 SENSORY SYSTEM

It is a part of the nervous system that consists of

(i) Sensory receptors
(ii) The neural pathways
(iii) Somato-sensory cortex

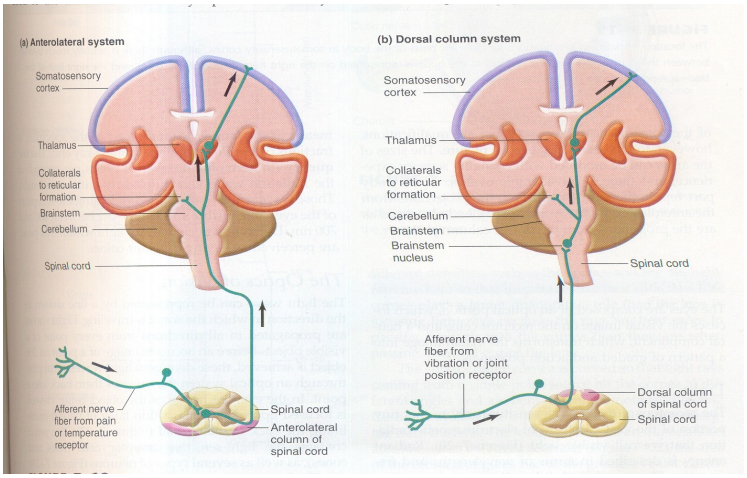
Sensory tracts in the spinal cord

a) Dorsal column lemniscal system – carrying fine touch, tactile discrimination, vibration sense, proprioception, position sense and pressure sense.

b) **Anterolateral system** – carrying crude touch, pain, temperature, itch and tickle and sexual sensations.

c) **Dorsal and Ventral spino cerebellar tracts** – carries unconscious kinesthetic impulses to cerebellum which is essential for the regulation of body posture.

The main ascending tracts



***Somato sensory cortex*:** It is divided in to somato sensory area I (SI) and II (SII). SI is located in the postcentral gyrus containing Brodmann's area 3,1,2. SII is located in the superior wall of the sylvian fissure.

1.4.5 *MOTOR SYSTEM*

The term motor neuron means an efferent neuron which carries impulses destined to reach a motor effector organ. The part of the cerebral cortex of the frontal lobes which on stimulation gives rise to the skeletal muscle responses constitute the motor areas. It is divided into,

(i) Primary motor cortex

(ii) Pre motor cortex and

(iii) Supplementary motor cortex

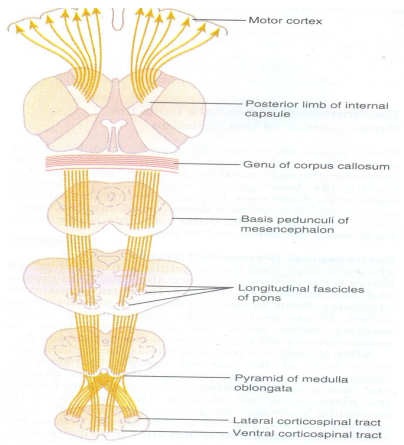
a) Pyramidal tract Origin

i) 30% from precentral gyrus on area 4

ii) 30% from area 6

iii) 40% from parietal lobe

Pyramidal tract



Functions of pyramidal tract

1. It controls the fine, precise voluntary movements.
2. It is involved in sensory motor coordination.

b) Extra pyramidal tracts

It is made up of those areas in the CNS that are concerned in the muscular movement and posture.

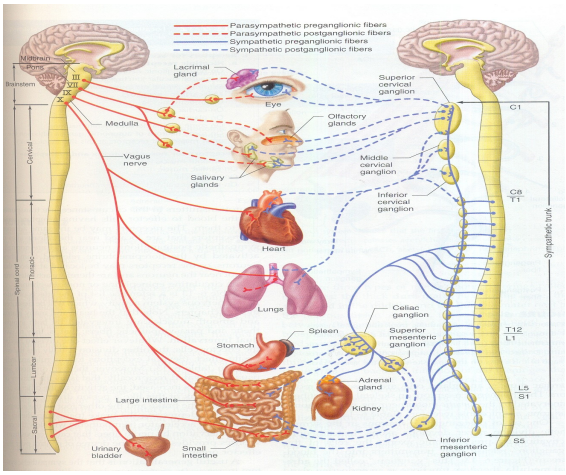
Functions of extra pyramidal tract:

1. It controls the movement of eyeballs
2. It is responsible for control of muscle tone, posture and equilibrium
3. It controls the complex movements of the body and limb

1.4.6 THE AUTONOMIC NERVOUS SYSTEM (ANS)

The ANS is divided into 2 divisions.

1. Sympathetic nervous system (or) Thoraco-lumbar division
2. Parasympathetic nervous system (or) Cranio-sacral division



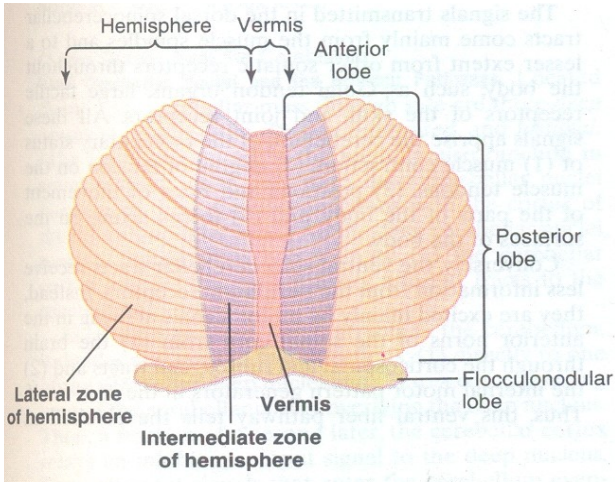
Functions of the Autonomic Nervous System

1. Sympathetic nervous system plays a role in “flight and fight” reaction, where there is redistribution of blood, sweating of the body, glycogenolysis, and pupillary dilatation.
2. Parasympathetic nervous system helps to reduce the energy expenditure and therefore, the body stores energy which can be utilized if and when the sympathetic over activity is needed.

1.4.7 THE CEREBELLUM

It sits astride the main sensory and motor systems in the brain stem on each side by a superior, middle and inferior peduncles.

Structure of cerebellum



Functions of Cerebellum

1. It controls the voluntary movements
2. It controls the muscle tone, posture and equilibrium.

1.4.8 THE THALAMUS

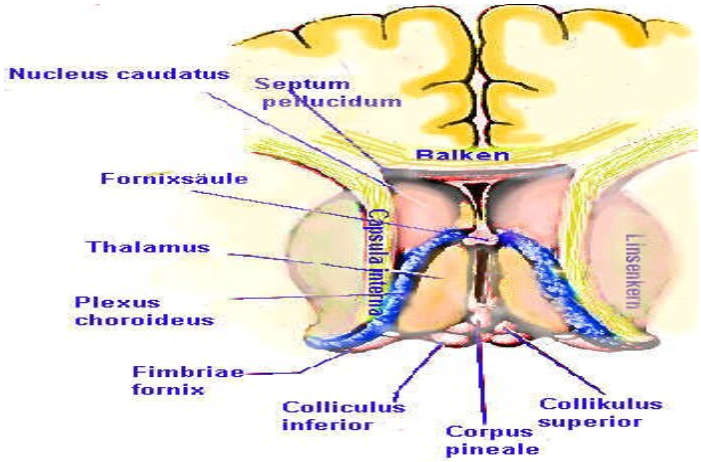
It is a great sensory relay station and integrating center for most inputs before relaying them to cerebral cortex.

Functions

1. It is a major relay station where all the specific sensory impulses relay before finally terminating in the cerebral cortex.

2. The non specific impulses to thalamus produce wakefulness, alertness and consciousness.
3. Thalamus is a part of limbic system.

Structure of thalamus

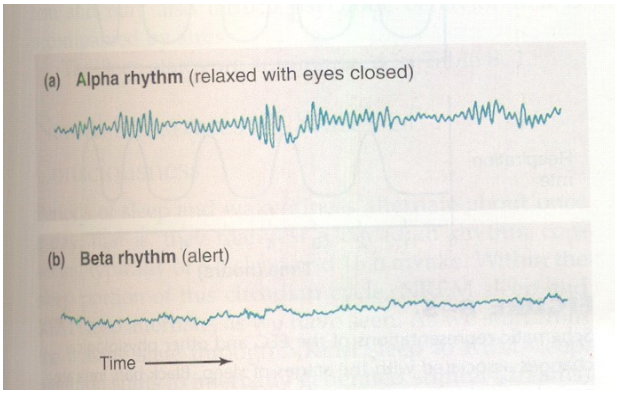


1.4.9 ELECTROENCEPHALOGRAM (EEG) AND SLEEP

The record of electrical activity of the brain is called electroencephalogram. In adult awake persons with the eyes closed and mind relaxed and wandering, when a pair of electrodes are placed in the occipital region of the scalp, δ rhythm is seen. These waves have 8 – 14 Hz frequency. If the person open his eyes, the α wave disappears, and in its place a new type of wave called α block is seen. Besides α wave, β,δ,θ waves may appear in EEG. β waves are of 10-30 Hz frequency and low amplitude seen in frontal region.

δ waves - high amplitude, 1-2 Hz freq.

θ waves - low amplitude, 4-7 Hz freq.



Uses of Electroencephalogram (EEG)

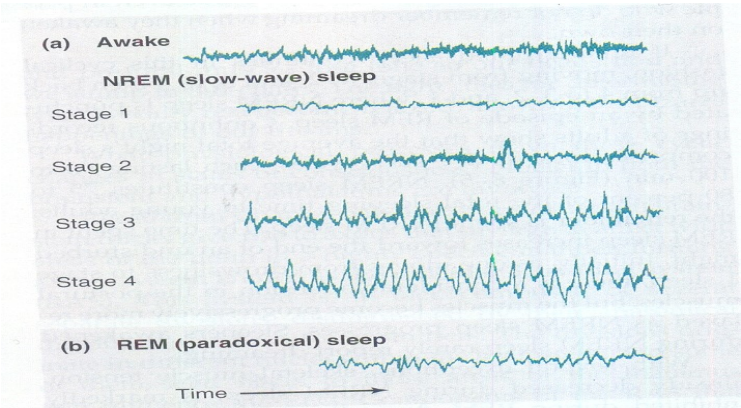
1. Localization of pathological conditions like sub dural hematoma or fluid collection over cortex
2. Diagnosis of epilepsy

SLEEP

It is a physiological process by which bodily functions are periodically rested.

Types of Sleep

1. Non-rapid eye movement sleep (NREM sleep)
2. Rapid eye movement sleep (REM sleep)



Mechanism of sleep

1. The activity of reticular activating system (RAS) leads to awakening. Conversely, inhibition of RAS promotes sleep.

2. When serotonergic neurons of the brain are stimulated electrically, the animals fall asleep.

Sleep disorders

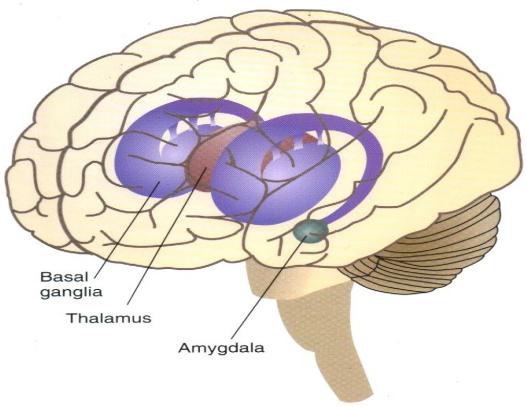
1. Insomnia	-	Inability to fall asleep
2. Somnambulism	-	Sleep-walking
3. Nocturnal enuresis	-	bed-wetting
4. Narcolepsy	-	irresistible urge to sleep
5. Sleep apnoea	-	obstruction of airway during inspiration
6. REM behavior disorder	-	hypotonia fails to occur during REM sleep

1.4.10 THE BASAL GANGLIA

This term is applied to group of nuclei in the forebrain and upper part of the brain stem that have motor functions. It includes

1. Caudate nucleus
2. Putamen
3. Globus pallidus
4. Subthalamic nucleus
5. Substantia nigra

Structure of basal ganglia



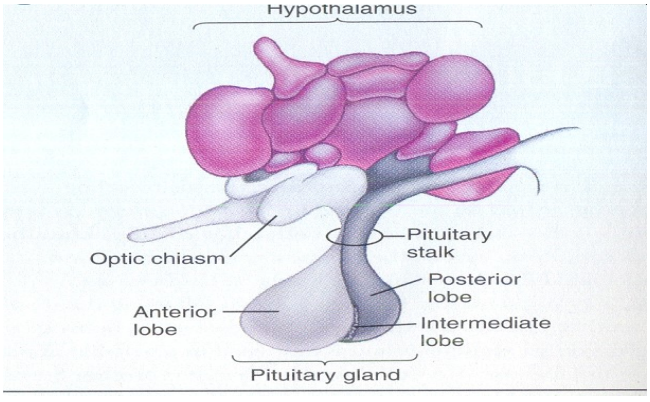
Functions of basal ganglia

1. In fact basal ganglia is necessary for normal degree of tone and posture
2. It controls the voluntary and associated movements
3. It helps for programming the voluntary movements.

1.4.11. *The Hypothalamus*

It is a diencephalic structure lies below the thalamus.

Structure of hypothalamus



Functions of hypothalamus

1. Regulates body temperature
2. Controls the activity of anterior and posterior pituitary glands
3. It controls the circadian rhythm
4. It controls the sleep waking cycle, helps to integrate autonomic nervous system
5. It controls hunger, feeding, water intake and thirst.

1.4.12 HIGHER FUNCTIONS OF THE NERVOUS SYSTEM

It includes language (speech), learning and memory.

1. ***Language :*** To understand the spoken and printed words and to express ideas in speech and writing is called language. It involves Broca's and Wernicke's areas.
2. ***Learning :*** The ability to alter behavior on the basis of experience is called learning.
3. ***Memory :*** It is the ability to recall past events at the conscious or unconscious levels.

Types of Memory

1. Short term memory
2. Long term memory

Mechanism of memory: Basic mechanism of memory is the development of new neuronal circuits by the development of new synapses.

Alzheimer's disease: It is characterized by progressive loss of memory and cognitive function.

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Describe in detail the course, termination and functions of various ascending and descending tracts of spinal cord.
2. Describe the functions of hypothalamus.

Short Notes: (3 X 5 = 15)

1. Synapse
2. Thalamus
3. Sleep and EEG

P.1.5 MUSCULAR SKELETAL SYSTEM

There are three types of muscles in our body: skeletal, smooth and cardiac muscles.

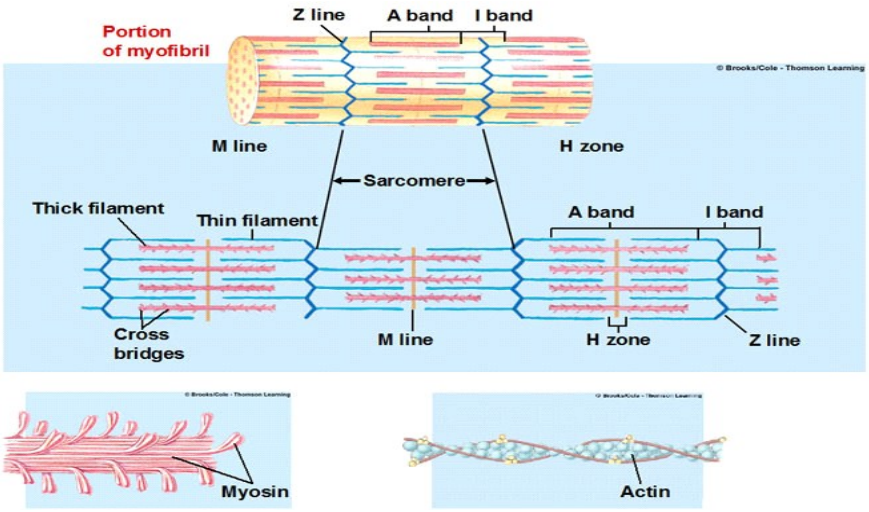
1.5.1 THE SKELETAL MUSCLE

FUNCTIONAL ANATOMY

Skeletal muscles also called as striated or voluntary muscles are found in association with the bones. It accounts for about 40% of adult body mass in a healthy person. A muscle belly consists of large number of fasciculi. The whole belly is wrapped by epimysium and connective tissue sheaths covering fasciculi are called perimysium. Each fasciculus consists of large number of muscle fibers.

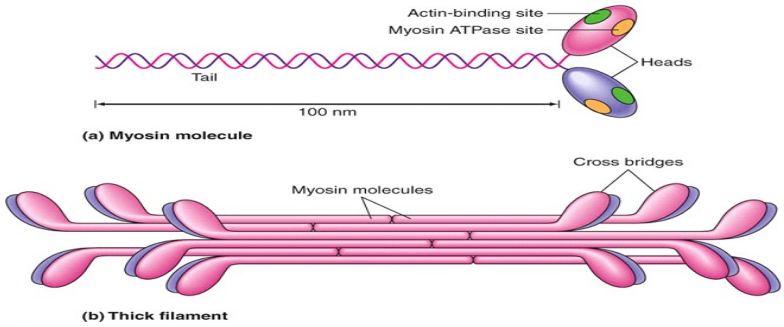
The cell membrane of an individual muscle fiber is called sarcolemma. The cross striations are due to the dark and light bands. A single muscle fiber contains numerous myofibrils. Each myofibril is divided into a number of compartments by Z lines. The portion of a myofibril, in between any two successive Z lines is called sarcomere.

Structure of sarcomere

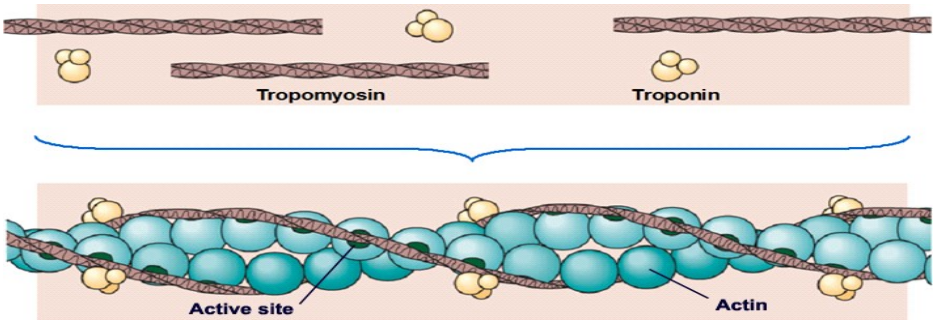


Each sarcomere contains thin and thick filaments. The central part of myosin filament is called H zone. The central part of H zone contains M band.

Structure of myosin filament



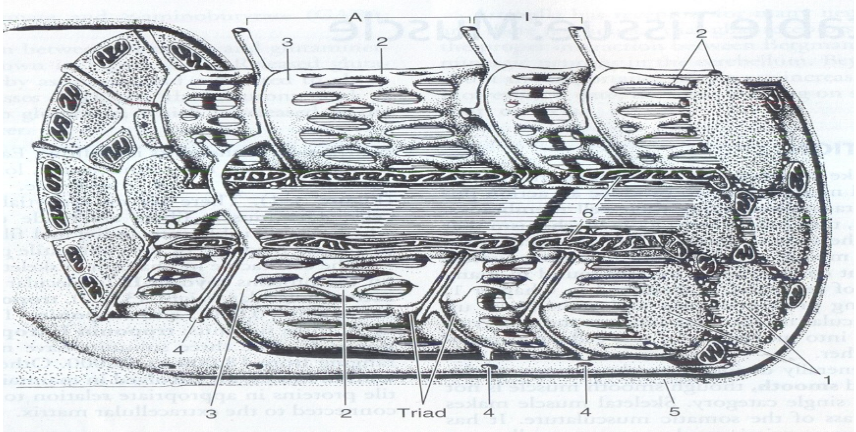
Structure of actin filament



T AND L TUBULES

The sarcolemma of individual muscle fibre makes deep in roads inside the muscle fibers and are called T tubules. They communicate with extracellular fluid. Another kind of tubules called L tubules are due to sarcolemmal invaginations. The term triad means a portion of the T-tubule plus two cisterns, one on either side of the T-tubule.

STRUCTURE OF SARCOTUBULAR SYSTEM

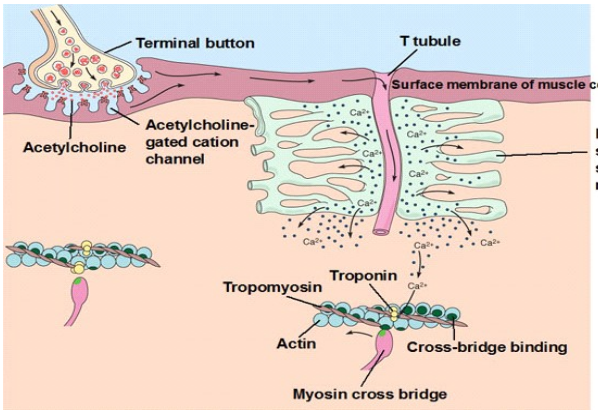


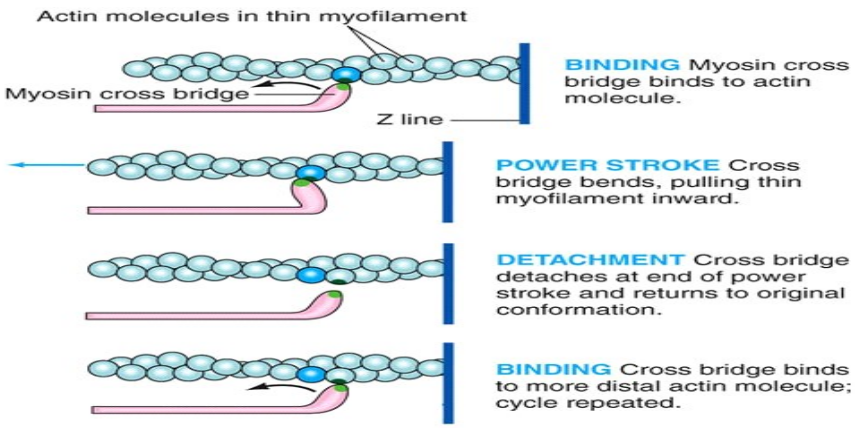
MECHANISM OF SKELETAL MUSCLE CONTRACTION

Steps in contraction

1. Discharge of motor neuron
2. Release of acetylcholine at motor end-plate
3. Binding of acetylcholine to nicotinic acetylcholine receptors
4. Increased Na^+ and K^+ conductance inside the muscle fiber.
5. Generation of end-plate potential
6. Generation of action potential
7. Inward spread of depolarization along T-tubules
8. Release of Ca^{++} from terminal cisterns of sarcoplasmic reticulum
9. Binding of Ca^{++} to Troponin C, uncovering myosin binding sites on actin.
10. Formation of cross-linkages between actin and myosin producing contraction.

EXCITATION - CONTRACTION COUPLING





STEPS IN MUSCLE RELAXATION

1. Ca^{++} is pumped back into the sarcoplasmic reticulum
2. Release of Ca^{++} from troponin
3. Cessation of interaction between actin and myosin

PROPERTIES OF SKELETAL MUSCLE

A. Mechanical Properties

a) Simple muscle curve : When the nerve of an isolated nerve-muscle preparation is given a single shock of adequate strength the muscle responds by a twitch, it contracts and relaxes which can be recorded on a kymograph paper called simple muscle curve.

b) Effect of successive Stimuli :

(i) If the second shock is applied too closely after the first one, no response will be obtained, due to absolute refractory period.

(ii) When the second stimulus falls on the second half of the latent (or contraction period) beneficial effect and summation are produced respectively.

(iii) When the 2^{nd} stimulus falls on the relaxation period – M curve (or superposition) is obtained.

c) Tetanus and Clonus : If a large number of stimuli are applied consecutively, it is called tetanus. If each stimulus falls during the phase of relaxation, it results in clonus (or) incomplete tetanus. If each stimulus falls during contraction phase, it results in complete tetanus.

d) Refractory period : It is the period during which the muscle fails to respond to the second stimulus. It is divided into absolute and relative refractory periods.

e) All or none law : A single muscle fiber, when stimulated adequately, develops a tension as it contracts. If the strength of stimulus is increased the tension does not increase. This is all or none law.

f) **Fatigue :** If a nerve-muscle preparation is repeatedly stimulated fatigue sets in. The seat of fatigue is neuromuscular junction. But in intact human body, the seat of fatigue is in central synapses.

g) **Effect of temperature :** Hot Ringer increases the force of contraction of the muscle whereas the cold Ringer decreases the force of contraction.

B. *Thermal Properties*:

a) **Activation heat***:* It is liberated before the actual contraction of the muscle. It is due to the heat liberated while Ca^{++} ions are released from the L tubules.

b) **Shortening heat***:* It is produced during muscle shortening. This is due to the movement of cross-bridges and myofilaments.

c) **Heat for the work done***:* According to Fenn, more work done causes more expenditure of ATP.

d) **Recovery Heat***:* It is released when the muscle is recovering from the effect of contraction.

C. *Electrical properties*

The resting membrane potential is -90 mv. Action potential lasts for about 2-4msec. Velocity of conduction is 5m/Sec. Absolute refractory period is 1-3 msec long.

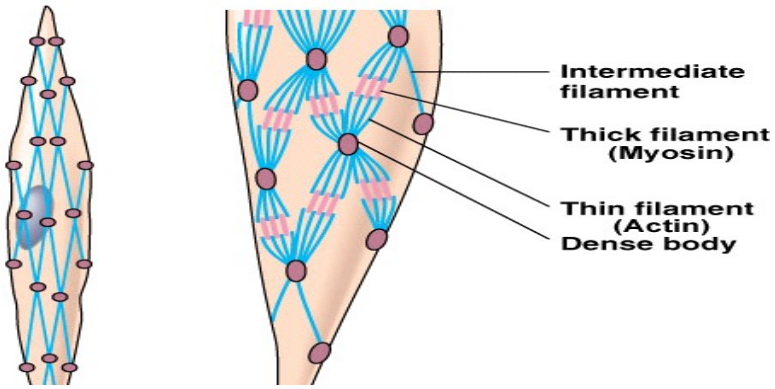
RIGOR MORTIS

Some hours after death the muscles are stiffened and the phenomenon is called “rigor mortis”. It is important, as this helps fixation of the hour of death after a murder and thus helps to track the criminal. After death, local store of ATP molecules are exhausted, the detachment of myosin from actin cannot take place resulting in permanent state of contraction.

1.5.2 SMOOTH MUSCLE

The smooth muscles are found in the walls of hollow tubes of gastrointestinal viscera (stomach, small intestine, large intestine), bronchial tubes, urinary bladder and blood vessels. These muscles are supplied by autonomic nerves (sympathetic and parasympathetic).

I) Functional anatomy



The basic unit is muscle fibre. A smooth muscle fibre in spindle-shaped structure, 2-5 µm in diameter and 20 -500 µm in length. Adjacent muscle fibres are connected to each other by two types of connections.

1. Gap junctions which allow ionic movement between the cells
2. Desmosomes which provide stability and cohesiveness to tissues.

Smooth muscle consists of actin, myosin and tropomyosin filaments similar to that of skeletal muscle. But there is no troponin. It contains dense bodies containing the protein alpha-actinin. They are kept in place by intermediate fibrils made of a protein called desmin. Smooth muscle has poorly developed sarcoplasmic reticulum. The neuromuscular junctions are not as well developed in smooth muscle as in skeletal muscle. The efferent nerve fibres show multiple varicosities along their length. These contain neurotransmitter vesicles. When the nerve fibre is activated, the neuro transmitter is released which diffuses through the interstitial fluid and interacts with the sarcolemmal receptors to stimulate or inhibit muscle contraction.

II) Types of Smooth muscle

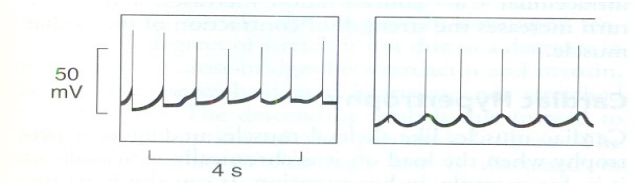
1. Single unit (or) Visceral smooth muscle
2. Multi unit smooth muscle

In single unit smooth muscle, the impulse of activation can spread rapidly from one cell to another through gap junctions. Eg., gut ureter, uterus. The multi unit smooth muscle is made up of individual units without inter connecting bridges. Eg., ciliary muscle, iris of the eye.

III) Electrophysiology

It is more complex. There is no true resting membrane potential (RMP). But it shows continuous, irregular contractions that are independent of its nerve supply. This maintained state of partial contraction is called tone. The RMP is around -60 mV. It is highly unstable and can reach the threshold for excitation with a very weak stimulus. The action potential may be brief or prolonged. The spikes have a duration of 10-50 ms.

Action potential in smooth muscle



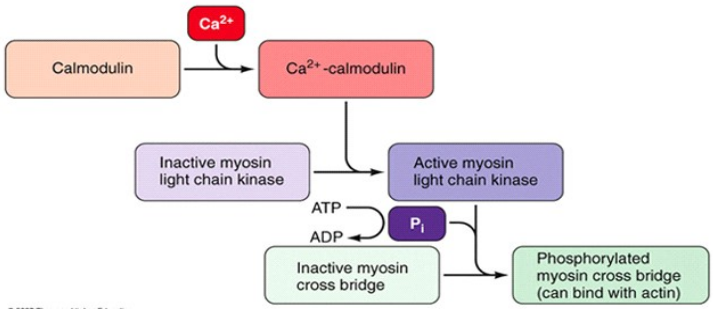
IV) Modes of stimulation

1. Sympathetic via norepinephrine
2. Parasympathetic via acetylcholine

V) Molecular basis of contraction

In smooth muscle, Ca^{++} from extracellular fluid binds to calmodulin and the resulting complex activates calmodulin-dependent myosin light chain kinase. This enzyme catalyses the phosphorylation of the myosin light chain which allows the myosin ATPase to be activated, the actin slides on myosin producing contraction.

Molecular basis of smooth muscle contraction



Myosin is dephosphorylated by phosphatases in the cell. The smooth muscle has a latch bridge mechanism where it produces sustained contraction. This muscle also shows plasticity.

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Describe in detail the mechanism of contraction of skeletal muscle.
2. Explain the various properties of skeletal muscle.

Short Notes: (3 X 5 = 15)

1. Smooth muscle
2. Sarcomere
3. Sarcotubular system

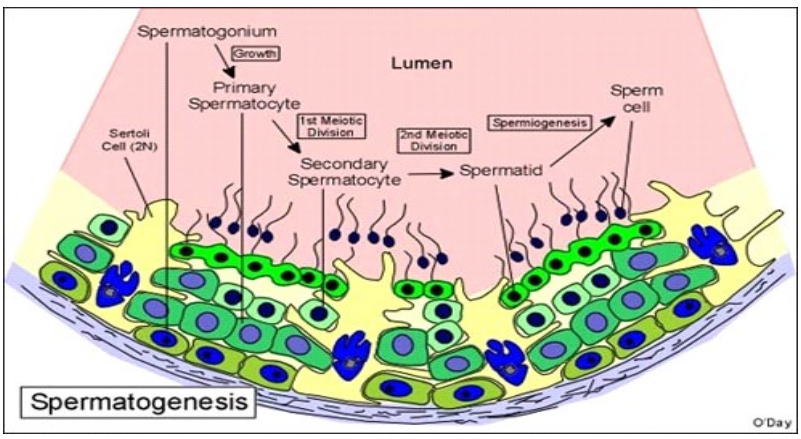
P.1.6 REPRODUCTIVE SYSTEM

1.6.1 MALE REPRODUCTIVE SYSTEM

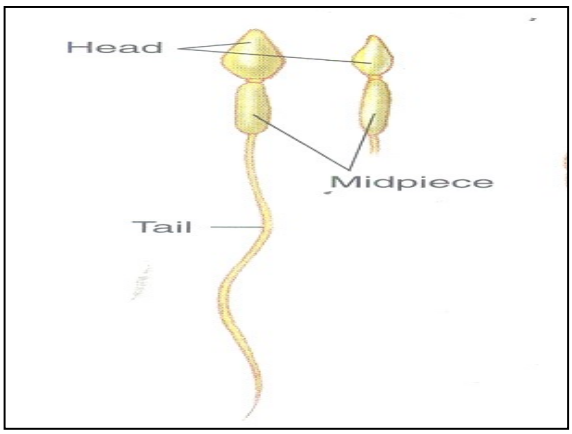
The testis is composed of seminiferous tubules in which the sperm is formed. Between the tubules are nests of cells, the interstitial cells of Leydig which secretes testosterone into the blood stream. The walls of the seminiferous tubules are lined by primitive germ cells and sertoli cells. Tight junctions between adjacent sertoli cells near the basal lamina form a blood-testis barrier.

SPERMATOGENESIS

The spermatogonia, the primitive germ cells mature into primary spermatocytes. This process begins during adolescence. The primary spermatocytes undergo meiotic division, reducing the number of chromosomes. They divide into secondary spermatocytes and then into spermatids which contain the haploid number of 23 chromosomes. The spermatids mature into spermatogonia (Sperms).



Sperm has a head and a tail. Head comprises the condensed nucleus and on the anterior two third is a thick cap called acrosome which contains powerful proteolytic enzymes. These enzymes play important role in allowing the sperm to enter the ovum and fertilize it. Tail helps in the motility of the sperm. It has a central skeleton called the axoneme and a collection of mitochondria around the axoneme.



Hormonal factors that stimulate spermatogenesis:

1. Testosterone is essential for growth and division of the testicular germinal cells.
2. Luteinizing hormone – stimulates Leydig cells to secrete testosterone
3. Follicle stimulating hormone – stimulates sertoli cells
4. Estrogens – essential for spermiogenesis.
5. Growth hormone – is necessary for controlling background metabolic functions of the testes.

The two testes of the human adult form up to 120 million sperm each day. A small quantity of these can be stored in the epididymis most are stored in the vas deferens. Semen is composed of fluid and sperm from the vas deference, fluid from the prostate gland, seminal vesicles, bulbourethral glands. At temperature below -100°c, sperms can be preserved for several years.

After ejaculation, the sperm becomes mobile and they also become capable of fertilizing the ovum, a process called fertilization.

TESTOSTERONE AND OTHER MALE SEX HORMONES

The testes secrete several male sex hormones called as androgens including testosterone, dihydrotestosterone, androstenedione.

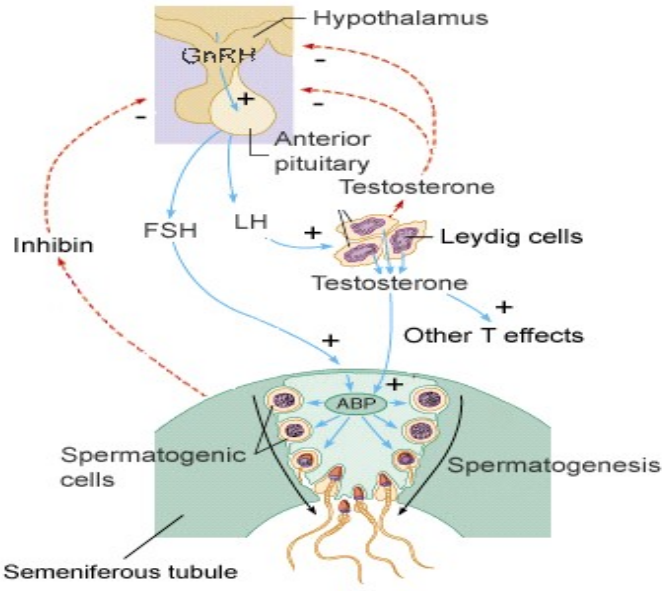
Functions of the testosterone

Testosterone begins to be secreted by the male fetal testis at seventh week of embryonic life. It is responsible for the development of male body characteristics and helps in the descent of the testis to the scrotum.

Testosterone causes the secondary sexual characteristics to develop. There will be increase in the genital size, voice becomes deeper, beard appears, hair line on the scalp recedes, shoulders broaden, muscles enlarge, sebaceous gland secretion thickens, increases the acne, basal metabolism increases and RBC count increases.

CONTROL OF TESTICULAR FUNCTION

Gonadotropin – releasing hormone (GnRH) secreted by the hypothalamus causes the release of luteinizing hormone (LH) and folicule – stimulating hormone (FSH) from the pituitary. LH stimulates the interstitial cells of Leydig to produce testosterone. Testosterone in turn inhibits the GnRH and LH secretion by negative feedback mechanism.



ABNORMALITIES OF TESTICULAR FUNCTION

Cryptorchidism **:** The testes develop in the abdominal cavity and normally migrate to the scrotum during fetal development. If this descent does not occur it is called as cryptorchidism. Early treatment is recommended because there is a higher incidence of malignant tumors in undescended testes. After puberty the higher temperature in the abdomen causes irreversible damage to the spermatogenic epithelium.

Male hypogonadism **:** In adults, if it is due to testicular disease, circulating gonadotropin levels are elevated (hypergonadotropic hypogonadism), if it is secondary to disorders of pituitary or hypothalamus, circulating gonadotropin levels are depressed (hypogonadotropic hypogonadism)

1.6.2 FEMALE REPRODUCTIVE SYSTEM

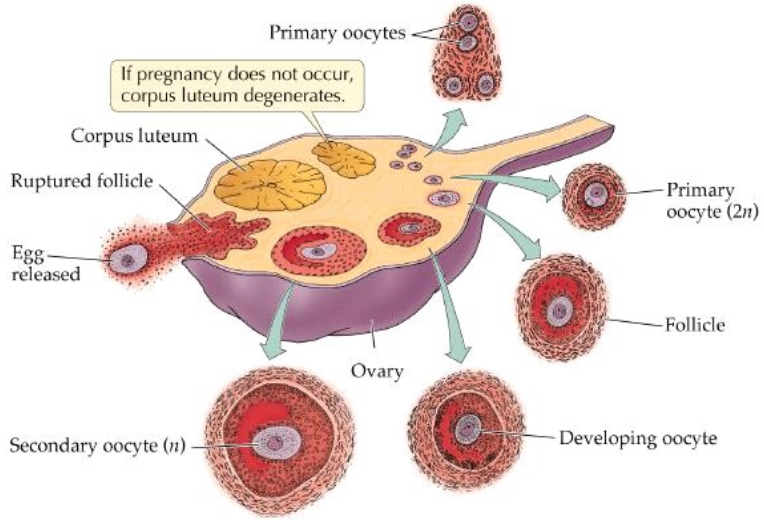
I) MENSTRUAL CYCLE

The reproductive system of women shows regular cyclic changes that may be regarded as periodic preparations for fertilization and pregnancy. In humans the cycle is a menstrual cycle and its conspicuous feature is the periodic vaginal bleeding that occurs with the shedding of the uterine mucosa (menstruation).

OVARIAN CYCLE

From the time of birth, there are many primordial follicles under the ovarian capsule which contains immature ovum. At the start of each cycle, several of these follicles enlarge and a cavity forms around the ovum known as antrum. It is filled with the follicular fluid. One of the follicles in one ovary starts to grow rapidly on the 6^{th} day and becomes dominant follicle. The mature follicle is known as the graafian follicle and has theca externa, theca interna which is the primary source of estrogens and the granulosa cells. At the 14^{th} day the distended follicle ruptures and the ovum is extruded into the abdominal cavity. This is the process of ovulation.

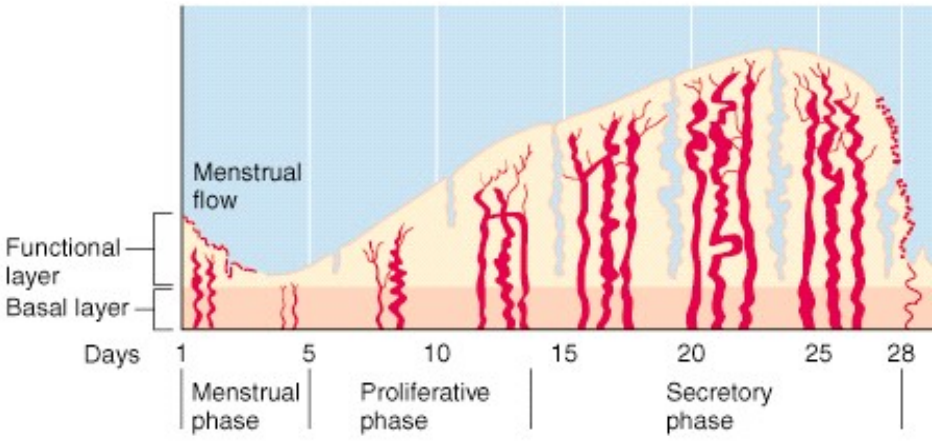
The follicle that ruptures fills with blood and is known as corpus hemorrhagicum. The granulosa and the theca cells of the follicle proliferates and the clotted blood is replaced with yellowish lipid rich luteal cells forming the corpus luteum. The luteal cells secrets estrogens and progesterone. If pregnancy occurs, corpus luteum persists and if there is no pregnancy, the corpus luteum degenerates and is replaced by scar tissue forming a corpus albicans.



UTERINE CYCLE

At the end of the menstruation, all but the deep layers of the endometrium have sloughed. During the proliferative phase, under the influence of the estrogens the endometrium increases rapidly in thickness from the fifth to the fourteenth day of the menstrual cycle. After ovulation the glands become coiled and tortuous and they begin to secrete a clear fluid and this phase of the cycle is called the secretory or luteal phase. During this phase the endometrium becomes highly vascularized and slightly edematous under the influence of estrogen and progesterone.

When the corpus luteum regresses, hormonal support for the endometrium is withdrawn. The endometrium becomes thinner, foci of necrosis appear and these coalesce. There is spasm of the spiral arteries due to the prostoglandins. Necrosis of the walls of the spiral arteries occurs leading to spotty hemorrhages that becomes confluent and produce the menstrual flow.



The menstrual blood contains tissue debris, prostaglandins and fibrinolysin that lyses the clots.

Control of Ovarian function

During the early part of follicular phase, FSH is elevated. At 36-48 hrs before ovulation the estrogen feedback effect becomes positive and initiates the burst of LH secretion that produces ovulation. During the follicular phase the estrogens are increased and during the luteal phase the progresterone levels are increased.

II) FUNCTIONS OF THE OVARIAN HORMONES

Estrogens

1. The size of the uterus and the external genitalia is increased. Estrogens facilitate the growth of the ovarian follicles and increase the motility of the uterine tubes.
2. Estrogens causes the development of the stromal tissues, growth of the ductile system, fat deposition in the breasts.
3. Estrogens increase the osteoblastic activity in the bones.
4. They cause increase in the total body protein.
5. Estrogens cause the skin to develop a texture that is soft and smooth.
6. They also cause sodium and water retention.

Progesterone

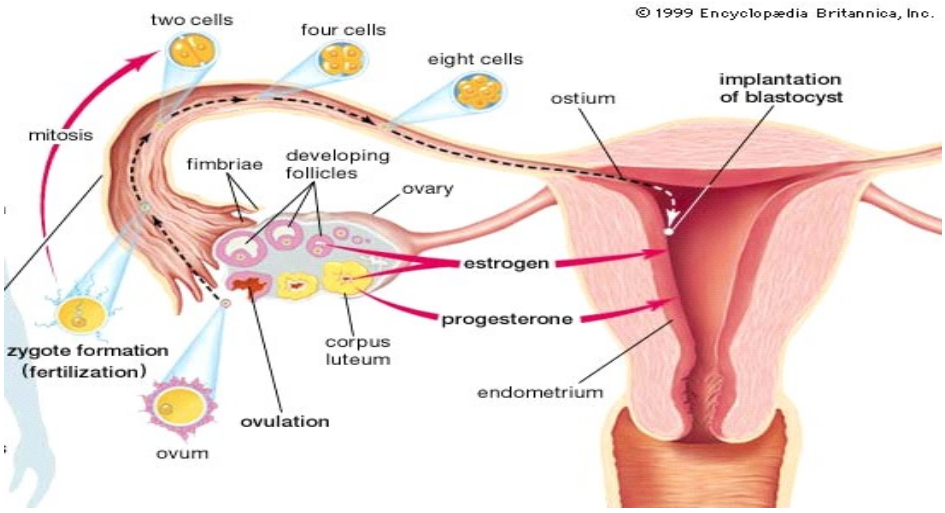
1. Progesterone promotes the secretory changes in the uterine endometrium and increases the secretion by the mucosal lining of the fallopian tubes.
2. Progesterone promotes the development of the lobules and alveoli of the breasts, causing the alveolar cells to proliferate, enlarge and become secretory in nature.

   Puberty means the onset of adult sexual life and menarche means the beginning of the cycles of menstruation. At the age of 40 – 50 years, the sexual cycles become irregular and ovulation fails to occur during many of the cycles. This period during which the cycles cease and the female sex hormones diminish is called menopause.

III) PREGNANCY

In humans, fertilization of the ovum by the sperm occurs in the mid portion of the uterine tube. The enzyme acrosin produced by the sperm facilitates the penetration of the sperm through the zona pellucida of the ovum.

The developing embryo, now called a blastocyst moves down the tube into the uterus. Once in contact with the endometrium the blastocyst becomes surrounded by an outer layer of syncytiotrophoblast. The syncytiotrophoblast erodes the endometrium and the blastocyst burrows into it and this process is implantation. The placenta then develops and the trophoblast remains associated with it.



Edocrine changes

The enlarged corpus luteum of pregnancy secretes estrogens, progesterone, relaxin. The relaxin helps to maintain pregnancy by inhibiting myometrial contractions. Placenta secretes human chorionic gonadotropin (hCG); human chorionic somato mammotropin (hCS) ; progesterone and estrogens.

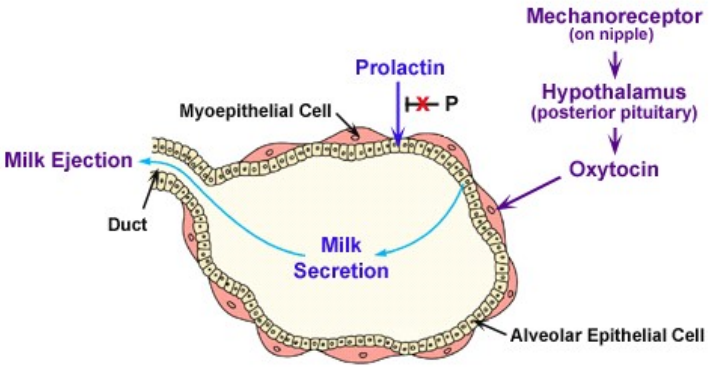
IV) PARTURITION

In humans the duration of pregnancy averages 270 days from fertilization. There is increase in ACTH secretion in the fetus with a consequent increase in secretion of the androgens from the fetal adrenal cortex. These androgens are converted into estrogens which will cause increase in the prostaglandins which initiate contractions. Progesterone that has a quieting effect on the uterine smooth muscle decreases at the onset of the labor.

Estrogens also increases the number of oxytocin receptors in the uterus. Oxytocin also increases the uterine contractions. During labor, spinal reflexes and voluntary contractions of the abdominal muscles (bearing down) also aid in delivery.

V) LACTATION

Development of the breasts **:** Many hormones are necessary for full mammary development. Estrogens are responsible for proliferation of the mammary ducts and progesterone for the development of the lobules. During pregnancy prolactin levels increase steadily until term and under the influence of this hormone plus the high levels of estrogens and progesterone, full lobuloalveolar development of the breasts takes place.



Alveolus of Mammary Gland

Secretion and ejection of milk : In estrogen and progesterone primed breasts, prolactin causes the formation of milk droplets and their secretion into the ducts. Oxytocin causes contraction of the myoepithelial cells lining the duct walls with consequent ejection of the milk through the nipple. After expulsion of the placenta at partutrition, there is an abrupt decline in circulating estrogens and progesterone. The drop in circulating estrogen initiates lactation.

Effect of lactation on menstrual cycles : Women who do not nurse their infants usually have their first menstrual period 6 weeks after delivery. However, women who nurse regularly have amenorrhea for 25 – 30 weeks. Nursing stimulates prolactin secretion which inhibits GnRH secretion. Ovulation is inhibited and the ovaries are inactive during the period of nursing the baby.

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Describe the functions of Testosterone and other harmonses in the male reproductive system?
2. Describe in detail the menstrual cycle?

Short Notes: (3 X 5 = 15)

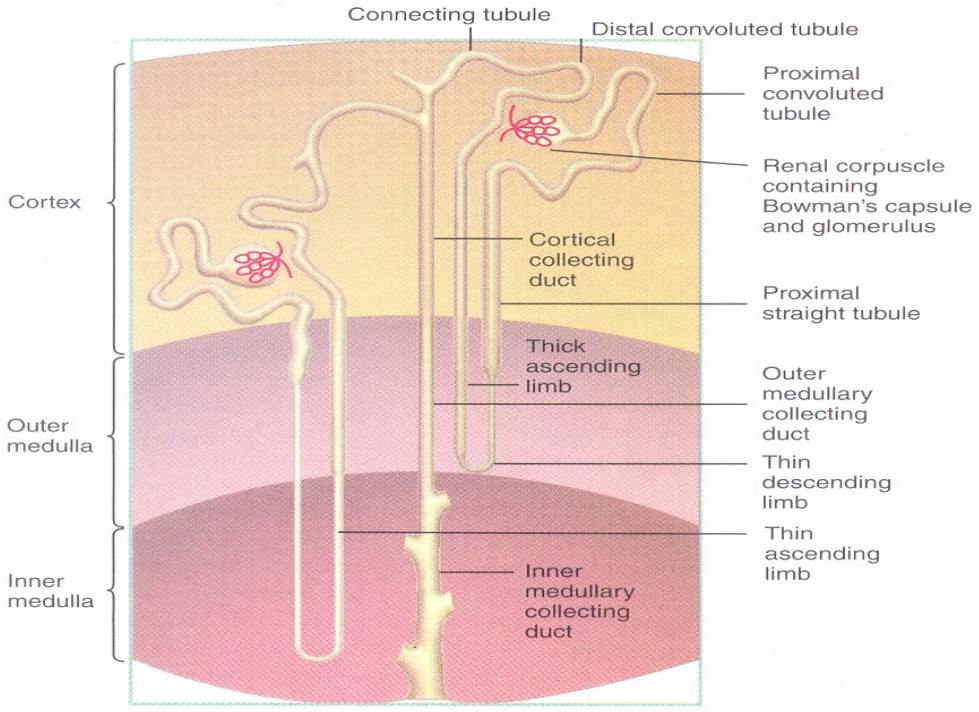
1. Spermatogenesis
2. Ovarian cycle
3. Lactation

P.1.7 EXCRETORY SYSTEM

In the kidneys a fluid that resembles plasma is filtered through the glomerular capillaries into renal tubules known as glomerular filtration. As this glomerular filtrate passes down the tubules, there is reabsorption of water and solutes by the processes of tubular reabsorption. There is secretion of tubular fluid known as tubular secretion to form urine that enters the renal pelvis. From the renal pelvis the urine passes to the urinary bladder and is expelled to the exterior by the process of micturition.

1.7.1 FUNCTIONAL ANATOMY

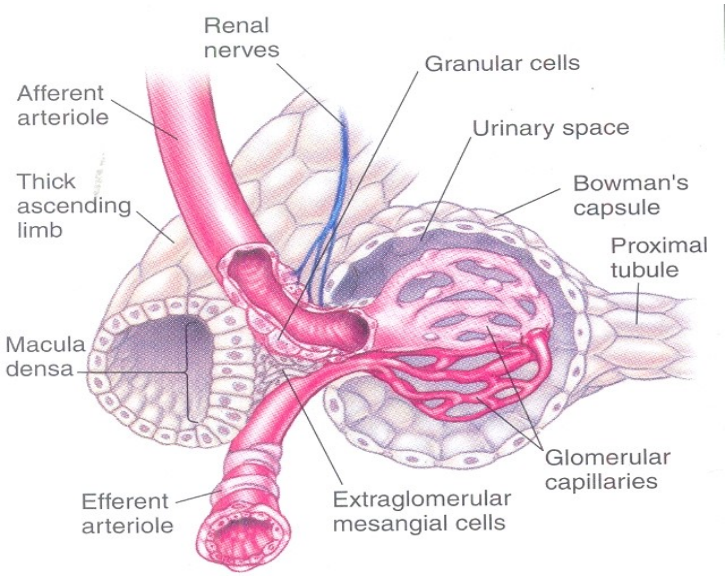
Each individual renal tubule and its glomerulus is a unit called as nephron. There are approximately 1.3 million nephrons in each human kidney. The glomerulus is 200 µm in diameter and is formed by the invagination of a tuft of capillaries into the dilated, blind end of the nephron known as Bowman's capsule. The capillaries are supplied by an afferent arteriole and drained by efferent arteriole.



The glomerular membrane permits free passage of neutral substances up to 4 nm diameter and excludes the substances greater than 8 nm. Fluid filtered from glomerular capillaries flows in to Bowman's capsule and then into the proximal tubule which lies in the cortex of the kidney. The fluid then passes in to the loop of Henle which has a descending and ascending limb. The walls of descending and lower part of ascending limb are thin and is called as thin segment of loop of Henle. Remaining part of the ascending limb has a thick wall is called on thick segment of ascending limb.

Cortical nephrons are the nephrons with glomeruli in outer portions of the renal cortex having short loops of Henle and juxta medullary nephron are those with glomeruli in juxta medullary region of cortex and have long loops of Henle.

The thick ascending limb of loop of Henle reaches the glomerulus of the nephron from which the tubule arose and passes close to its afferent and efferent arteriole. At this point the tubular epithelium is modified histologically to form the macula densa. The juxta glomerular cells, maculadensa, lacis cells near them are collectively known as juxta glomerular apparatus.



The fluid next passes into distal convoluted tubule and then into the collecting ducts which is made up of principal or p cells and intercalated or I cells.

1.7.2 FORMATION OF URINE

1) Glomerular filtration

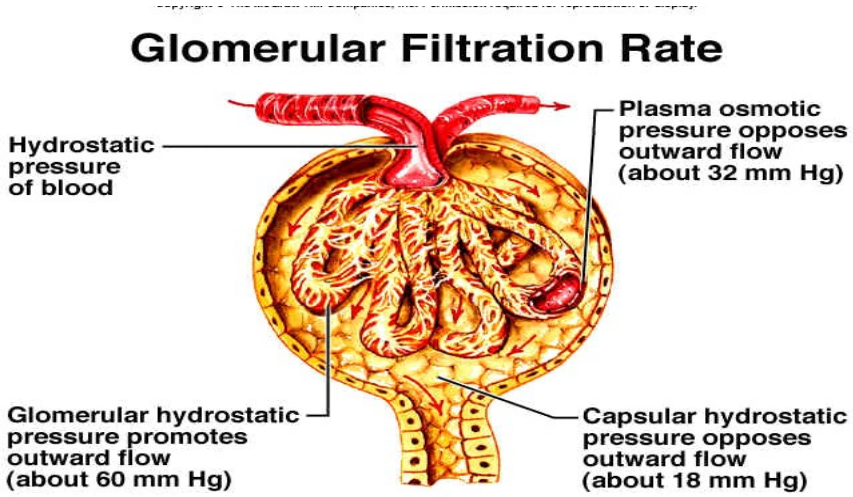
Urine formation begins with filtration of large amounts of fluid through the glomerular capillaries into Bowman's capsule. It gets filtered through the glomerular capillary membrane which has 3 layers.

a. Endothelium of the capillary which has pores called as Fenestrae through which the substances are filtered.

b. Basement membrane consists of collagen and proteoglycan fibrillae that have large spaces through which can filter large amounts of water and small solutes. It has negative electrical charges which will not allow positively charged substances to filter.

c. Epithelial cells that line the outer surface of the glomerulus. These cells also have slit pores through which the glomerular filtrate moves.

The total Glomerular filtration rate (GFR) for both the kidneys is 125 ml/min or 180 L/day. Insulin is the substance used to measure GFR.



Determinants of Glomerular Filtration Rate

Forces favoring filtration (mmHg)

Glomerular hydrostatic pressure – 60

Bowman's capsule colloid osmotic pressure – 0

Forces opposing filtration (mmHg)

Bowman's capsule hydrostatic pressure 18

Glomerular Capillary Colloid motic Pressure 32

So the net filtration pressure = 60-18-32 = +10 mm Hg

Auto regulation of Glomerular Filtration Rate

The auto regulatory mechanisms of the kidney prevent potentially large changes in GFR and renal excretion of water and solutes that would otherwise occur with changes in blood pressure.

(1) Tubuloglomerular feedback mechanism

The changes in sodium ion concentration in macula densa, controls the renal arteriolar resistance and thus helps in auto regulation.

(2) Myogenic mechanism

Stretch of the vascular wall allows increased movement of calcium ions from the extra cellular fluid into the cells causing them to contract. This contraction raises the vascular resistance and prevents excessive increase in renal blood flow and Glomerular Filtration Rate when arterial pressure increases.

2) Tubular reabsorption and secretion

As the glomerular filtrate enters the renal tubules, some substances are selectively reabsorbed from the tubules back into the blood whereas others are secreted from blood into the tubular lumen.

Proximal tubule

Substances reabsorbed: Sodium, potassium, calcium, bicarbonate phosphate, citrate, lactate, water, vitamins, urea, glucose, amino acids, proteins.

Substances secreted: Bile salts, oxalate, water, catecholamines, penicillin, salicylates.

Loop of Henle

Descending limb

Reabsorption of water, urea, sodium occurs in this part of the nephron.

Ascending limb

This part of nephron is impermeable to water. Reabsorption of sodium, chloride, potassium, calcium, bicarbonate, magnesium occurs.

Distal tubule

The early part of distal tubule reabsorbs sodium, potassium and chloride. Water reabsorption occurs with the presence of Antidiuretic hormone (ADH).

Late distal tubule and cortical collecting tubule

Anatomically they consist of principal cells and the intercalated cells. The principal cells reabsorb sodium and secretes potassium. The intercalated cells secrets hydrogen and reabsorb bicarbonate and potassium. The permeability of this part of the nephron to water is controlled by ADH.

Medullary Collecting duct

The permeability of the medullary collecting duct to water is controlled by the level of ADH. Urea is reabsorbed and hydrogen ions are secreted.

Hormones that regulate tubular function

Hormone	Site of Action	Effects
(1) Aldosterone	Collecting tubule	Increase Nacl, H_2O re absorption
(2) Angiotensin II	Proximal tubule	Increase K^+ Secretion
(3) Anti diuretic hormone	Thick ascending loop of Henle, Distal tubule	Increase Nacl, H_2O re absorption
(4) Atrial Natriuretic Peptide	Distal tubule	Increase H^+ Secretion
(5) Parathyroid hormone	Collecting tubule & collecting duct	Increase in H_2O reabsorption
	Distal tubule	Decrease in Nacl reabsorption
	Collecting tubule & collecting duct	Decrease in Phosphate reabsorption
	Proximal tubule, thick ascending loop of Henle, distal tubule.	Increase in Calcium re absorption

Use of clearance methods

Renal clearance of a substance is the volume of plasma that is completely cleared of the substance by the kidneys per unit time. Inulin clearance is used to determine GFR and para amino hippuric acid (PAH) clearance is used to estimate the renal plasma flow.

RENAL MECHANISMS FOR EXCRETING A DILUTE URINE

When there is a large excess of water in the body, the kidney can excrete dilute urine with a concentration on low as 50 mOsm/L. When the fluid flows through the proximal tubule, solute and water are reabsorbed in equal proportions, so little change in osmolarity occurs. In the loop of Henle only solutes are reabsorbed and so the tubular fluid becomes more dilute. When vasopressin is absent, the collecting duct epithelium is relatively impermeable to water. The failure to reabsorb water and the continued reabsorption of solutes lead to a large volume of dilute urine.

Mechanism of formation of concentrated urine

The concentrating mechanism depends upon the maintenance of a gradient of increasing osmolality along the medullary pyramids. This gradient is produced by the operation of the loop of Henle as counter current multiplier and maintained by the operation of vasarecta as counter current exchanger. High level of ADH increases the permeability of the distal tubules and collecting ducts to water allowing these tubular segments to avidly reabsorb water.

High osmolarity of the renal medullary interstitial fluid which provides the osmotic gradient necessary for water reabsorption to occur in the presence of high levels of ADH. The factors that contribute to the build up of solute concentration into the renal medulla which increases the osmolarity of the medulla are

- Active transport of sodium ions and co-transport of potassium , chloride and other ions out of thick ascending limb of loop of Henle and collecting duct.
- Passive diffusion of large amounts of urea from inner medullary collecting ducts.

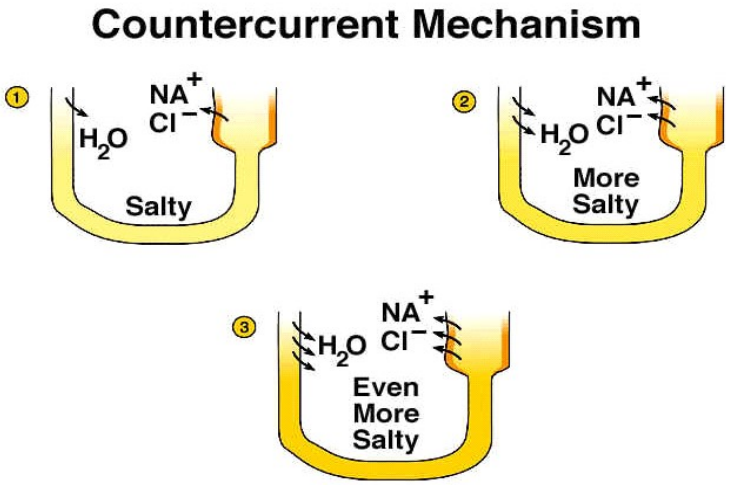
Steps involved in causing hyper osmotic renal medullary interstitium.

Step 1: Loop of Henle is filled with fluid of 300 mOsm/L

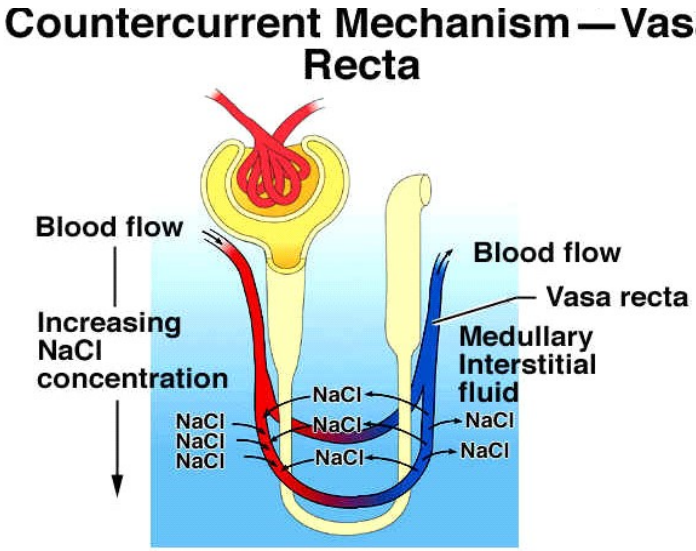
Step 2: Reabsorption of solutes from the thick ascending limb of loop of Henle reduces the Osmolarity to 200 m0sm/L

Step 3: Tubular fluid in the descending limb of the loop of Henle and interstitial fluid reach osmotic equilibrium. The interstitial osmolarity is maintained at 400 m0sm/L.

Step 4: When additional fluid flows into loop of Henle from the proximal tubule, the fluid from the descending limb which has the osmolarity of 400 m0sm/L flows into the ascending limb. Here the ions are pumped into the interstitium with water remaining behind until a 200 mosm/L osmotic gradient is established.



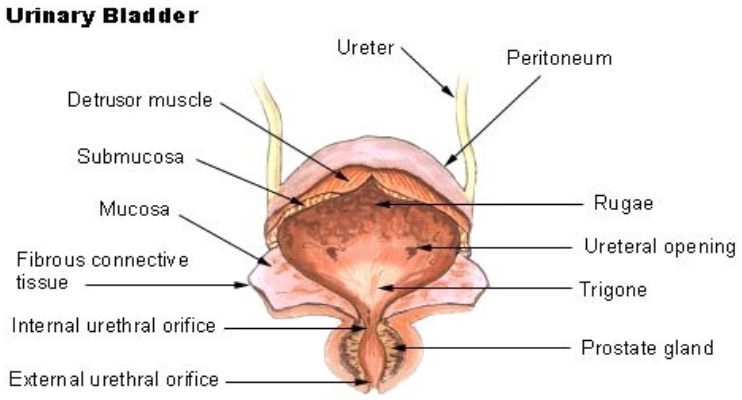
Thus the repetitive reabsorption of sodium chloride from the proximal tubule into the loop of Henle is called the counter current multiplier.



Counter current exchange in the vasarecta preserves hyperosmolarity of the renal medulla. As blood descends down and enters the medulla it becomes more concentrated partly by solute entry from the interstitium and partly by loss of water into the interstitium. As blood ascends back toward the cortex, it becomes progressively less concentrated as solutes diffuse back out into the medullary interstitium and water moves into the vasarecta. Thus vasarecta serves as counter current exchanger minimizing washout of solutes from the medullary interstitium.

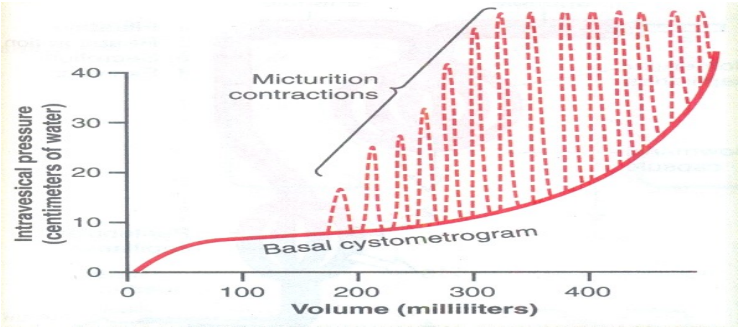
The medullary blood flow is low and this sluggish blood flow helps to minimize solute loss from the medullary interstitium. Thus vasarecta functions as counter current exchanger.

MICTURITION



Micturition is the process by which the urinary bladder empties when it becomes filled. Urine flowing from the collecting ducts into the renal calices stretches the calices and initiates peristalitic contractions that spread to the renal pelvis thereby forcing urine from the renal pelvis toward the bladder. The change in the volume of the bladder and the intravesical pressure change can be plotted and is known as cystometrogram. When there is no urine in the bladder, the intravesicular pressure is 0 but by the time 30 to 50 ml of urine has collected; the pressure rises to 5 to 10 cm of water. Next 200 – 300 ml can collect with only a small additional rise in pressure. This constant level of pressure is caused by intrinsic tone of the bladder wall itself. Beyond 300 – 400 ml, collection of more urine in the bladder causes the pressure to rise rapidly.

Superimposed on the tonic pressure changes during filling of the bladder are periodic acute increases in pressure. These pressure peaks are called micturition waves.



Micturition reflex

When the bladder is only partially filled, the micturition contractions usually relax spontaneously after a fraction of a minute. Thus the micturition reflex is a complete cycle of progressive and rapid increase of pressure followed by a period of sustained pressure and then return of the pressure to the basal tone of the bladder. Once the micturition reflex becomes powerful enough, it causes another reflex which passes through the pudendal nerves to external sphincter and inhibits it. If this inhibition is more potent in the brain then urination occurs.

The higher centers keep the micturition reflex partially inhibited except when micturition is desired. When it is time to urinate, the cortical centers can facilitate the sacral micturition centers to help initiate a micturition reflex and so urination can occur.

Abnormalities of micturition

(1) Atonic bladder: It is caused due to the destruction of the sensory nerve due to the crush injury to the sacral region of the spinal cord or certain diseases. Here, instead of emptying periodically, the bladder fills to capacity and overflows a few drops at a time through the urethra. This is called overflow incontinence.

(2) Uninhibited Neurogenic bladder: It results in frequent and uncontrolled micturition. This condition derives from partial damage in the spinal cord

or brainstem that interrupts the inhibitory signals. So the facilitatory impulses pass continuously and so even small quantity of urine will elicit uncontrollable micturition.

ACID BASE BALANCE

Precise hydrogen ion regulation is essential for almost all enzyme systems in the body. Changes in hydrogen concentration alter virtually all cell and body functions. So regulation of acid base balance is very essential. There are three primary systems that regulate the hydrogen ion concentration in the body fluids.

(i) The chemical acid base buffer systems of the body fluids

They immediately combine with acid or base to prevent excessive changes in hydrogen ion concentration. A buffer is a substance that can reversibly bind hydrogen ions.

a. The bicarbonate buffer system : When a strong acid such as Hcl is added to the bicarbonate buffer solution, the increased hydrogen ions released from the acid are buffered by HCO_3^-.

$$\uparrow H^+ \longrightarrow HCO_3^- \longrightarrow H_2CO_3 \longrightarrow CO_2 + H_20$$

The CO_2 is eliminated from the lungs. When a strong base is added to the bicarbonate it is buffered.

$$NaOH + H_2CO_3 \longrightarrow NaHCO_3 + H_2O$$

Thus the weak base $NaHCO_3$ replaces the strong base NaoH.

b. The phosphate buffer system : When a strong acid is added it is accepted by the phosphate buffer and a weak acid is formed and the decrease in pH is minimized.

$$Hcl + Na_2HPO_4 \longrightarrow NaH_2PO_4 + Nacl$$

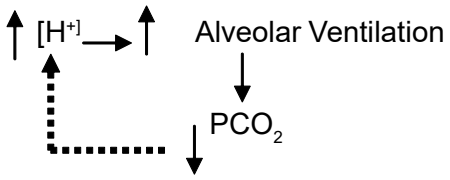
A strong base is converted into a weak base Na_2HPO_4 causing only a slight increase in pH.

$$NaOH + NaH_2PO_4 \longrightarrow Na_2H\,PO_4 + H_2O$$

c. Proteins : Intracellular proteins like hemoglobin acts as a buffer.

(i) Respiratory regulation of acid base balance : If the rate of metabolic formation of CO_2 increases the H_2CO_3 concentration and hydrogen ion concentration increases, thus lowering the extracellular pH. The CO_2 level stimulates the pulmonary ventilation and CO_2 is blown off from the lungs and PCO_2 in the extracellular fluid decreases.

Because increase hydrogen ion concentration stimulates respiration and because increased alveolar ventilation decreases the hydrogen ion concentration, the respiratory system acts as a typical negative feedback controller of hydrogen ion concentration.



(c) Renal control of acid base balance : The kidneys regulate extracellular fluid hydrogen ion concentration through three fundamental mechanisms.

(i) Secretion of hydrogen ions : Hydrogen ions are secreted by proximal tubule, ascending limb of loop of Henle and the distal tubule by secondary active transport mechanism (sodium – hydrogen counter transport). In the late distal tubules and the collecting ducts the hydrogen ion is secreted by primary active transport mechanism

(ii) Reabsorption of filtered bicarbonate ions : The bicarbonate ions combine with hydrogen ions to form H_2CO_3 which eventually becomes CO_2 & H_2O. CO_2 moves across the tubular membrane and recombines with H_2O to generate H_2CO_3. Thus each time a hydrogen ion is formed in the tubular epithelial cells, a bicarbonate ion is also formed and released back into the blood.

(iii) Production of new bicarbonate ions : Whenever hydrogen ion secreted combines with a buffer other than bicarbonate, the net effect is addition of a new bicarbonate ion to the blood. Hydrogen ion can combine with the phosphate

buffer system. After hydrogen ion combines with phosphate it can be excreted as a sodium salt (NaH_2PO_4) carrying with it the excess hydrogen.

Ammonium ion is synthesized from glutamine which is actively transported into the epithelial cells. Inside the cell each molecule of glutamine is metabolized to form two NH_4^+ and two HCO_3^- ions. NH_4^+ is secreted into the tubular lumen and HCO_3^- moves across the basolateral membrane along with the reabsorbed sodium ion. Thus for each molecule of glutamine metabolized, two new HCO_3^- ions are generated.

In the collecting tubule the hydrogen ion secreted into the lumen, combines with ammonia to form NH_4^+ which is then excreted. For each NH_4^+ excreted a new HCO_3^- is generated and added to the blood.

Disorders of acid base balance

A rise in arterial PCO_2 due to decreased ventilation causes respiratory acidosis and a decline in PCO_2 causes respiratory alkalosis.

When strong acids are added to blood metabolic acidosis is produced and when the free H^+ level falls as a result of addition of alkali or removal of acid, metabolic alkalosis results.

REVIEW QUESTION

Long Essays Questions: (3 X 15 = 45)

1. Describe in detail the mechanism of formation of urine.
2. Describe in detail the counter current mechanism.

Short Notes: (3 X 5 = 15)

1. Hormones regulating tubular function
2. Cystometrogram
3. Abnormalities of urinary bladder
4. Renal regulation of acid base balance

P.1.8 ENDOCRINE GLANDS

Endocrinology is defined as a discipline concerned with the "internal secretions of the body". The hormones are chemical substances liberated by specific types of cells, carried by the blood stream to act on distant target cells. The word hormone was derived from the Greek word "Hormaein" meaning "to excite" (or) "to arouse". They fall into three classes,

1. Amines – eg. thyroid hormones, catecholamines
2. Proteins (or) peptides – eg. parathyroid hormone and growth hormone
3. Steroids – eg. adrenocortical and reproductive gland hormones

1.8.1 THE PITUITARY GLAND

It plays a central role in hormonal regulation of a wide variety of processes and most extremely studied. Its function is largely controlled by hypothalamus. It consists of,

(1) Anterior lobe: secretes growth hormone (GH), thyroid stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), luteinizing hormone (LH), follicle stimulating hormone (FSH) and prolactin (PRL).

(2) Intermediate lobe: secretes melanotropins.

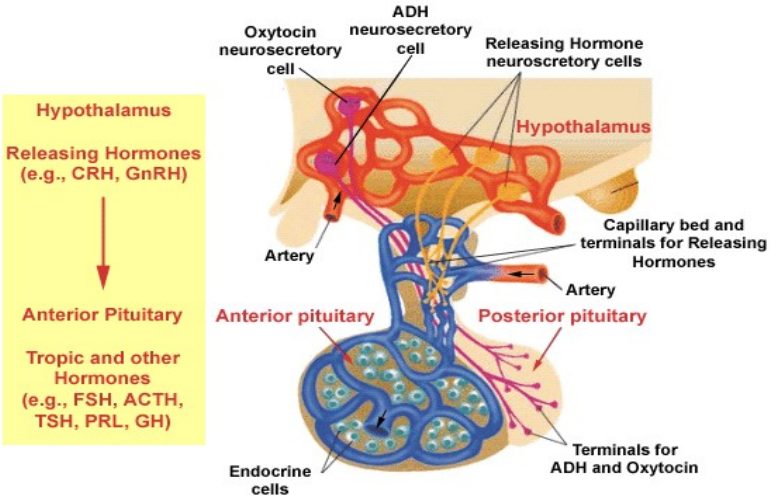
(3) Posterior lobe: secretes oxytocin and vasopressin. The pituitary gland is connected to the hypothalamus by a thin segment of tissue known as the pituitary stalk. In humans, the intermediate lobe is rudimentary.

ANTERIOR PITUITARY

Five cell types in anterior pituitary

1. Somatotropes - GH
2. Corticotropes - ACTH
3. Thyrotropes - TSH
4. Lactotropes - PRL
5. Gonadotropes - LH & FSH

STRUCTURE OF PITUITARY GLAND



GROWTH HORMONE

It is a peptide hormone of 191 amino acids. Its secretion is under the dual control of somatostatin and growth hormone releasing hormone. The most consistent period of GH secretion occurs about one hour after the onset of deep sleep.

Effects of Growth Hormone

It is an anabolic hormone.

1. It stimulates the linear growth of the skeleton
2. It directly stimulates the uptake of amino acids into the muscles.
3. It stimulates liver protein and RNA synthesis
4. In adipose tissue, Growth Hormone decreases the glucose uptake
5. It stimulates break down of fat stores.
6. It decreases glucose uptake into the muscle and increases gluconeogenesis in the liver.

Growth Hormone stimulates the production of somatomedin from the liver. The two important somatomedins are

1. Insulin – like growth factor I (IGF – I)
2. Insulin – like growth factor II (IGF – II)

Dwarfism

- Dwarfism may be due to Growth Hormone deficiency or GHRH deficiency.
- Some have abnormalities of Growth Hormone - secreting cells.
- Laron dwarfism – It is due to abnormality of Growth Hormone receptors.
- In African pygmies, the plasma IGF – I concentration fails to increase at the time of puberty.
- Dwarfism is also seen in precocious puberty and cretinism.

The tumours of somatotropes secreting large amounts of GH leading in children to gigantism and in adults to acromegaly.

ADRENOCORTICOTROPIC HORMONE

It is a polypeptide hormone. Its secretion exhibits circadian rhythms, cyclic bursts and feedback control. Adrenocorticotropic hormone (ACTH) secretion has a diurnal pattern. A large peak occurs 2 – 4 hours before awakening. The basal concentration is 20 – 100 pg/ml.

Action of Adrenocorticotropic hormone (ACTH)

1. It stimulates the growth of specific zones of adrenal cortex and secretion of cortisol.
2. It increases the size of the adrenal cells.
3. It may have neuromodulatory and paracrine functions in brain and GIT.
4. It increases skin pigmentation.

THYROID STIMULATING HORMONE

It is a glycoprotein hormone. It has a molecular weight of 28,000. It has α and β subunits. The β subunit confers the specific biological activity. The secretion of Thyroid Stimulating Hormone is regulated by 2 major factors. Thyrotrophin Releasing Hormone (TRH) increases the rate of secretion and thyroid hormone decreases the rate of secretion by negative feedback.

The circulating TSH level in plasma is 0.3 to 5 μU/ml.

Factors affecting Thyroid Stimulating Hormone secretion

1. Fasting 2. Exposure to cold

Actions of Thyroid Stimulating Hormone

The action of TSH is to promote growth and differentiation of the gland and stimulates all steps involved in thyroid hormone synthesis.

PROLACTIN

It is a protein hormone concerned with stimulating breast development and milk production. Prolactin (PRL) is a single chain protein of molecular weight 23,000. The secretion of PRL is consistent with its role in lactation. The first peak appears 60-90 min after the onset of slow-wave sleep. The dopamine from hypothalamus constantly inhibits PRL release. The normal basal concentration of PRL is 10 ng/ml. Daily production is 350 µg.

Actions of Prolactin (PRL)

1. It stimulates the development of breast tissue and its hyperplasia during pregnancy.
2. It is the principle hormone responsible for lactogenesis.
3. Excess PRL blocks the synthesis and release of gonadotropin - releasing hormone.

GONADOTROPIC HORMONES (LH, FSH)

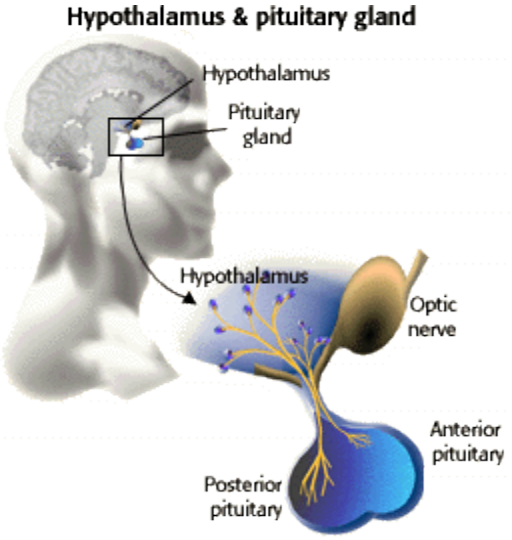
They are glycoproteins. Molecular weight of LH is 28,000. Molecular weight of FSH is 33,000. Each is composed of the common α subunit and a unique β subunit. Both the secretions are stimulated mainly by a single hypothalamic hormone called gonadotropin releasing hormone. Both LH and FSH both circulate unbound to plasma proteins. The average concentration of both hormones are in the range of 4-20 m IU/ml in men and in women.

Actions of gonadotropins

1. FSH stimulates ovarian granulosa cells and testicular sertoli cells to synthesize and secrete estradiol.
2. LH stimulates ovarian thecal cells and testicular Leydig cells to secrete testosterone and other products.

POSTERIOR PITUITARY

It secretes antidiuretic hormone (ADH) and oxytocin.



1. ANTIDIURETIC HORMONE

It is a polypeptide.

*Actions of A*nti Diuretic Hormone (*ADH)*

1. It increases the permeability of distal tubules and collecting ducts to water and decreases medullary blood flow.
2. It stimulates the increase of ACTH from anterior pituitary.

Applied Physiology

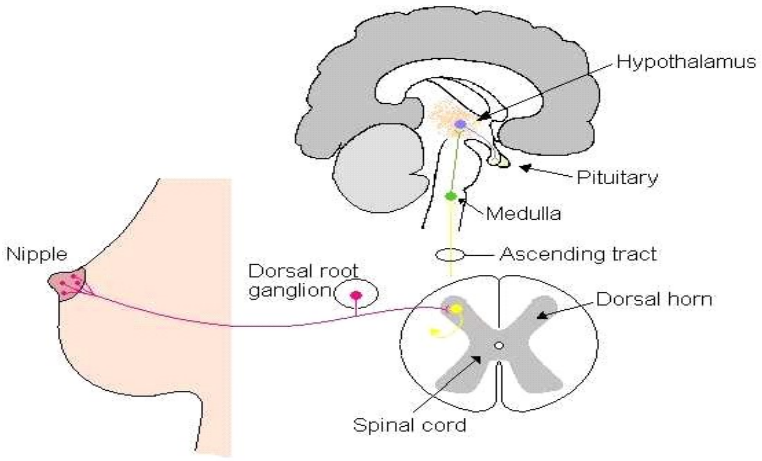
1. **Syndrome of inappropriate ADH secretion:** It is due to excessive secretion of antidiuretic hormone (ADH).
2. **Diabetes insipidus:** It is due to the complete or partial failure of ADH secretion.

2. Oxytocin: It is an octapeptide.

Actions of Oxytocin

1. It stimulates the contraction of the smooth muscle cells lining the ducts of mammary glands causing milk ejection.

Milk Ejection Reflex

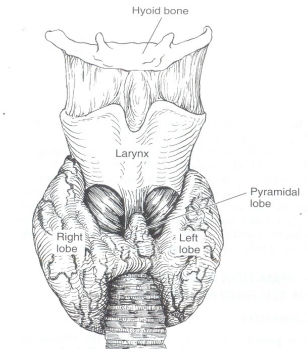


2. It stimulates the contraction of myometrium of uterus during partition.
3. It may facilitate the transport of sperm to the uterus by uterine contraction.

1.8.2 THYROID GLAND

It is the largest endocrine gland, weighing 15 – 25 gms and highly vascular. It is made up of acini lined by columnar epithelium when active and flat when inactive.

Structure of Thyroid Gland



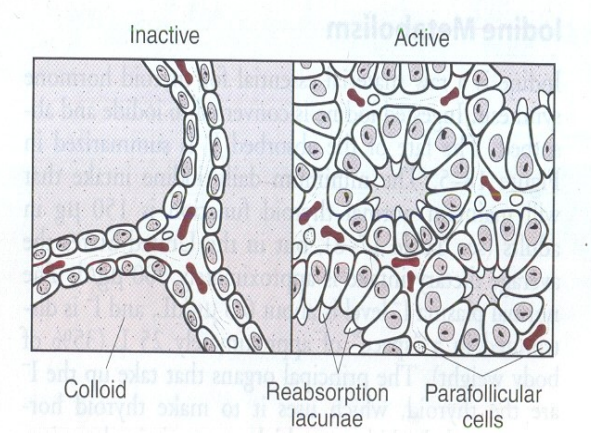
Thyroid hormones are

(i) Thyroxine (T_4)

(ii) Tri-iodo thyronine (T_3)

(iii) Calcitonin

Structure of Acini

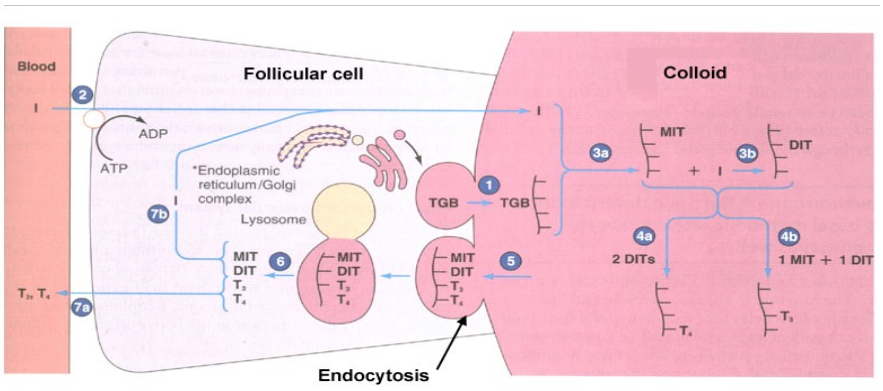


Formation and Secretion of Thyroid Hormones

Iodine is the raw material needed for thyroid hormone synthesis. Daily requirement of I_2 is 100 – 200 µgm. The RMP of thyroid cells is -50mV, therefore I^- is reabsorbed into the thyroid cells by iodide pump. I^- gets oxidized by thyroid peroxidase into I_2 in the colloid. I_2 gets bound to 3' position of tyrosine forming mono-iodo-tyrosine (MIT). It is next iodinated in 5' position to form di-iodo tyrosine (DIT).

DIT + DIT ⟶ Thyroxine (T_4). MIT + DIT ⟶ Tri-iodothyronine (T_3)

Formation of Thyroid hormones



Actions of Thyroid hormones

i) Calorigenic action: They stimulate heat production in the body. Basal metabolic rate is increased.

ii) Protein metabolism: When the Basal Metabolic Rate is increased by T_4 and T_3, nitrogen excretion is increased; if food intake is not increased, endogenous protein stores are catabolized.

iii) Large doses lead to extra heat production. Peripheral resistance decreases because of cutaneous vasodilation.

iv) Thyroid hormones are necessary for hepatic conversion of carotene to vitamin A.

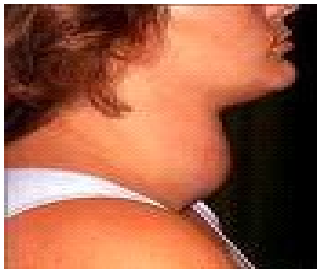
v) They increase the number and affinity of β – adrenergic receptors in the heart.

vi) They increase the rate of absorption of carbohydrates from Gastro Intestinal Tract and lower circulating cholesterol levels.

vii) They are essential for normal growth and skeletal maturation.

Applied Physiology

A. Goiter – Any enlargement of thyroid gland. Goitrogen – substances that cause thyroid enlargement.



B. Hypothyroidism – It is due to reduced circulating levels of T_4 and T_3.

1. Myxoedema 2. Cretinism

1. Myxoedema: It is hypothyroidism in adults characterized by swelling of skin and sub cutaneous tissues.

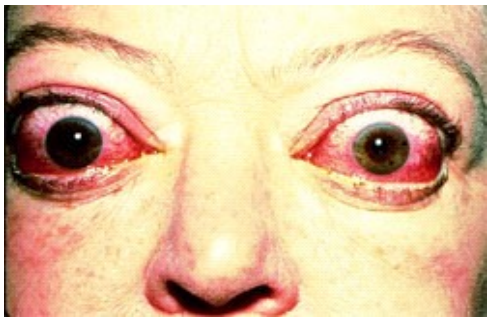
Features*:* Goiter, puffiness of face, ptosis, dry skin, low Basal Metabolic Rate, periorbital swelling.

2. Cretinism: It is hypothyroidism in children. It is due to maternal iodine deficiency.

Features ***:*** Gross mental retardation, dwarfism, stunted growth, protruded abdomen with enlarged tongue.

A. ***Hyperthyroidism:*** It is characterized by increased circulating levels of free T_4 and T_3. The commonest condition is

(1) Grave's disease*:* It is an autoimmune disorder.



Features: Exophthalmos, lid retraction, increased Basal Metabolic Rate, hypersensitive to heat, tachycardia, precipitates diabetes mellitus, tumors, irritability and nervousness.

1.8.3 PARATHYROID GLAND

In humans there are 4 parathyroid glands embedded in the thyroid gland on the posterior surface. It consists of chief cells secreting parathyroid hormone (PTH) and oxyphil cells. PTH is a polypeptide containing 84 aminoacids.

Actions of Para Thyroid Hormone

(i) ***On bones:*** It increases plasma ca^{2+} and decreases plasma phosphate by promoting bone resorption.

(ii) ***On kidneys:*** It decreases reabsorption of phosphate from Proximal Convoluted Tubule (PCT) and increases its excretion in Distal Convoluted Tubule (DCT) – phosphaturic action.

(iii) On Gastro Intestinal Tract: Decreased serum phosphate increases the production of 1,25– dihydroxycholecalciferol (1,25 – DHCC) which increases Ca^{2+} and phosphate absorption from Gastro Intestinal Tract.

(iv) On mammary glands: PTH decreases the amount of Ca^{2+} secreted into the milk.

Calcitonin is a Ca^{2+} lowering hormone. It is a 32 aminoacid polypeptide secreted from C- cells of the thyroid gland. Normal secretion – 0.5 mg/day.

Actions

- On bones: It exerts Ca^{2+} lowering effect by inhibiting bone resorption
- It inhibits Ca^{2+} permeability of osteoblasts and osteoclasts.
- It decreases the renal formation 1,25 - DHCC which decreases serum Ca^{2+} and phosphate.

Applied Physiology

A. Rickets: It is a disease characterized by bone deformities in young children.

Causes: Inadequate intake of vitamin D_3, liver dysfunction and kidney failure.

B. Hypoparathyroidism: The cause is removal of parathyroid glands. The resulting hypocalcemia increases the excitability of muscle and nerve resulting in tetany. It is characterized by neuromuscular hyperexcitability, facial irritability, carpopedal spasm.

1.8.4 THE ADRENAL CORTEX

There are two adrenal glands. It consists of outer adrenal cortex and inner adrenal medulla.

The adrenal cortex is divided into,

(i) Zona glomerulosa – mineralocorticoids

(ii) Zona fasciculata – glucocorticoids

(iii) Zona reticularis – sex steroids

Mineralocorticoids are aldosterone, deoxycorticosterone. Glucocorticoids are cortisol and corticosterone. Cholesterol is the precursor of all steroid hormones.

Actions of aldosterone

- It causes retention of sodium from the kidney and increased urinary excretion of potassium.
- It increases Na^+ reabsorption from Gastro Intestinal Tract, salivary and sweat glands.

APPLIED PHYSIOLOGY

A. Conn's Syndrome – It is due to the excessive secretion of aldosterone. It is characterized by,

- elevated plasma and urinary aldosterone levels.
- rise in plasma sodium and fall in potassium.
- prolonged hypokalemia with muscular weakness.

Actions of Cortisol

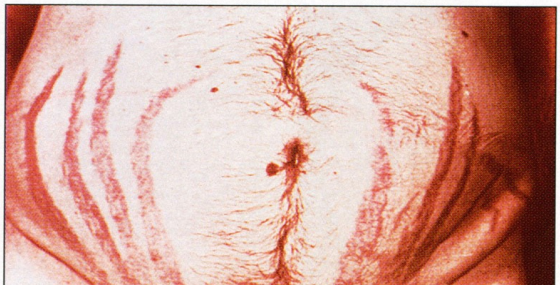
- It causes protein breakdown in muscles.
- It increases glucose formation in liver. It increases glycogen synthesis.
- It favours mobilization of fatty acids from adipose tissue.
- Permissive action: Small amounts of cortisol must be present for (i) glucagon and catecholamines to exert their calorigenic action (ii) catecholamines to exert their lipolytic effect.
- It increases gastric acid and pepsin secretion.
- It inhibits the inflammatory response to tissue injury.

APPLIED PHYSIOLOGY

B. Cushing's Syndrome*:* It is due to high blood levels of glucocorticoids.

Features are,

- Thinning of skin and subcutaneous tissue
- Muscles get wasted and poorly developed
- Poor wound healing and minor injuries produce bruises and ecchymoses.
- Negative nitrogen balance and retardation of growth
- Hyperglycemia precipitates diabetes mellitus
- Redistribution of fat
- Osteoporosis precipitates tetany
- Hirsutism
- Impotency and hypogonadism in males and amenorrhoea in females.



1.8.5 THE ADRENAL MEDULLA

It consists of densely innervated granules containing cells secreting epinephrine and norepinephrine.

Actions of catecholamines

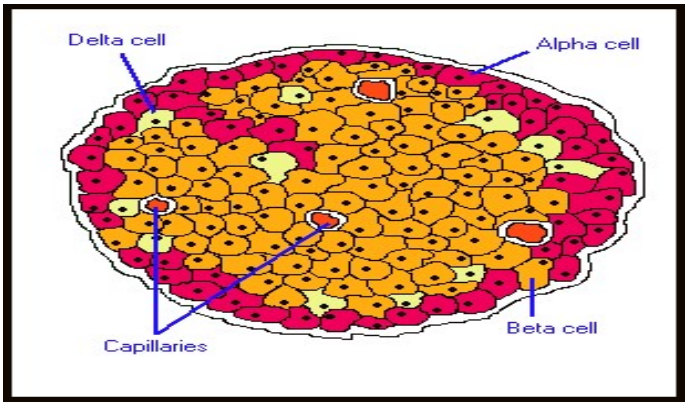
- They increase the heart rate and force of contraction of heart.
- They increase the secretion of insulin and glucagons via β receptors but inhibit the secretion via α receptors.
- They break down stored triglycerides to Free Fatty Acids (FFA) and glycerol.
- They increase the Basal Metabolic Rate. They produce anxiety, apprehension, hyperventilation and tremor of extremities.

1.8.6 ENDOCRINE PANCREAS

In between the masses of pancreatic acini, lie the islets of Langerhans which make up 3% of the volume of the gland. The cells are divided into,

1. α cells – glucagon
2. β cells – insulin
3. δ cells – Somatostatin
4. F cells – Pancreatic polypeptide

Islets of Langerhans



I) INSULIN

It is a polypeptide containing 2 chains of amino acids linked by 2 disulphide bridges.

Actions of insulin*:* They are divided into rapid, intermediate and delayed actions.

Rapid actions*:* Increased transport of glucose, amino acids and K^+ into insulin sensitive cells. Insulin promotes entry of glucose into all cells of the body except kidney, Gastro Intestinal Tract, brain and red blood cells.

Intermediate actions

- Increase in mRNAs for lipogenic and other enzymes.
- Inhibition of protein degradation
- Activation of glycogen synthase and glycolytic enzymes
- Inhibition of phosphorylase and gluconeogenic enzymes

Delayed actions: Increase in mRNAs for lipogenic and other enzymes

II) GLUCAGON

It is a linear polypeptide

a) Actions of glucagon

- Glycogenolysis in the liver
- Gluconeogenesis in the liver
- Increases the strength of the heart
- Increases bile secretion
- Inhibits gastric acid secretion

III) SOMATOSTATIN

It is a polypeptide containing 14 amino acids.

Actions

- It inhibits the secretion of insulin, glucagon and pancreatic polypeptide.
- It decreases the motility of the stomach, duodenum and gall bladder.
- It decreases the secretion and absorption in Gastro Intestinal Tract.

IV) Pancreatic polypeptide:It is a linear polypeptide of 36 aminoacids. Its secretion is increased by a meal containing protein and by fasting, exercise and acute hypoglycemia.

Applied Physiology

Diabetes mellitus: Insulin deficiency produces a clinical state called diabetes mellitus. It is characterized by hyperglycemia, glycosuria, polyuria, dehydration, polydipsia, polyphagia, loss of weight, ketonuria and poor resistance to infection.

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Describe in detail the hormones released and functions of anterior pituitary gland.
2. Describe in detail the hormones of adrenal cortex

Short Notes: (3 X 5 = 15)

1. Cushing's syndrome
2. Functions of oxytocin
3. Actions of thyroid hormones

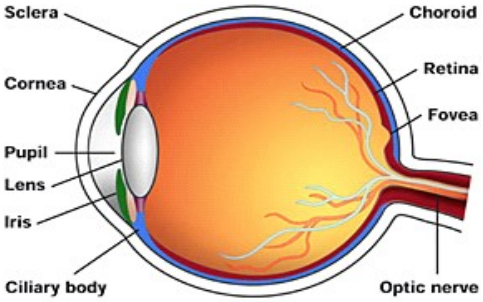
P.1.9 SPECIAL SENSES

Encephalization is a trend in which special sensory organs develop in the heads of animals along with the neural systems of the brain. These include the visual, auditory, olfactory and gustatory systems that allow the animal to detect and analyze light, sound and chemical signals in the environment.

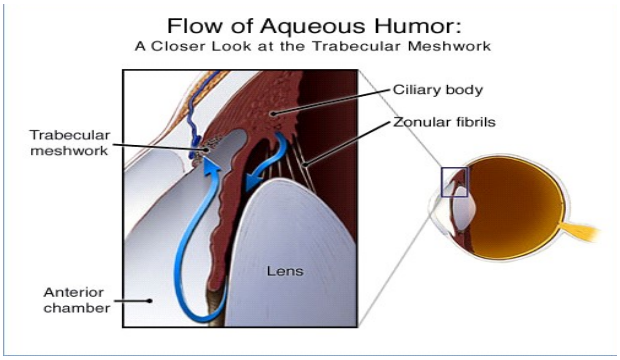
1.9.1 VISION

It is one of the most important special senses in humans. The eye is a rounded structure and is commonly called the eyeball which is housed in the eye orbit. The wall of the eye is composed of 3 concentric layers, namely sclera, choroid and retina.

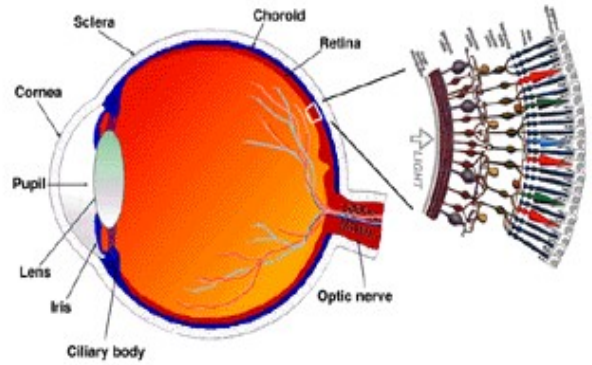
Structure of eye



The central part of the retina is responsible for more sharp vision and is called macula lutea. The fovea centralis is a pit like depression in the centre of the macula, where visual acuity is maximal. The functional part of the retina contains rods and cones and covers the entire posterior eye except for the blind spot. The eye contains a lens to focus light on the retina, pigment to reduce the light scatter and fluids called aqueous and vitreous humor. Aqueous humor is the principal determinant of the intraocular pressure. The normal pressure is 15 mm Hg. Chronically elevated intraocular pressure can give rise to glaucoma.



I) THE RETINA



It is a layered structure and begins with

- Pigment epithelium

(i) it absorbs stray light, reducing the light scatter.

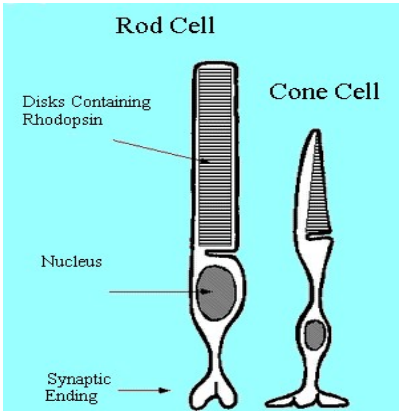
(ii) it serve a mechanical function in maintaining contact between layers 1 and 2

(iii) They phagocytose the ends of outer segments of rods.

- Photoreceptors (rods and cones)
- External limiting membrane
- Outer nuclear layer
- Outer plexiform layer
- Inner nuclear layer
- Inner plexiform layer
- Ganglion cell layer
- Optic fiber layer
- Inner limiting membrane

II) STRUCTURE OF RODS AND CONES

There are 6 million cones, 120 million rods in each eye and 1.2 million nerve fibers in each optic nerve. Each photoreceptor cell is composed of a cell body, an inner and an outer segment and a synaptic terminal. The outer segments of rods are longer than those of cones and contain stacks of freely floating membrane discs rich in rhodopsin molecules. It has the sensitivity to light at a wavelength of 505 nm.



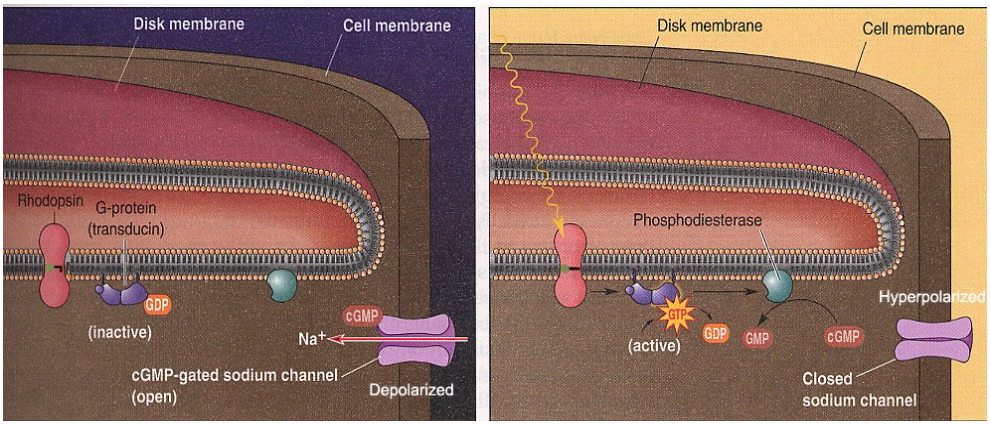
III) PHOTOCHEMISTRY OF VISION

In the dark, the retinene in rhodopsin is in 11-cis configuration. The action of light is to change the shape of the retinene, converting it to all-trans retinal. This causes bleaching of the visual pigment. The change in the opsin activates transducin, which binds with GTP. GTP activates cGMP phosphodiesterase which converts cGMP to 5'-GMP. cGMP normally acts directly on Na^+ channels to maintain them in the open position.

IV) VISUAL TRANSDUCTION

The transduction of visual signals involves hyperpolarization of rods and cones. In the dark, rods have open Na^+ channels in the outer segments. A net influx of Na^+ from inner to outer segments of the rods results in a dark current which maintains a constant state of depolarization (-40 mV). As a result of this glutamate is tonically released at rod synapses on bipolar and horizontal cells.

Visual transduction

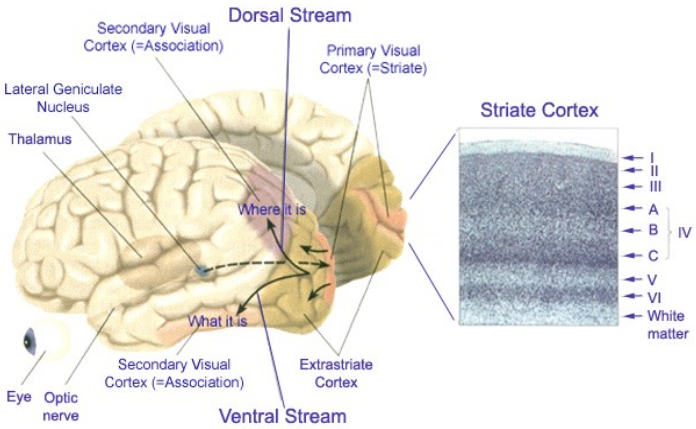


V) VISUAL PATHWAY

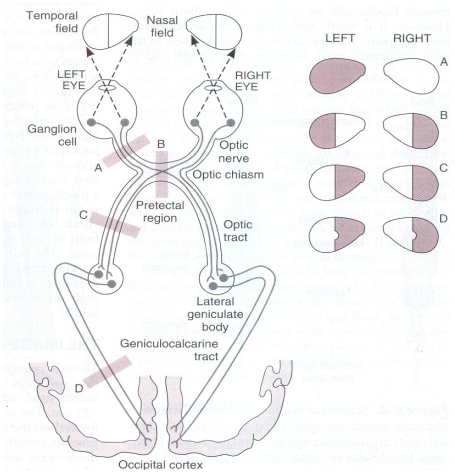
The retinal ganglion cells transmit information to the brain via optic nerve, optic chaisma and optic tract and then to lateral geniculate body (LGB). Each LGB contains six well defined layers. The first two layers contain large neurons are called magnocellular layers. Layers 3-6 have small neurons are called parvocellular layers. These 2 pathways project to primary visual cortex. The axons from LGB that form magnocellular pathway and parvo cellular pathways end in layer 4c of visual cortex.

1. Primary visual cortex (Brodmann's area 17)
2. Secondary or visual association areas (Broadmann's areas 18 & 19)

Structure of visual cortex



VI) OPTIC PATHWAY AND EFFECT OF LESIONS



A- Complete blindness

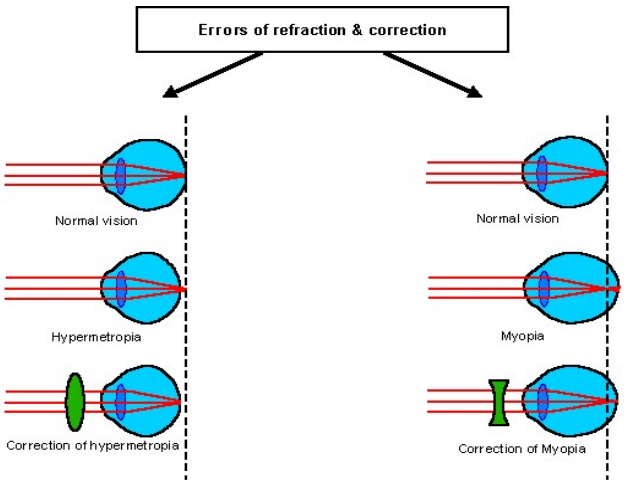
B- Bitemporal hemianopia

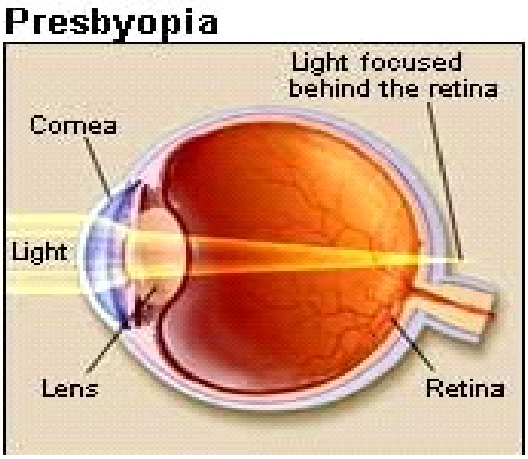
C- Right homonymous hemianopia

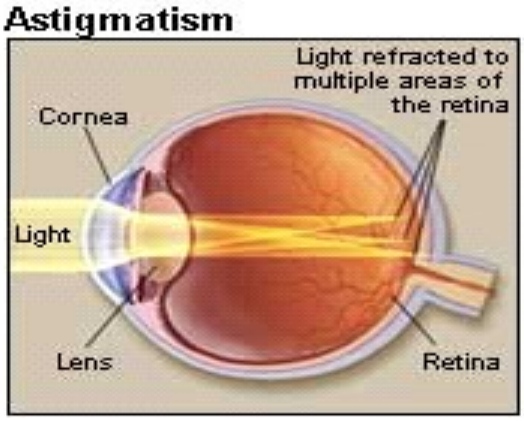
D- Right homonymous hemianopia with macular sparing

VII) REFRACTIVE ERRORS

- Myopia
- Hypermetropia
- Presbyopia
- Astigmatism

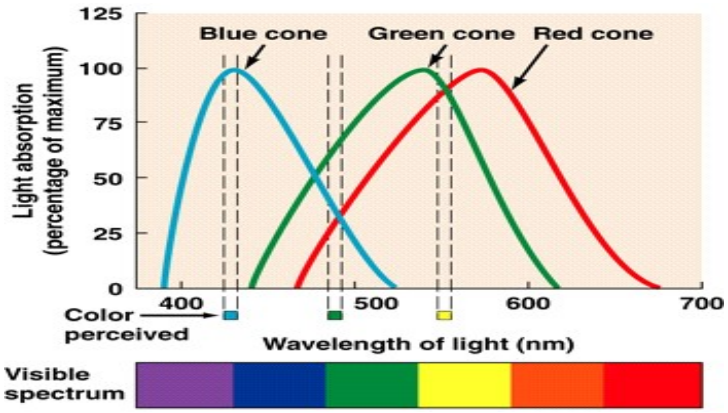






VIII) COLOUR VISION

The three visual pigments in cone outer segments have opsins that differ from the opsin found in rhodopsin. The cone pigments absorb best at 420 nm (blue), 531 nm (green) and 588 nm (red).



Colour blindness: Defects in colour vision may be genetic or acquired. They are classified in to 3 categories.

1. Trichromats : A normal person whose colour vision is based on 3 types of cones is called a trichromat.

(i) Protanomaly – deficiency of red cones

(ii) Deuteroanomaly – deficiency of green cones

(iii) Tritanomaly – deficiency of blue cones

2. Dichromats: They have only 2 types of cones in the retina.

(i) Protanopia – absence of red cones

(ii) Deuteroanopia – absence of green cones

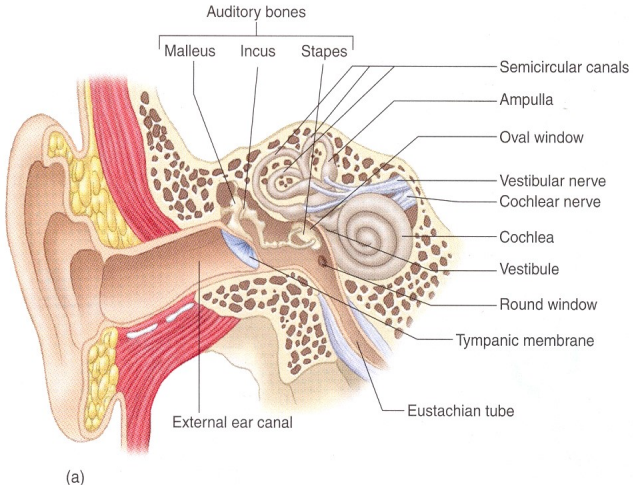
(iii) Tritanopia – absence of blue cones

3. Monochromats: They have only one type of cones. Such individuals are totally colour blind. Fortunately, this defect is very rare.

1.9.2 AUDITION

Receptors for two sensory modalities, hearing and equilibrium are present in the ear. The external ear, middle ear and the cochlea of the inner ear are concerned with hearing. Sound is produced by waves of compression and decompression. It propagates 344 m/sec in air and 1450 m/sec in fresh water and even greater in salt water.

Structure of ear



I. MECHANISM OF HEARING

A. Role of external ear

1. ***Pinna:*** It helps to collect the waves and to localize the source of sound.
2. ***External auditory meatus:*** It helps to transport the sound waves to the middle ear.

B. Role of middle ear

1. Tympanic membrane :

(i) It acts as a pressure receiver i.e. it is extremely sensitive to pressure changes produced by sound waves.

(ii) It acts as a resonator i.e. it starts vibrating when sound waves strike

(iii) It critically dampens the sound waves

2. Ear ossides

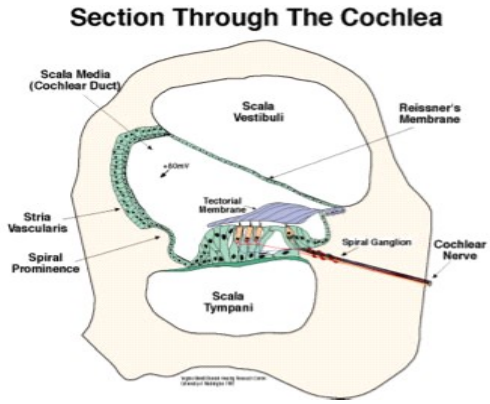
(i) Impedance matching: The increase in pressure in the middle ear by ear ossicles.

(ii) Tympanic reflex: It is a protective reflex against loud sound.

3. Eustachian tube

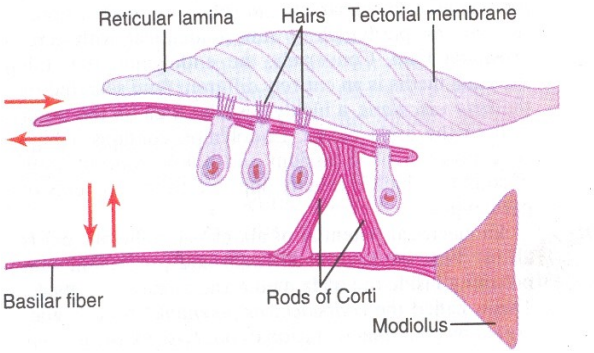
It is usually closed but during swallowing and chewing it opens, keeping the air pressure on the two sides of the ear drum equalized.

C. Role of internal ear

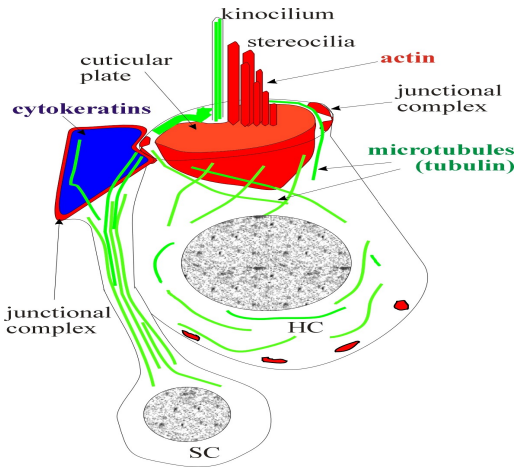


It includes bony and membranous labyrinths. The cochlea is a spiral shaped organ. The membranous labyrinth of the cochlea is the scala media (or) cochlear duct, containing endolymph. The scala vestibuli and tympani contain peilymph. The neural apparatus responsible for sound transduction is the organ of corti.

Structure of organ of corti

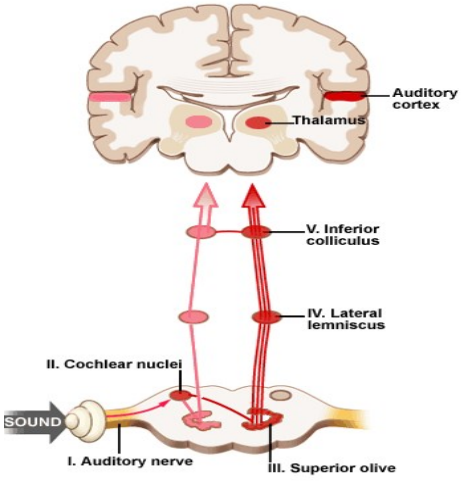


Structure of hair cell



The resting membrane potential of the hair cells is about -60mV. When the stereocilia are pushed toward the kinocilium, the membrane potential is depolarised to -50 mV. If it is toward the opposite direction, the cell is hyperpolarized. The hair processes provide a mechanism for generating changes in membrane potential proportionate to the direction of displacement. The hair cells when depolarized, release glutamine which produces generator potential that excite the cochlear afferent nerve fibers with which the hair cells synapses. The signals reach the auditory cortex.

Auditory pathway



1. Primary auditory cortex (Brodmann's area 41)
2. Secondary or auditory association cortex (Brodmann's area 42)

II. HEARING TESTS

1. Rinne's test
2. Weber's test

1.9.3 OLFACTION

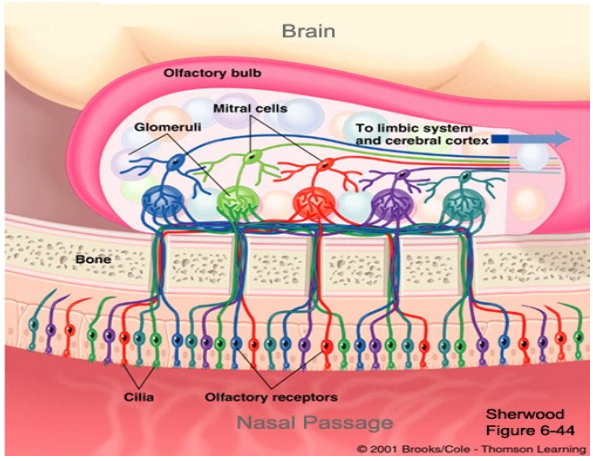
The olfactory sense is highly developed in rabbits and dog and much less in man, apes and monkeys (primates). There are 6 primary odours: floral, ethereal, musky, camphor, putrid and pungent.

I. OLFACTORY MUCOUS MEMBRANE

The olfactory receptors are located in a specialized portion of nasal mucosa, the yellowish pigmented olfactory mucous membrane. In humans, it contains

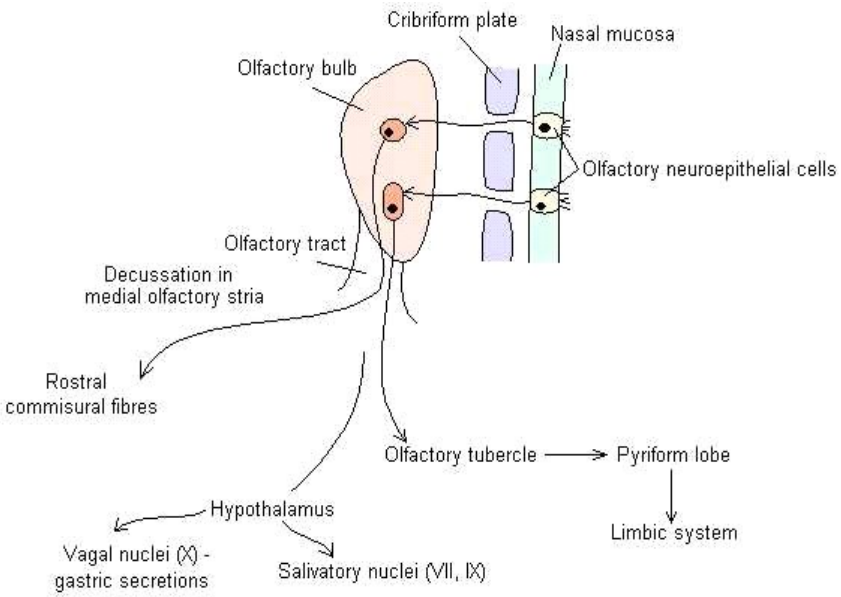
10-20 million receptor cells with supporting cells. Each receptor has an expanded end called olfactory rod. From these rods, project cilia (10-20 cilia/ receptor neuron).

Olfactory epithelium



The axons of the receptors pierce the cribriform plate of ethmoid bone and enter the olfactory bulbs. In the olfactory bulb the axons of the receptor contact the primary dendites of the mitral cells to form globular synapses called olfactory glomeruli. The axons of the mitral cells pass through the intermediate olfactory stria and lateral olfactory stria to olfactory cortex. The olfactory cortex in humans is piriform cortex.

Olfactory pathway



II. PHYSIOLOGY OF OLFACTION

The olfactory mucus containing odorant binding proteins (OBP) concentrate the odorants and transfer them to the receptors. All the odorant receptors are coupled to heterotrimeric G proteins. Some act via adenylyl cyclase and cyclic AMP, and others act via phospholipase C and the products of phosphatidylinositol hydrolysis. Most of them open cation channels causing an inward-directed Na^+ current, but in amphibians, some odorants have also been reported to inhibit this current.

Abnormalities

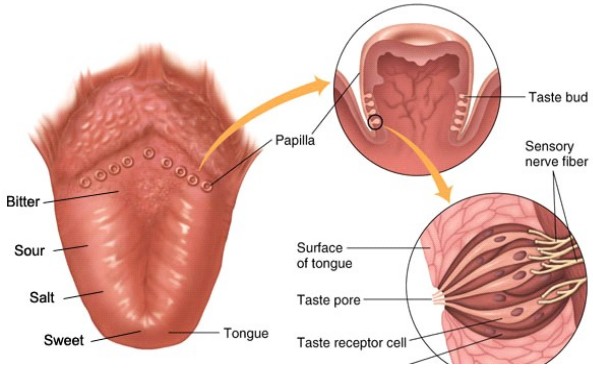
1. Anosmia – absence of the sense of smell
2. Hyposmia – diminished olfactory sensitivity
3. dysosmia – distorted sense of smell

1.9.4 GUSTATION

I. RECEPTOR ORGANS

The receptor for taste are chemoreceptors which are stimulated by substances dissolved in the oral fluids. They are located on the edges and dorsum of the tongue, on the epiglottis, soft palate and pharynx. The anterior surface of the tongue is covered with small projections called papillae. The taste buds are located in the walls of these papillae. There are 4 types of papillae

- Fungiform papillae - They have 5 taste buds / papilla
- Filiform papillae - No taste buds
- Circumvallate papillae - They have 100 taste buds /papilla
- Foliate papillae - They are found occasionally on the tongue



II. TASTE PATHWAYS:

The sensory afferent fibers from the taste buds on the anterior 2/3rds of the tongue travel through chorda tympani branch of facial nerve and those from the posteriof 1/3rd via glossopharyngeal nerve. The fibres from areas other than tongue reach the brain via glossopharyngeal nerve. On each side, the myelinated taste fibers enter the nucleus of tractus solitarius. There, they synapse on 2nd order neurons, the axons of which cross the midline and join the medial lemniscus to thalamus. Impulses from thalamus are relayed to the footplate of post central gyrus.

Taste pathway

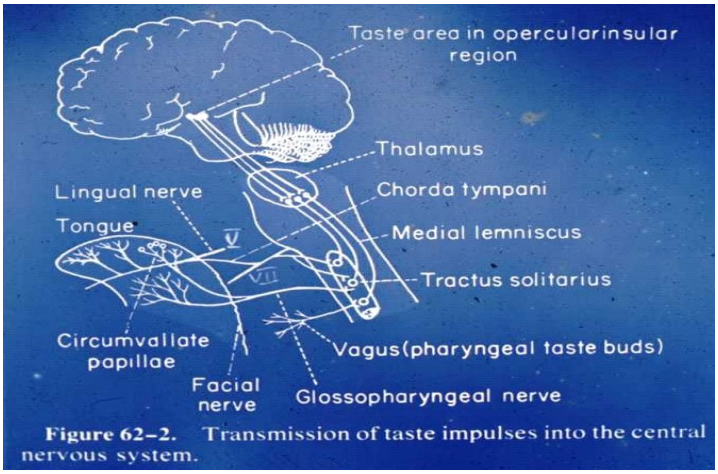
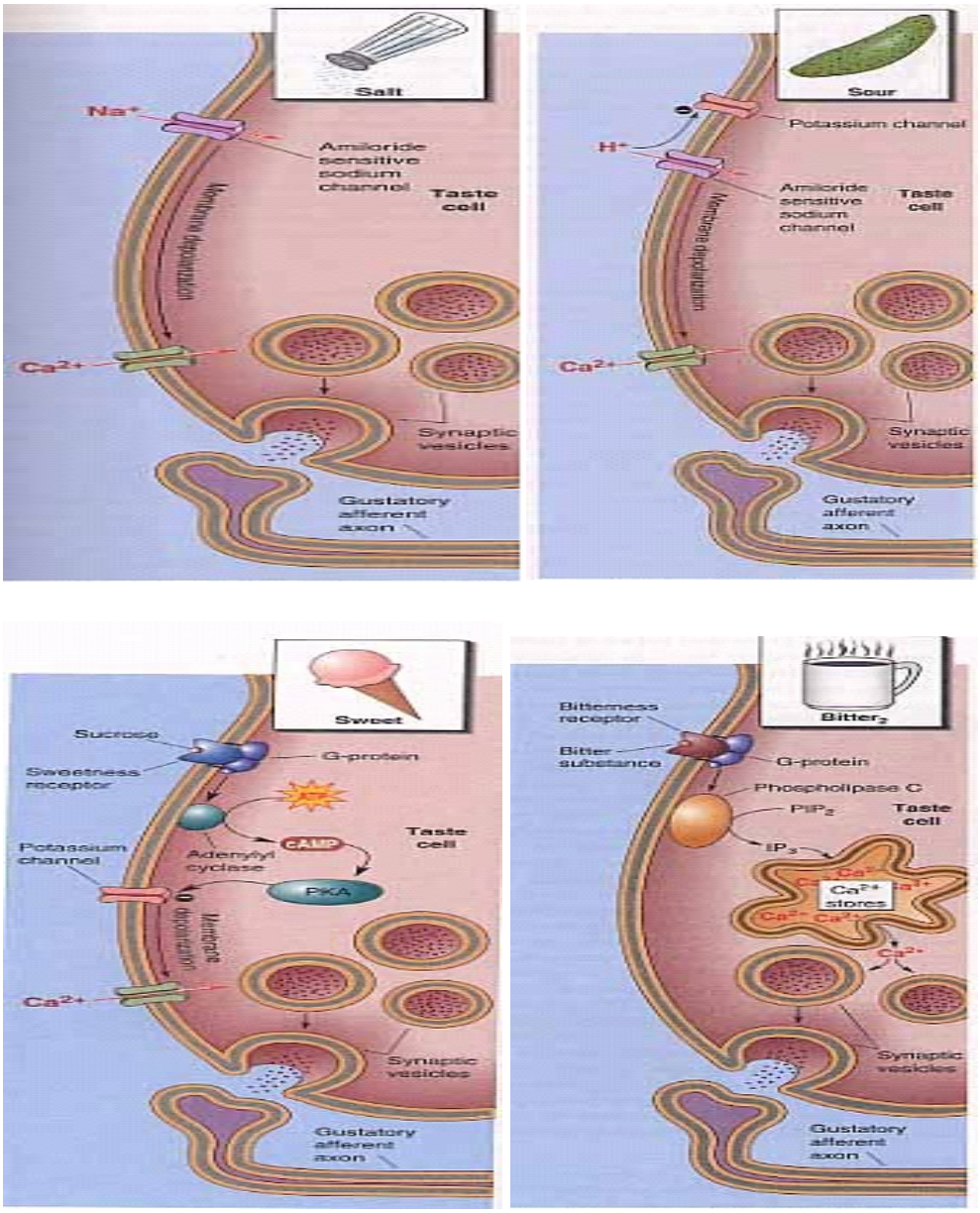


Figure 62–2. Transmission of taste impulses into the central nervous system.

III. PHYSIOLOGY OF TASTE PERCEPTION

There are 4 basic taste sensations: sweet, salt, sour and bitter. The bitter on the back, sour along the edges, sweet at the tip and salt on the dorsum. Acids taste sour. The sourness depends on the concentration of H^+ ions. Salt taste is produced by Na^+ ions. Sweet substances are organic maltose, sucrose, glucose and lactose. Polysaccharides, glycerol, alcohols, ketones, chloroform, beryllium salts and lead salts also taste sweet. Bitter taste is by quinine sulphate. Other compounds like morphine, nicotine, caffeine and urea taste bitter.



The gustatory receptor cells are also chemoreceptors that respond to substances dissolved in oral fluids. These substances act on the exposed microvilli in the taste pore to evoke generator potentials in the receptor cells, which generate action potential in the sensory neurons.

Abnormalities

1. Ageusia – absence of the sense of taste
2. hypogeusia – diminished taste sensitivity
3. Dysgeusia – disturbed sense of taste

REVIEW QUESTIONS

Long Essays Questions: (3 X 15 = 45)

1. Describe in detail the photo chemistry of vision
2. Describe in detail the mechanism of audition

Short Notes: (3 X 5 = 15)

1. Optic pathway and the effect of lesions
2. Refractive errors
3. Colour vision
4. Functions of middle ear
5. Taste pathway

SUMMARY

We have discussed about Human Physiology in this unit which is the science of the mechanical, physical and biochemical functions of humans in good health, their organs, and the cells of which they are composed. In this unit, we have gone through details regarding the digestive system, respiratory system, circulatory system, central nervous system, muscular skeletal system, reproductive system, excretory system, endocrine glands and special senses like eye, ear, tongue, nose and skin. The types of each system has been explained and their functions highlighted which provides the reader an understanding of the activities carried out by the various systems.

KEYWORDS

Salivary Gland	Gastric Secretion
Mastication	Deglutition
Haustrations	Mass Movement

SUGGESTED READINGS

Text book of Medical Physiology	-	Guyton
Review of Medical Physiology	-	Ganong
Text book of Physiology	-	Jain
Text book of Physiology	-	Mahapatra

Unit A.1

HUMAN ANATOMY

Structure
Overview
Learning Objectives
A.1 Human Anatomy
A.1.1 Digestive System
1.1.1 Mouth
1.1.2 Pharynx & Esophagus
1.1.3 Stomach
1.1.4 Small Intestine
1.1.5 Large Intestine
A.1.2 Respiratory System
1.2.1 Nose
1.2.2 Pharynx
1.2.3 Layrnx
1.2.4 Trachea
1.2.5 Lungs
A.1.3 Circulatory System
1.3.1 Systemic Circulation
1.3.2 The Pulmonary Circulation
1.3.3 The Portal Circulation
1.3.4 The Fetal Circulation
A.1.4 Central Nervous System
1.4.1 Central Nervous System
1.4.2 Peripheral Nervous System
1.4.3 Autonomic Nervous System
A.1.5 Musculo Skeletal System
1.5.1 Bones of the Head and Trunk
1.5.2 Bones of the Limbs
1.5.3 Joints or Articulations
1.5.4 Structure of Muscle
A.1.6 Reproductive System
1.6.1 Male Reproductive System
1.6.2 Female Genital System
A.1.7 Excretory System
1.7.1 Kidneys
1.7.2 Ureters
1.7.3 Urinary Bladder
1.7.4 Urethra
A.1.8 Endocrine System
1.8.1 Pituitary Gland
1.8.2 Pineal Gland
1.8.3 Thyroid Gland
1.8.4 Parathyroid Gland
1.8.5 Adrenal Gland
1.8.6 Pancreatic Islets

A.1.9Special Senses
1.9.1 Eyeball
1.9.2 Ear
1.9.3 Tongue
1.9.4 The Nose
1.9.5 The Skin
Keywords
Review Questions
Suggested Readings

OVERVIEW

Anatomy is the branch of biology that deals with the structure of living things. Human anatomy, including gross anatomy and histology, is primarily the scientific study of the morphology of the adult human body.

LEARNING OBJECTIVES

After completing this unit, you should be able to explain the various systems of Human Anatomy in detail. This includes

- Digestive system
- Circulatory System
- Musculo Skeletal System
- Excretory System
- Special Senses
- Respiratory System
- Central Nervous System
- Reproductive System
- Endocrine Glands and

A.1.1 DIGESTIVE SYSTEM

Parts of Digestive System are: 1. Mouth, 2. Pharynx & Esophagus, 3. Stomach, 4. Small Intestine, 5. Large Intestine, 6. Digestive glands.

1.1.1 MOUTH

The mouth or ***oral cavity***, is bounded externally by the cheeks and lips. The cleft between the upper and lower lips is the aperture of the mouth. The teeth form 2 dental arches, one set in the upper jaw or maxillae and the other in the lower jaw or mandible. The space external to the teeth and gums is the ***vestibule*** of the mouth. The space internal to the teeth and gums is the ***mouth proper***. The tongue lies in the floor of the mouth. The roof comprises of the hard and soft palate and median finger like process, the ***uvula***.

THE TONGUE

The tongue is a muscular organ which is attached to the hyoid bone and the mandible. It is covered in certain areas with modifications of the mucous membrane which appear as projections to increase the surface area and are called ***papillae***. In addition, specialized areas called taste buds are widespread over almost the entire area of the tongue. The under surface of the anterior part of the tongue is connected to the floor of the mouth by a fold of mucous membrane called the ***frenulum***.

THE TEETH

Humankind is provided with two sets of teeth which make their appearance at different periods of life. The first set are ***deciduous or primary teeth*** and erupt through the gums during the first and second years of life. The second set begin to replace the first about the sixth year and the process is usually complete by the twenty-fifth year. Since they cannot be replaced, and may be retained until old age, they are known as the ***permanent teeth***. There are four types of teeth: 1. Incisor teeth, 2. Canine teeth, 3. Premolar, 4. Molar teeth.

There are 20 deciduous teeth and 32 permanent teeth.

THE SALIVARY GLANDS

There are three pairs of salivary glands. The ***parotid gland*** is the largest and lies just below the ear; its duct is about 5 cm long and opens into the mouth opposite the upper second molar tooth. It is this gland which is affected by the disease commonly known as mumps. The ***submandibular gland*** and the ***sublingual gland*** open into the floor of the mouth.

1.1.2 PHARYNX & ESOPHAGUS

The pharynx and oesophagus are passages for food. They are protected by ***stratified squamous epithelium***. The oesophagus extends from the lower end of pharynx to the cardiac orifice of the stomach. It presents four constrictions.

1. At the pharyngo oesophageal junction, 2. At the point where it is crossed by the arch of aorta, 3. At the point where it is crossed by left bronchus, 4. Where it passes through the diaphragm. It also presents anteroposterior and lateral curvatures.

Blood Supply **:** The oesophagus is supplied by

1. Branches from descending thoracic aorta, 2. Bronchial arteries, 3. Left gastric artery and left phrenic artery.

Lymphatic Drainage **:** The lymph from the oesophagus drains into: 1. Lower deep cervical nodes, 2. Posterior mediastinal nodes.

Applied Anatomy

- During oesophagoscopy, the sites of constrictions must be borne in mind.
- Oesophageal varices due to portal vein obstruction can occur.
- In 'Barium Swallow' of oesophagus, the left atrial enlargement can be assessed in X-rays.

1.1.3 STOMACH

Stomach is the most dilated part of the alimentary tract.

Structure**:** It is pear shaped. It has two ends, upper and lower, two surfaces, anterior and posterior and two borders, right and left.

Subdivisions**:** ***Fundus*** is the part of the stomach which rises above the level of the cardiac end of the stomach.

Body is situated between fundus and incisura angularis.

Pylorus is situated below the body and consists of pyloric antrum, a pyloric canal and pyloric sphincter.

Relations**:** Right border (lesser curvature) gives attachment to the lesser omentum.

Left border (greater curvature) gives attachment to Gastrophrenic, Gastrosplenic ligaments and Greater omentum.

Anterior surface is related to liver, diaphragm, anterior abdominal wall and spleen.

Posterior surface - the structures related to the posterior surface are called stomach bed.

They are: 1. Pancreas, 2. Transverse mesocolon., 3. Left kidney, 4. Transverse colon, 5. Left suprarenal gland, 6. Lesser sac, 7. Spleen.

***Blood Supply*:** Five arteries supply the stomach. They are: a. Left gastric artery, b. Right gastric artery, c. Left gastro epiploic artery, d. Right gastro epiploic artery, e. Short gastric arteries.

***Venous Drainage*:** 1.Right and left gastric veins, 2. Right and left gastro epiploic veins, 3. Pre pyloric vein of mayo. Finally all the veins drain into the portal vein.

***Lymphatic Drainage*:** For descriptive purposes, the stomach is divided into 4 zones.

1. Fundus and left half of the body drains into pancreatico splenic nodes.

2. Upper part of right half of body drains into left gastric nodes.

3. Lower part of right half of body drains into right gastro epiploic nodes.

4. Pyloric region drains into pyloric, hepatic and left gastric nodes.

The lymph from these nodes pass ultimately to coeliac group of lymph nodes.

Internal features: The mucosa of the stomach is thrown into irregular folds called ***gastric rugae***. There are 2 longitudinal folds in the gastric mucosa along the lesser curvature which form a canal – the gastric canal, when fluids are swallowed to allow the rapid passage of the swallowed liquids directly to the lower part of the stomach.

***Histology*:**

- Innermost mucous layer: It is lined by simple tall columnar epithelium. Beneath this is the connective tissue lamina propria layer. It contains gastric glands. ***Zymogenic or chief cells*** which secrete pepsin, ***parietal*** or ***Oxyntic cells*** which secrete hydrochloric acid and ***mucous neck cells*** which secrete mucus are present in the mucous layer.

- Submucous coat has loose connective tissue and blood vessels.
- Muscular coat has outer longitudinal, middle circular and inner oblique layer.
- The outermost layer is serous coat.

***Applied Anatomy*:**

- The ***gastric ulcers*** are common in the lesser curvature.
- The interior of the stomach can be viewed directly by a gastroscope.
- ***Congenital pyloric obstruction*** is a condition which causes visible peristalsis in the epigastrium and vomiting after the feeds.

LIVER

The liver is the largest organ in the body. It is situated below the diaphragm and closely related to lower ribs. It occupies right hypochondrium and also extends into epigastrium and left hypochondrium. It is a highly vascular organ which gives it reddish brown color.

***Surface & Borders*:** It is a wedge shaped organ. The liver has five surfaces, superior, posterior, right lateral, anterior and inferior. The anterior, posterior, superior and right lateral surfaces are continuous with each other and together called as diaphragmatic surface since they are related to diaphragm. Inferior surface is called as visceral surface which is related to various visceral organs of abdominal cavity. The inferior border of the liver is sharp and can be palpated below the right costal margin.

Porta Hepatis*:** The hilum of the liver through which structures enter or leave the liver is called ***porta hepatis.

Peritoneal Relations*:** The peritoneum covers the liver from anteriorly and posteriorly and gets reflected over to the diaphragm and anterior abdominal wall forming ligaments. They are the ***lesser omentum, ***coronary ligament***, right and left ***triangular ligament*** and ***falciform ligament***. On its posterior surface, liver is not covered by peritoneum and that part is called as ***"Bare area of the Liver"***.

***Lobes*:** The liver is divided into two lobes, large right and small left lobes.

***Blood Supply*:** 30% of blood supply to liver comes from hepatic artery and 70% from portal vein. The branching pattern of the vessels divides the liver into eight vascular segments.

Venous blood is drained by three hepatic veins namely, right, middle and left hepatic veins which in turn open directly into the inferior vena cava.

Lymphatic vessels of liver drain into hepatic nodes and coeliac nodes.

***Microscopic structure*:** The liver is made up of hepatocytes, sinusoids, biliary canaliculi and portal triads.

The hepatocytes are arranged radially around central vein. It is called as hepatic lobule. In between the rows of hepatocytes, sinusoids run. Hepatocytes have both exocrine and endocrine function. They secrete bile which is collected by biliary canaliculi and transported to duodenum. It is important for the digestion of fat. It also secretes various enzymes and proteins.

Sinusoids carry blood and surrounded by a space called ***space of disse***. They are lined by special phagocytic cells called ***Kupffer's cells***.

Reticulin fibres and Its cells present in the space of disse helps to maintain liver architecture and repair. ***Portal triads*** are areas located at the periphery of hepatic lobule which contain the branches of hepatic artery and portal vein and also a radicle of bile duct.

***Clinical Anatomy*:** The liver may be injured by a broken lower rib or a stab injury.

Cirrhosis is a disease of the liver due to scarring or fibrosis due to toxic effects of drugs or ingested substance like alcohol.

Hepatitis is inflammation of the liver due to viral infections.

Hepatic carcinoma is the primary carcinoma of liver. Secondary carcinoma is very common in the liver due to its high vascularity, carcinoma from other parts of Gastro Intestinal tract spread to liver.

GALL BLADDER AND THE BILIARY DUCTS

Gall Bladder is a pear shaped storage organ which lies on the visceral surface of the liver. The gall bladder has a fundus, body and neck. The fundus is related to right 9^{th} costal cartilage.

It receives bile via hepatic duct. The duct of gall bladder is called as cystic duct. When the hepatic duct and cystic duct fuse, they form common bile duct which runs behind Ist part of duodenum and pancreas to open into the II part of duodenum along with pancreatic duct.

Clinical Application:-

- Gall Bladder is prone to develop gall stones.
- ***Cholecystitis*** is the inflammation of gall bladder.

PANCREAS

The pancreas is a long, flat lobulated gland. It is located in the upper part of the abdomen and closely related to duodenum.

The gland is deep in position located in the posterior abdominal wall behind peritoneum and not accessible to physical examination. It extends from the right side of $L_{1,-}$, L_2 & L_3 vertebrae, crosses them and inferior venacava and aorta, to the left as far as the hilum of the spleen.

***Parts and Relations*:** Pancreas consists of a head, neck, body and tail. Head is connected with a process called uncinate process. Head, neck and body of the pancreas are related closely to duodenum, transverse colon and stomach. Tail is related to hilum of spleen.

Micro Anatomy*:** Pancreas has both ***exocrine and ***endocrine functions***. Exocrine part is made up of compound tubuloalveolar glands which secrete pancreatic juice rich in digestive enzymes. These glands are drained by duct of pancreas which carries it to the duodenum. Endocrine part is called as ***"Islets of Langerhans"***. They lie in between the exocrine glands. They secrete hormones like ***Insulin, Glucagon*** and ***Somatotropin***.

***Ducts*:** Pancreatic duct drains along with common bile duct into the second part of duodenum.

***Blood Supply*:** Superior and Inferior pancreatico duodenal arteries supply the head & neck of pancreas. Body and Tail are supplied by branches from splenic artery. Venous blood from pancreas is drained by superior mesenteric and splenic veins. Lymphatics drain into coeliac and superior mesenteric nodes.

***Clinical Application*:**

1. Because of its deep seated position, pancreas can be examined by doing special imaging procedures like ***computed tomography, ERCP etc***.
2. Inflammation of Pancreas***, Pancreatitis*** is a life threatening condition.

1.1.4 SMALL INTESTINE

The small intestine is about 7m long. It is subdivided into ***Duodenum, Jejunum*** and ***ileum.***

DUODENUM

It is the most fixed part of the small intestine; it is situated on the posterior abdominal wall and is in the form of letter C. It is divided into four parts – I, II, III, IV.

I Part: It is related to the quadrate lobe of the liver anteriorly and to the bile duct, portal vein and IVC posteriorly.

II Part: It is related to the transverse mesocolon anteriorly and to the right kidney posteriorly. Head of the pancreas is related medially. The ampulla of vater (fused common bile duct and pancreatic duct) pierces the second part of duodenum in the middle. The accessory pancreatic duct pierces the duodenum a little above. The opening of ampulla of vater is seen on a conical mucous elevation inside the duodenum called the major duodenal papilla.

III Part: Anteriorly it is related to the superior mesenteric vessels. Posteriorly it is related to the right Ureter, IVC and abdominal aorta. It is related to the head of pancreas superiorly.

IV Part: It is related on the right side to the abdominal aorta and on the left side to the left kidney and ureter.

***Blood Supply*:** The arteries supplying the duodenum are: 1. Supraduodenal and Retroduodenal branches of Gastroduodenal artery, 2. Superior and inferior pancreaticoduodenal arteries. **Venous Drainage:** It is brought about by the corresponding veins which finally drain in to the portal vein.

Lymphatic Drainage: The lymph vessels drain into pancreaticoduodenal nodes.

***Applied Anatomy*:**

1. Stenosis or Atresia – the duodenal lumen gets obliterated.
2. Diverticula – They are common on the II part of the duodenum.
3. Annular pancreas – it surrounds the II part of the duodenum which leads to duodenal obstruction.

***Histology*:**

This has mucous, submucous, muscular and serous layers. The mucosa is lined by tall columnar epithelium. The submucous layer has loose connective tissue and ***duodenal glands of Brunner***, which are mucus secreting glands. Intestinal glands, paneth cells and argentaffin cells are also present in the mucous layer. Finger like microscopic projections from the surface of the mucous membrane called villi are also present.

JEJUNUM AND ILEUM

The coils of jejunum and ileum are suspended by a fold of peritoneum called the mesentery from the posterior abdominal wall and are freely movable.

***Extent*:** The jejunum starts at the duodeno jejunal flexure. The upper 3/5 of the coils of small intestines forms the jejunum and the lower 2/5 form the ileum. The ileum ends in the ileocaecal junction in the right iliac fossa.

MECKEL'S DIVERTICULUM (DIVERTICULUM ILEI)

It is a short diverticulum 2 inches in length, 2 feet proximal to the ileocaecal junction and it occurs in 2% of individuals. It represents the persisting proximal part of the ***vitellointestinal duct***. Its mucosa may present heterotropic pancreatic tissue or gastric mucosa, the secretions of which may lead to ulcer formation, perforations or diverticulitis.

***Blood Supply*:** The jejunum and ileum are supplied by the superior mesenteric artery.

***Venous drainage*:** By the superior mesenteric vein which joins the portal vein.

***Lymphatic Drainage*:** Into the superior mesenteric group of lymph nodes.

***Contents of Mesentry*:** The mesentry contains superior mesenteric vessels, superior mesenteric plexus of nerves, lymph nodes and pad of fat.

DISTINGUISHING FEATURES

a. The diameter and thickness of the wall of the jejunum are greater than that of the ileum.
b. The arterial arches in the mesentery of the jejunum are less in number hence, the vasa recta are longer.

   In the case of ileum, the arterial arches are more hence, the vasa recta are short.
c. There are transparent windows in the mesentery of jejunum due to absence of fat while in the case of ileum, there are opaque windows due to presence of fat.

***Histology*:** The wall of the small intestine is made of

a. Mucous layer – the epithelium lining the mucosa is simple columnar type. Numerous villi are present in the mucosa. Many tubular intestinal glands are present in the mucosa.
b. Submucous layer – in the ileum there are large collections of lymphatic tissue called ***Peyer's patches***. c. Muscular layer, d. Serous layer

Applied Anatomy

a. The Peyer's patches may ulcerate in typhoid fever and give rise to vertically oriented ulcer in the intestinal mucosa.
b. The parasitic infestations like round worm, hook worm are commonly seen.

c. ***Intussusception*** is the invagination of a segment of intestine into the lumen of preceding or succeeding part of small intestine. It causes intestinal obstruction.

1.1.5 LARGE INTESTINE

The large intestine begins at the ileocaecal junction and ends at the anus in the perineum. The approximate length of it is 1.5 metres. The main function of large intestine is absorption of water and electrolytes and help in formation and expulsion of faeces. With the help of natural bacterial flora, it also synthesizes vitamin B. The parts of large intestine are ***Caecum, Appendix, Ascending colon, Transverse colon, Descending colon, Sigmoid colon, Rectum and Anal canal***.

Features: The large intestine has a large calibre. The longitudinal muscle coat forms three narrow ribbon like bands called ***Taenia coli***. The taeniae are shorter than the length of the large intestine. Because of it, the large intestine has series of sacculations called ***"haustra coli"***. On the surface of large intestine, fat filled bags of peritoneum are present which are called as ***"Appendices epiploicae".***

Relations:

a*)* Caecum: It is the blind end of the large intestine located at the right iliac fossa. It has two openings for ileum and appendix.

Vermiform Appendix: It has worm like appearance. The length and position of the appendix are variable. It contains large aggregations of lymphoid tissue.

b) Colon: The ascending and descending colon are situated in the right and left flanks of the abdominal cavity respectively. They are fixed to posterior abdominal wall. The transverse colon lies in between the two and it is mobile. Sigmoid colon is located in the left iliac fossa and it too is mobile.

c) Rectum: It lies between sigmoid colon and anal canal. It is fixed to the posterior pelvic wall. The faeces is stored here until its evacuation. It is related anteriorly to urinary bladder in males and uterus is females.

d) Anal canal: It is the terminal part of the large intestine. It lies below the pelvic cavity in the perineum. It is guarded by a valve called anal sphincter which keeps the anal canal closed except during defecation.

***Blood Supply*:** Two arteries give branches to large intestine which form arterial anastomosis before entering into it. They are the superior mesenteric artery and inferior mesenteric artery. The lower part of the rectum and anal canal receives blood supply from middle and inferior rectal arteries which are branches from internal iliac artery. Venous drainage is through superior and inferior mesenteric veins which carry the venous blood to portal vein. The lower part of rectum and anal canal drain into internal iliac veins. Lymphatics follow the arteries and drain into superior mesenteric, inferior mesenteric and internal iliac nodes.

***Microscopic Anatomy*:** The large intestine has mucosa which is lined by single layer of columnar cells except at anorectal junction and anal canal where it is lined by stratified squamous non keratinized epithelium. It also has sub mucosa which is made of connective tissue, nerve plexuses and blood capillaries and two layers of smooth muscle coat namely inner circular and outer longitudinal.

***Clinical Anatomy* :**

- ***Appendicitis*** is the commonest disease which occurs due to inflammation of the appendix.
- Caecum is the area affected in Ameobiasis.
- Because of its mobility, the sigmoid colon may undergo sudden change in position called ***volvulus***.
- Veins of the rectum will enlarge and protrude into the mucosa due to various conditions which lead to increase in intra abdominal pressure. This condition is called as ***"haemorrhoids"***.

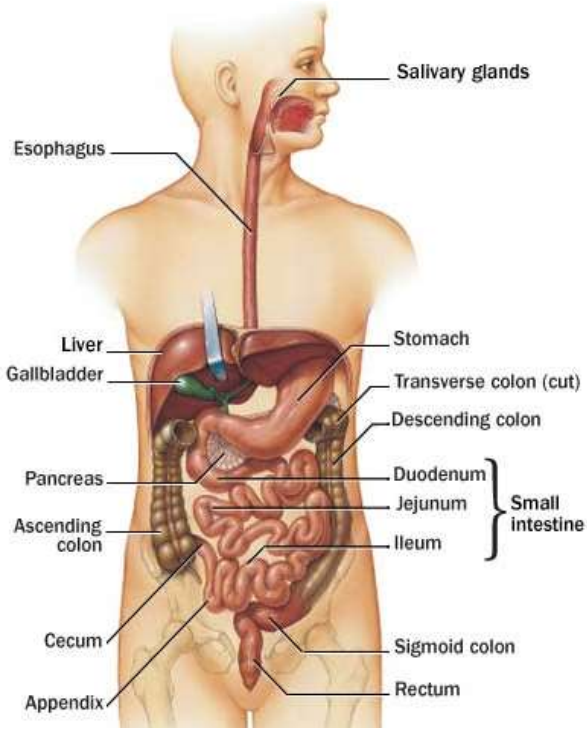
Activity A

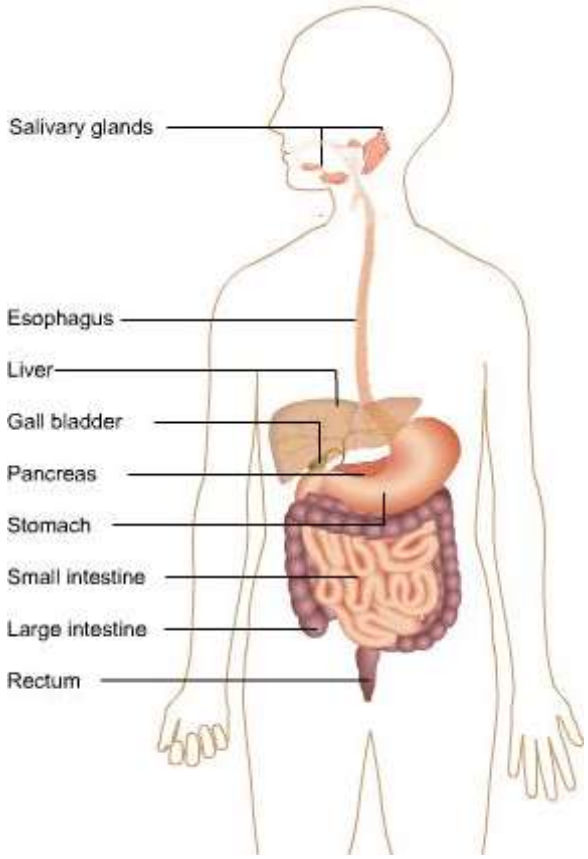
A 47-year-old woman was operated on for the treatment of a chronic gastric ulcer that had not responded to medical treatment. At operation for partial gastrectomy, it was found that the posterior wall of the stomach was stuck down to the posterior abdominal wall. The surgeon had to proceed with great care to avoid damaging important structures lying on the posterior abdominal wall.

1. The following structures located on the posterior abdominal wall were possibly involved in the disease process except which?

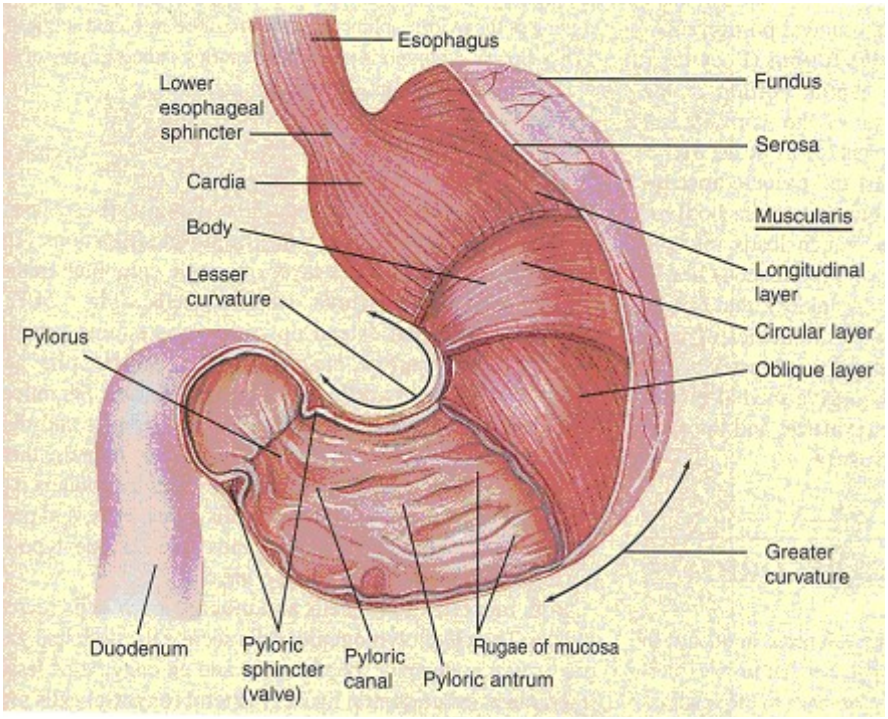
A. The right kidney, B. The pancreas, C. The left suprarenal gland, D. The left kidney

PARTS OF DIGESTIVE SYSTEM





INTESTINE



STOMACH

REVIEW QUESTIONS

Long Essay Questions: (3 X 15 = 45)

1. Enumerate the parts of digestive system and describe the stomach in detail.
2. Describe the liver in detail.
3. Describe the anal canal in detail.

Short Notes (3 X 5 = 15)

1. Meckel's diverticulum
2. Microscopic structure of stomach
3. Duodenum

A.1.2 RESPIRATORY SYSTEM

In this chapter, we will study about the different parts and anatomical features of respiratory system.

The respiratory system consists of two parts, upper respiratory tract and lower respiratory tract. The nose, pharynx and larynx are part of upper respiratory tract. The larynx below vocal cords, trachea and lungs make the lower respiratory tract.

Functionally, the respiratory tree has two parts, the conducting passage and the respiratory surface. The parts of the respiratory system from the nose to respiratory bronchioles are called conducting passage. The alveolar ducts, alveolar sacs and alveoli constitute the respiratory surface.

1.2.1 NOSE

The skeleton of the nose is made up of bones and cartilages. It has nasal cavity and openings of air filled cavities around it, called Para nasal air sinuses. The nose opens externally through nares and communicates with pharynx posteriorly through posterior nasal aperture or choanae.

The nasal cavity is separated into right and left by a median nasal septum. The lateral walls of the cavities has three curved shelf like projections called conchae which overhang three anteroposteriorly running passages

called meatuses. They are named from above downwards superior, middle and inferior concha and meatus. The nasolacrimal duct opens into inferior meatus. The para nasal air sinuses open into other meatuses.

The nasal cavities are lined by pseudo stratified ciliated columnar epithelium. The mucous membrane covering the conchae contains dilatable venous sinuses which warm and humidify the inhaled air. It also contains mucous and serous glands and lymphoid follicles.

In the uppermost part of each nasal cavity, there is olfactory area where special cells for smell sensation are located.

There are four para nasal air sinuses, frontal, sphenoid, ethmoid and maxillary. They are inflated with air, invade the surrounding bones and help to reduce the weight of the facial skeleton, humidify the air and add resonance to our voice.

***Blood Supply*:** The nose and para nasal air sinuses are supplied by branches from facial artery and maxillary artery.

The veins drain into pterygoid plexus of veins, ophthalmic vein and facial vein.

The lymphatics drain into deep cervical and retropharyngeal nodes.

***Nerve Supply*:** It receives general sensory supply from the branches of maxillary division of trigeminal nerve. Para sympathetic fibres coming from facial nerve give secretomotor innervation. Sympathetic fibres from internal carotid plexus also supply the nose.

***Applied Anatomy*:**

- Little's area is the lower part of the nasal septum which is prone to bleed.
- DNS or Deviated nasal septum is where the nasal septum deviates to one side and causes obstruction.
- Infections of the para nasal air sinuses is called sinusitis.

1.2.2 PHARYNX

The pharynx is a fibro muscular tube extending from the base of skull to sixth cervical vertebra. Below it is continuous with the Oesophagus. In front, it communicates with nasal cavity, oral cavity and larynx. Accordingly it is divided into Nasopharynx, Oropharynx and Layrngopharynx.

Nasopharynx and oropharynx communicate via oropharyngeal isthmus which can be closed by soft palate during swallowing. The nasopharynx receives the opening of auditory tubes through which it is connected with the middle ear cavity. There are two lymphoid aggregations in the pharynx namely nasopharyngeal tonsil and tubal tonsil.

The palatine tonsils which guard the food passage is located in the lateral walls of oropharynx.

The pharynx is lined by stratified squamous non keratinized epithelium. The wall contains three circular constrictor muscles superior, middle and inferior constrictor and three pairs of longitudinal muscles Stylopharyngeus, Salphingo pharyngeus & Palato pharyngeus. Between the mucosa and muscles there is a fibrous coat called pharyngo basilar fascia and externally phayrnx is covered by buccopharyngeal fascia.

***Blood Supply*:** Phayrnx is supplied by branches from ascending pharyngeal artery, facial artery, maxillary artery and lingual artery. The veins of pharynx form a plexus called pharyngeal plexus which drains into internal jugular vein and facial vein.

Nerve Supply*:** Mucosa is supplied by sensory branches from ***Glosso phayrngeal and ***Vagus nerves***. The muscles are supplied by cranial accessory except Stylopharyngeus which is supplied by glosso pharyngeal nerve.

***Applied Anatomy*:**

a) Carcinoma in the nasopharynx occurs in pharyngeal recess.
b) Enlargement of nasopharyngeal tonsil due to infection is known as adenoiditis.
c) Infection of the palatine tonsils is called tonsillitis.

1.2.3 LAYRNX

The layrnx or voice box extends from the lower part of the pharynx to the trachea. It is kept rigid by three unpaired [epiglottis, thyroid and cricoid] and three paired [arytenoid, corniculate and cuneiform] cartilages. It is lined by mucous membrane.

The thyroid cartilage is the largest cartilage of layrnx made of two quadrangular plates united anteriorly forming laryngeal prominence in males.

The cricoid is the signet ring shaped cartilage which is situated below the thyroid cartilage and articulates with it.

Epiglottis is the leaf shaped cartilage which guards the laryngeal inlet.

Arytenoid is the paired, pyramidal shaped cartilage gives attachment to vocal cords.

Other than the cartilages, there are intrinsic muscles which help in the movement of vocal cords and extrinsic muscles which move the layrnx.

***Blood Supply*:** Layrnx is supplied by superior and inferior laryngeal arteries and drained by corresponding veins. The lymphatics drain into deep cervical and pre laryngeal nodes.

Nerve Supply*:** The sensory innervation is given by ***internal laryngeal and recurrent laryngeal nerves, branches of ***vagus*** nerve. The intrinsic muscles of the larynx are supplied by recurrent laryngeal nerve except crico thyroid which is supplied by external laryngeal nerve.

***Applied Anatomy*:** 1.Vocal cords are important for voice production. Injury to recurrent laryngeal nerve leads to paralysis of vocal cords.

1.2.4 TRACHEA

Trachea or wind pipe is a cartilaginous tube extending from the lower end of larynx. It is situated partly in the neck and partly in the superior mediastinum. It lies in the midline at neck and in thorax it is slightly deviated to right. The ‘C’ shaped cartilages help to keep the trachea patent. The posterior ends of the tubes are connected by a smooth muscle called trachealis.

Trachea bifurcates in the upper part of the thorax at the level of sternal angle into right and left bronchus.

***Blood Supply*:** Inferior thyroid arteries and bronchial arteries supply the trachea. It is drained by inferior thyroid venous plexus.

Lymphatics from trachea drain into tracheo bronchial nodes.

***Nerve Supply*:** Vagus nerve supplies trachea.

***Applied Anatomy*:**

a. Tracheal position can be palpated at the suprasternal notch.
b. The bronchoscope helps to examine and remove foreign bodies from the interior of trachea.
c. Tracheostomy is making artificial opening in trachea if there is any obstruction of larynx.

1.2.5 LUNGS

The lungs are paired organs situated on either side of the mediastinum. The lungs contain elastic tissue specialized for the exchange of gases between the atmosphere and the blood.

The lungs are covered by a bilayered membrane called pleura. Between the two layers of pleura, there is pleural cavity containing fluid. Each lung has apex, base, medial surface and costal surface. There are three borders, anterior, posterior and medial. The medial surface contains hilum through which structures enter and leave the lung. The right lung is divided into three lobes by horizontal and oblique fissure. The left lung is divided into two lobes by oblique fissure. The left lung has a notch in anterior border called ***Cardiac notch*** to accommodate heart.

Internally, the lungs contain bronchial tree. The principal bronchus which enters divides repeatedly along with its vessels form the substance of the lung. The part of the lung which is aerated by a segmental bronchi is called ***"Broncho Pulmonary Segment"***. There are 10 broncho pulmonary segments in each lung. The cartilage content of the walls decrease and smooth muscle increase progressively as the bronchi branch. The respiratory tree ends finally in alveoli. The alveoli are lined by squamous epithelium which facilitates gaseous exchange between air and blood.

***Blood Supply*:** The lung has two types of circulation. Pulmonary artery carries deoxygenated blood from right ventricle to the lungs and the bronchial arteries provide oxygenated blood.

The oxygenated blood is carried back to left atrium by a pair of pulmonary veins from each lung. Small bronchial veins drain the lungs.

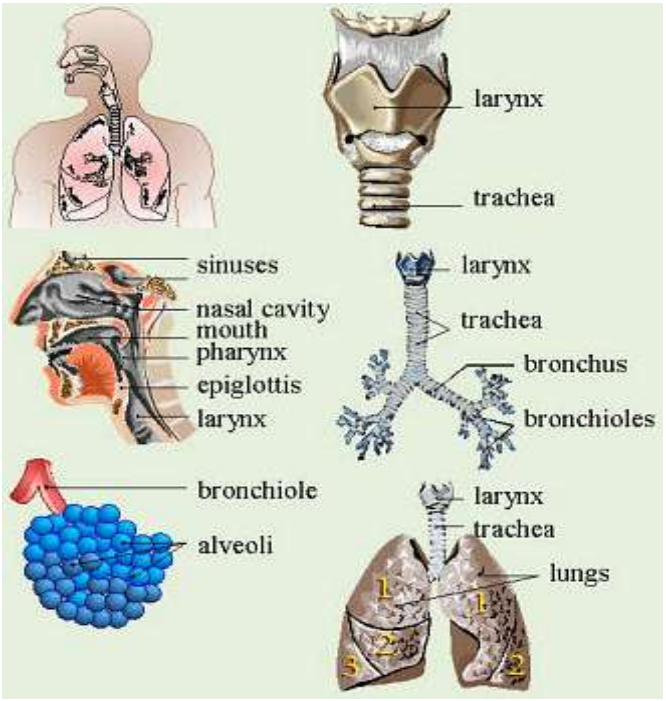
Lymphatic vessels end in pulmonary nodes.

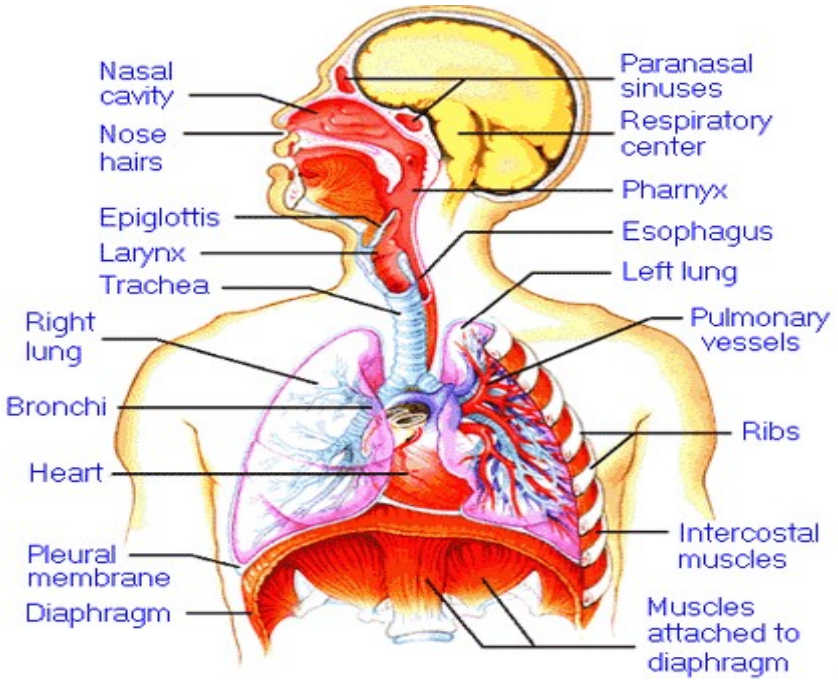
***Nerve Supply*:** The lungs receive parasympathetic innervation from vagus and sympathetic from thoracic part of sympathetic chain.

***Applied Anatomy*:**

a. ***Broncho scopy*** helps to visualize the bronchial tree up to segmental bronchi.
b. Inflammation of pleura is called ***pleurisy***.
c. Accumulation of fluid in the pleural cavity called ***pleural effusion*** causes difficulty in breathing.
d. Lung is prone to develop infections such as pneumonia and lung abscess.
e. Carcinoma of lung is quite common in smokers.

PARTS OF RESPIRATORY SYSTEM





RESPIRATORY TRACT

Activity B

1. A 36 year old man came to the hospital with complaints of severe pain in the right side of the chest and difficulty in breathing. When auscultated, there was no breadth sounds in the right lower part of chest and X-ray revealed accumulation of fluid in right pleural cavity.

What is the probable diagnosis?

2. A 40 year old woman lost her voice after thyroidectomy.

What is the reason for this?

REVIEW QUESTIONS

Long Essay Questions: (3 X 15 = 45)

1.Classify the parts of the Respiratory tract. Write in detail about larynx.

2.Describe the lungs in detail.

Short Notes: (3 X 5 = 15)

1. Trachea
2. Nose
3. Pharynx

A.1.3 THE CIRCULATORY SYSTEM

The circulation of the blood is divided into three main parts:

a. The ***systemic*** circulation
b. The ***pulmonary*** circulation
c. The ***portal*** circulation

1.3.1 THE SYSTEMIC CIRCULATION

The vessels which carry the blood from the left ventricle through the body, to the right atrium constitute the systemic circulation. Arteries may subdivide into several branches at the same point or several branches may be given off in succession. Arteries do not always end in capillaries but may unite with one another, forming ***anastomoses***. Examples are found in the brain where two vertebral arteries anastomose to form the basilar artery.

THE ARTERIES

a) Aorta: The ***aorta*** is the main artery which carries oxygenated blood to the tissues of the body. It arises from the upper part of the left ventricle, passes upwards and to the right – the ***ascending aorta*** – and then arches backwards to the left – the ***arch of the aorta*** – and passes down through the thorax on the left side of the spine – the ***descending thoracic aorta***. It enters the abdominal cavity through an opening in the diaphragm called the aortic hiatus and is then called the ***abdominal aorta***. It ends at the lower border of the fourth lumbar vertebra by dividing into the right and left common iliac arteries.

The ascending aorta has two branches, the right and left ***coronary arteries***. They supply the heart wall.

The arch of the aorta has three branches which arise form the top of the arch:

- ***Brachiocephalic trunk*** – which divides into the right subclavian artery and the right common carotid artery
- ***Left common carotid artery***
- ***Left subclavian artery***

The common carotid arteries supply the head and neck. Each divides into two at the level of the thyroid cartilage to form the ***external*** and ***internal carotid arteries***. The external carotid artery supplies the outer parts of the face and scalp and has many branches such as the ***facial***, ***temporal***, ***occipital*** and ***maxillary*** branches. The internal carotid artery supplies a large part of the cerebrum, the eyes, the nose and forehead.

The ***vertebral*** arteries arise from the first part of the subclavian arteries and pass upwards in the foramina of the transverse processes of the cervical vertebrae: they enter the skull through the foramen magnum and join together to form the ***basilar artery***.

An anastomoses named the ***circulus arteriosus*** connects the vertebral arteries and the two internal carotid arteries. This circle is situated at the base of the brain. In front the two anterior cerebral arteries are joined by the anterior communicating artery. Behind the basilar artery, formed by the junction of the two vertebral arteries, divides into two posterior cerebral arteries, each of which is joined to the internal carotid arteries by the posterior communicating artery.

Blood is supplied to the upper limb through one main artery which is called the ***subclavian artery*** as far as the outer border of the first rib, the axillary artery as far as the middle third of the humerus and ***the brachial artery*** as far as the neck of the radius, where it divides into the ***radial*** and ***ulnar*** arteries. The radial artery passes along the radial side of the forearm to

the wrist, where its pulsation can be felt quite easily, and then crosses into the palm of the hand to form the ***deep palmar arch*** and to unite with the deep branch of the ulnar artery.

The ulnar artery runs down the ulnar side of the forearm to the wrist and crosses to form the ***superficial palmar arch***.

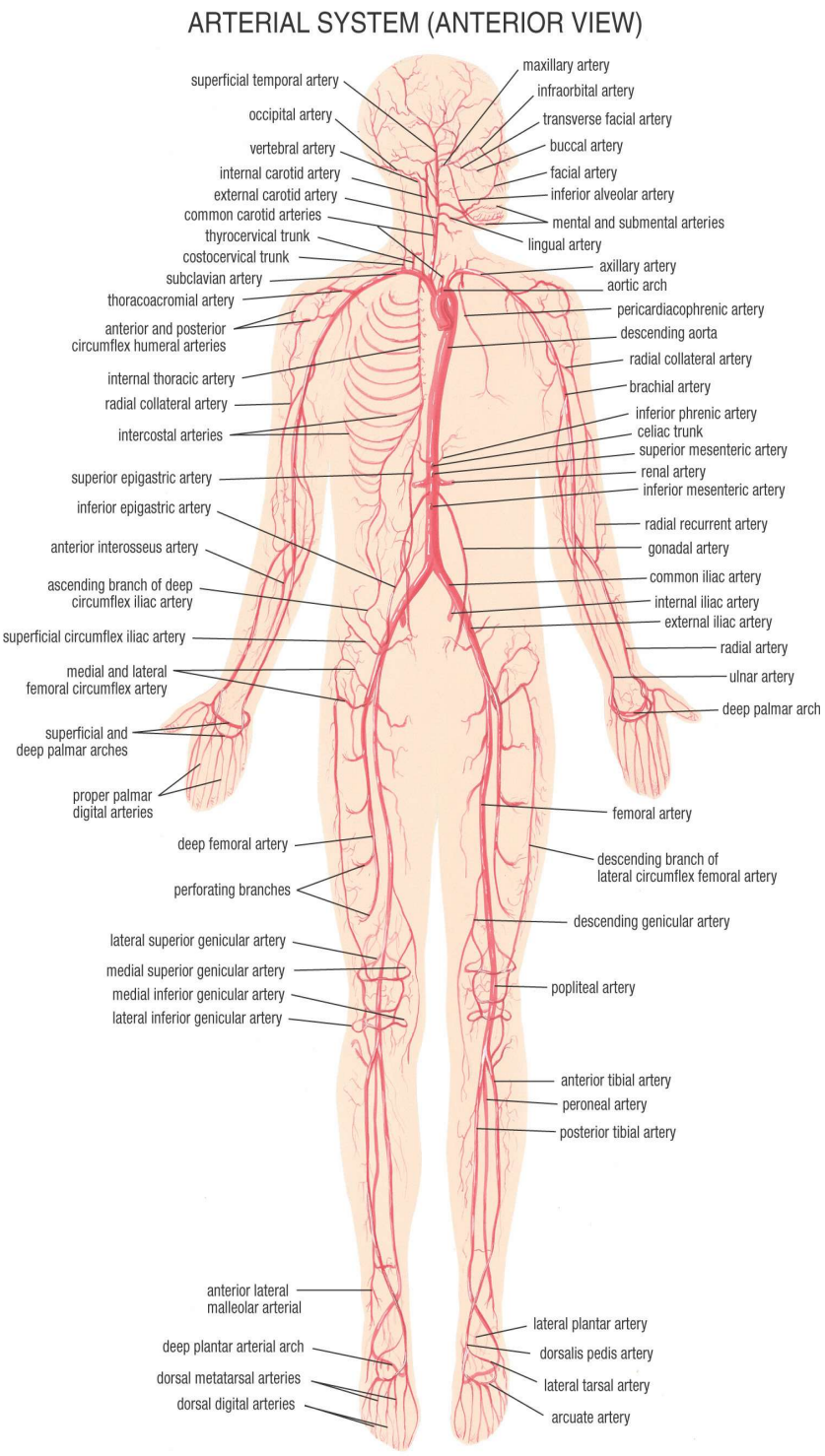
The ***descending thoracic aorta*** is situated in the mediastinum; it supplies the pericardium, bronchi, oesophagus, mediastinum, intercostal muscles and breasts through branches which are named after the part they supply.

The abdominal aorta begins at the aortic hiatus of the diaphragm, at the level of the 12th thoracic vertebra. The branches of the abdominal aorta are: 1. Phrenic arteries, 2. Coeliac trunk, 3. Superior mesenteric artery, 4. Middle suprarenal arteries, 5. Renal arteries, 6. Ovarian arteries, 7. Inferior mesenteric artery.

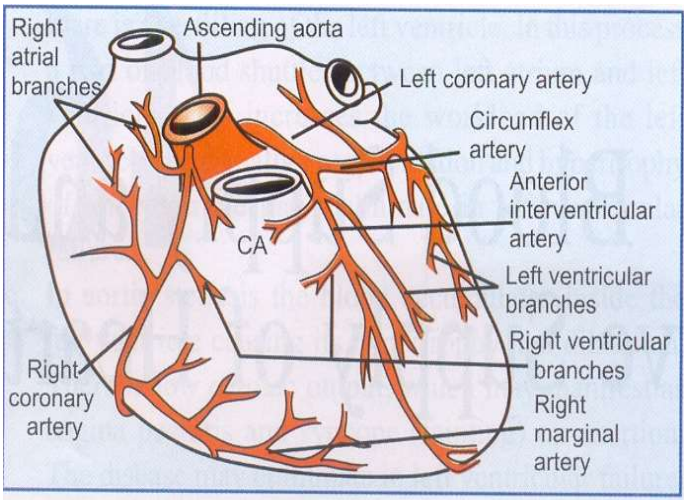
The abdominal aorta divides into two ***common iliac arteries*** and these again divide into the ***internal iliac artery*** which supplies the pelvis, the perineum and the gluteal region and the ***external iliac artery*** which supplies the lower limb.

Blood is supplied to the lower limb through the external iliac artery which crosses the groin and enters the thigh as the ***femoral artery***; this in turn becomes the ***popliteal artery*** at the lower one-third of the thigh. The popliteal artery divides into:

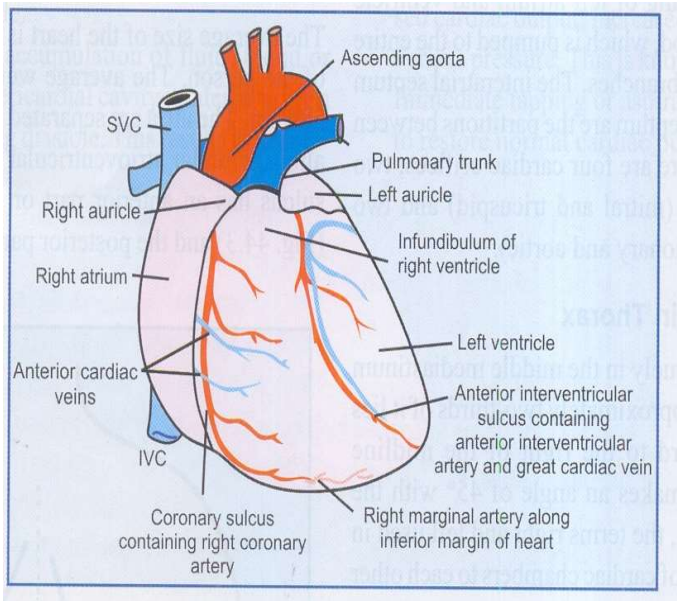
1. The ***anterior tibial artery***, which runs down the front of the leg on the anterior surface of the interosseous membrane, crosses the front of the ankle joint and supplies the front of the foot as the dorsalis pedis artery.
2. The ***posterior tibial artery*** which runs down the back of the leg to the back of the ankle joint and to the sole of the foot to form the plantar arch.



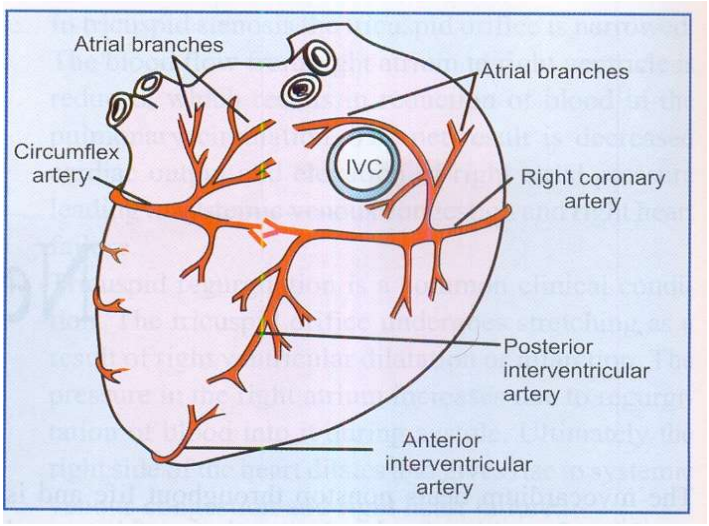
The arteries around the ankle joint anastomose freely with one another to form network of vessels.



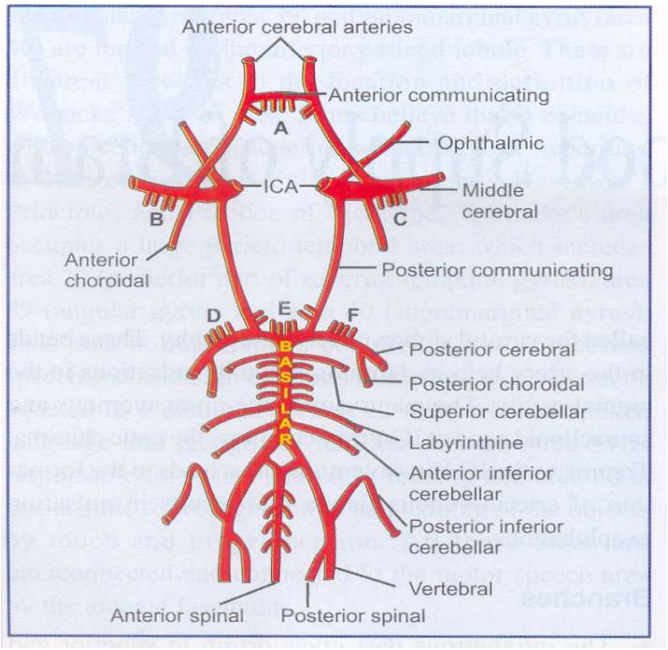
BLOOD VESSELS OF HEART



CORONARY ARTERIES ANTERIOR VIEW



CORONARY ARTERIES POSTERIOR VIEW



CIRCLE OF WILLIS

THE VEINS

The veins, which return venous blood to the heart, are either superficial veins which vary considerably in position, or deep veins which usually accompany arteries.

The veins can be described in two groups:

- The veins of the head, neck, upper limbs and thorax, which all end in the ***superior vena cava***.
- The veins of the lower limbs, abdomen and pelvis, which all end in the ***inferior vena cava***.

The blood from the brain is collected into vessels which are situated between the two layers of the ***dura mater*** and are called ***venous sinuses***. These in turn empty into the ***internal jugular veins*** along with blood from the superficial parts of the face and from the neck.

The ***external jugular veins*** receive blood from the exterior of the cranium and from the deep parts of the face. At the root of the neck the internal jugular veins join with the subclavian veins to form the ***Brachiocephalic veins*** which in turn unite to form the superior vena cava through which blood is poured into the right atrium.

The veins of the upper and lower limbs are in two groups: superficial and deep.

- Superficial veins – ***the cephalic***, ***basilic*** and ***median*** veins and their tributaries
- Deep veins – these pour their blood into the ***axillary vein***, which is a continuation of the ***basilic vein***, and which becomes continuous with the ***subclavian vein***.

While the veins of the lower limbs are:

- Superficial veins – the ***short saphenous veins***, which empty into the popliteal vein and the ***long saphenous veins***, which drains into the femoral veins.
- Deep veins – the ***anterior*** and ***posterior tibial veins***, the popliteal vein and the femoral vein.

Between the deep and superficial veins of the lower limbs a number of ***'perforating' veins*** exist which have their valves so arranged that normally blood is prevented from flowing from the deep to the superficial veins. The femoral vein ends at the inguinal ligament by becoming the ***external iliac vein***. The ***internal iliac vein***, returning blood from the pelvis, unites with the external iliac vein to become the ***common iliac vein***, one on either side of the body. These unite at the level of the fifth lumbar vertebra to form the ***inferior vena cava*** which receives several tributaries:

a. ***Renal veins***,

b. ***Ovarian or testicular veins***,

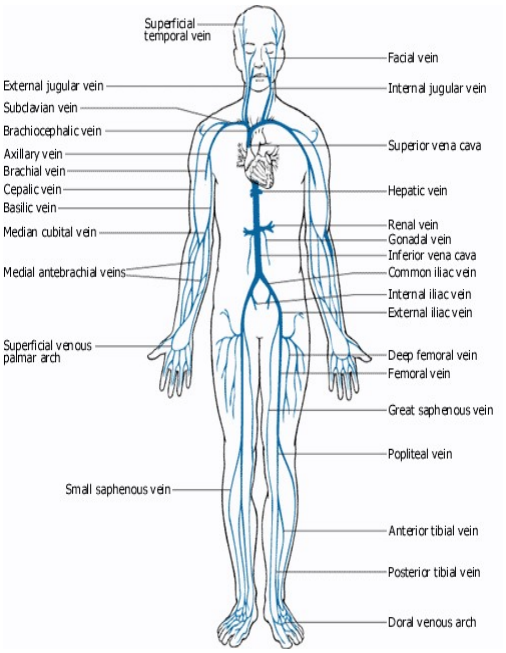
c. ***Hepatic veins***

The vena cavae pour all venous blood into the right atrium except that from the coronary circulation which is conveyed by the coronary sinus directly into the right atrium.

1.3.2 THE PULMONARY CIRCULATION

These vessels are concerned with carrying deoxygenated blood from the heart to the lungs and oxygenated blood from the lungs back to the heart. The ***pulmonary trunk*** carries venous blood from the right ventricle: it divides into ***right*** and ***left pulmonary arteries*** which then branch to carry blood to the various segments of the lungs. These vessels are the only arteries carrying deoxygenated blood.

The ***four pulmonary veins*** return the oxygenated blood from the lungs to the left atrium, two vessels from each lung. These are the only veins which carry oxygenated blood.



VENOUS SYSTEM ANTERIOR VIEW

1.3.3 THE PORTAL CIRCULATION

The portal system includes all the veins which drain blood from the abdominal part of the digestive system and from the spleen, pancreas and gall bladder. The blood from these organs is carried to the liver by the ***portal vein***, which ends in vessels like capillaries, called ***sinusoids***. The blood is then conveyed by the ***hepatic veins*** to the ***inferior vena cava***.

1.3.4 THE FETAL CIRCULATION

Fetal blood is carried to and from the ***placenta*** by ***umbilical arteries*** and ***veins***. Most of the blood which enters the right atrium through the inferior vena cava passes though an opening in the atrial septum, called the ***foramen ovale***, directly into the left atrium and thence into the left ventricle and aorta. The blood returning to the right atrium through the superior vena cava passes into the right ventricle and pulmonary trunk, after which only a small part of it goes to the lungs. Most of it passes through the ***ductus arteriosus*** directly to the aorta.

At birth the foramen ovale closes, so that blood cannot pass from the right atrium to the left atrium but is directed into the pulmonary trunk and thence to the lungs. The ductus arteriorsus also closes shortly after birth.

Activity C

A 40-year-old man visited his physician complaining that he experiences severe pain in both legs when taking long walks. He noticed recently that the cramp like pain occurs after walking only a hundred yards. On questioning, he said that the pain quickly disappears on rest only to return after he walks the same distance.

1. The symptoms and signs displayed by this patient can be explained by the following statements except which?

A. Arteriography of the abdominal aorta revealed blockage in the region of the bifurcation.

B. Only the right common iliac artery was involved by disease.

C. The gradual blockage of the aorta was caused by advanced arterio-sclerosis

D. An insufficient amount of blood was reaching both legs, causing pain (claudication) on walking.

REVIEW QUESTIONS

Long Essay Questions: (3 X 15 = 45)

1. Describe the origin, parts and branches of aorta in detail.
2. Describe the heart in detail.
3. Enumerate the veins of the body and describe the inferior vena cava in detail.

Short Notes: (3 X 5 = 15)

1. Microstructure of artery.
2. Foetal circulation.
3. Coronary circulation.

A.1.4 CENTRAL NERVOUS SYSTEM

It is the part of our body which monitors and maintains constant internal environment and responds to external environment. The basic functions of nervous system are to receive sensory inputs from internal and external environment, integrate the input and respond to the stimuli.

The nervous system is made up of specialized cells called neurons and neuroglia. Neurons constitute the functional unit of the nervous system. They have the special ability to conduct impulses from one part of the body to another. There are many types of neurons which are classified according to their size, shape and function. The total number of neurons in human brain is approximately 10^{12}. The junction between two or more neurons is called as synapse. Neuroglias are special type of connective tissue which support the neurons.

The parts of the nervous system are broadly classified into

a. The central nervous system – which comprises of Brain and Spinal cord.
b. The peripheral Nervous system – which comprises of 31 pairs of spinal nerves and 12 pairs of cranial nerves.

1.4.1 CENTRAL NERVOUS SYSTEM

The central nervous system is composed of the brain and spinal cord. They are protected by the bony skull and vertebrae. They are covered by 3 layers of meninges called ***Dura mater, Arachnoid mater*** and ***Piamater*** from outside to inside respectively. The space between the dura mater and arachnoid mater is called as ***subdural space***. The space between arachnoid mater and piamater is called ***subarachnoid space*** which contains ***cerebro spinal fluid***. It cushions and protects the brain and spinal cord.

The brain is composed of three parts namely the ***Cerebrum***, the ***Cerebellum*** and the ***Brainstem***.

BRAIN STEM

It is made of three parts, ***Midbrain***, ***Pons*** and ***Medulla oblongata*** from above downwards. It connects the cerebrum with cerebellum and spinal cord. It also gives origin to lower 10 cranial nerves.

Mid Brian**:** It is connected with cerebrum by crus cerebri. It is continuous with pons below and connected to cerebellum through ***superior cerebellar peduncles***. The Oculomotor nerve and Trochlear nerve take origin from here.

The parts of the midbrain from anterior to posterior are, crus cerebri, substantia nigra, tegmentum and tectum. The ***cerebral aqueduct of sylvius*** pass through it. Crus cerebri contains descending cortico pontine, cortico spinal and cortico nuclear fibres. Substantia nigra contains neurons which are part of extra pyramidal tract. Tegmentum contains neurons which give origin to cranial nerves 3 and 4. Tectum contains a pair of superior colliculi and a pair of inferior colliculi which are centres for vision and hearing.

Pons**:** Pons is part of brainstem which lies between midbrain and medulla. It is connected with cerebellum by ***middle cerebellar peduncle***. It is related posteriorly to fourth ventricle. It contains neurons which give origin to Trigeminal, Abducent, Facial and Vestibulo Cochlear nerves.

Medulla Oblongata*:** Medulla Oblongata extends from the lower border of pons to the upper border of spinal cord. It is connected with the cerebellum by ***inferior cerebellar peduncle. It gives attachments to Glassopharyngeal, Vagus, Accessory and Hypoglossal nerves. The upper part of the medulla is related to fourth ventricle posteriorly and the lower part has a central canal which is continuous with the central canal of spinal cord.

The brain stem has regulation centres for heart beat, breathing, blood pressure and reflex centres for vomiting, coughing, sneezing, swallowing and hiccupping.

SPINAL CORD

It continues as an extension from the lower part of medulla oblongata up to the lower border of the first lumbar vertebra. It lies inside the vertebral canal. The lowest part of the medulla is called as ***conus medullaris***.

Spinal cord gives attachment to 31 pairs of spinal nerves. The part of the spinal cord which gives attachment to a pair of spinal nerves is called as a ***spinal segment***. Spinal cord contains ***31 segments***, 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and one coccygeal.

The spinal cord is made of inner grey matter which is made of cell bodies of neurons and outer white matter which is made of ascending sensory tracts and descending motor tracts.

Cerebellum*:** Cerebellum lies behind the pons and medulla. It consists of right and left hemispheres joined by a midline structure called ***vermis. The three cerebellar peduncles connect the cerebellum with other parts of central nervous system.

The outer part or cortex contains gray matter and medulla contains white matter. Deep to the white matter, gray matter is present in groups, the four cerebellar nuclei.

Cerebellum co-ordinates the movements of muscles and body, maintains posture and balance. It also maintains the normal muscle tone.

Cerebrum*:** The largest part of the brain is called cerebrum. It is made of two cerebral hemispheres and Diencephalon. The two cerebral hemispheres are connected by a midline structure called ***corpus callosum. The part of the brain which lies in between the cerebral hemispheres is called ***Diencephalon*** which comprises of ***Thalamus*** and ***Hypothalamus***.

The surface of the cerebrum is thrown into folds called ***sulci*** and ***gyri***. The cerebrum is grossly divided into four lobes namely, frontal, parietal, occipital and temporal. The functions of these lobes are,

Frontal – motor activity, integration of muscular activity, speech, thought process.

Parietal – receives and processes, sensory information.

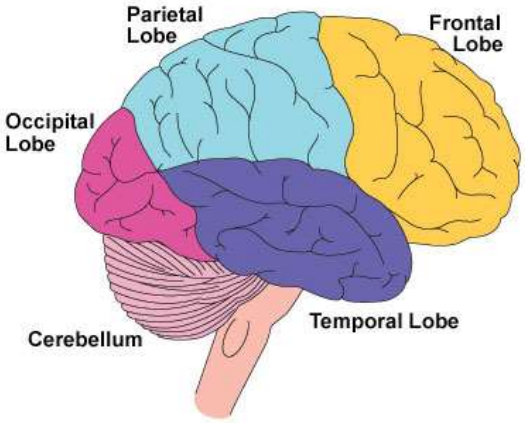
Occipital – receives and processes visual information.

Temporal – receives and processes auditory information. Processes language and meaning of words.

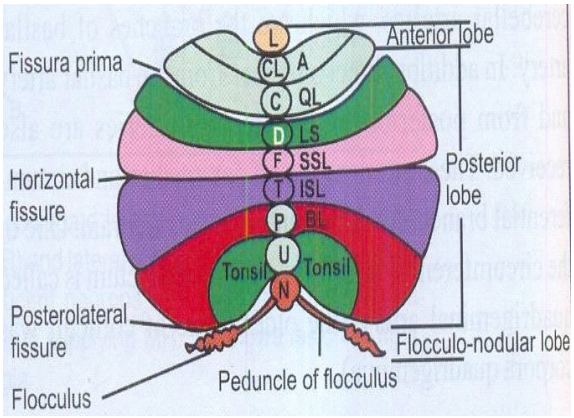
Thalamus – is the central relay station for sensory inputs. It receives all the sensory ascending tracts from spinal cord and brainstem and relays them to cerebrum.

Hypothalamus – regulates ***homeostasis***. It has regulatory areas for thirst, hunger, body temperature, water balance and Blood pressure. It also connects and integrates central nervous system and endocrine system.

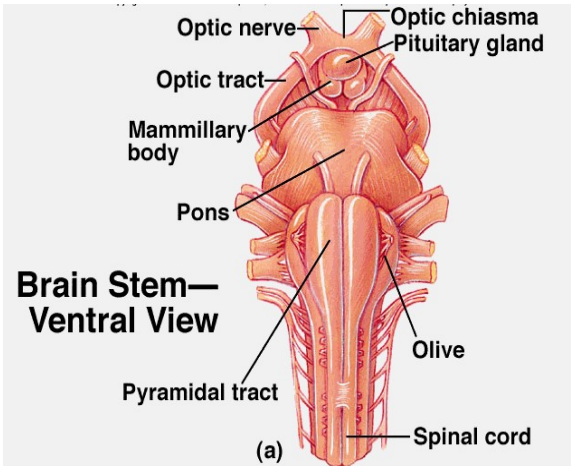
Blood supply of Brain: Brain is supplied by various branches from two pairs of arteries. The ***internal carotid artery*** and the ***vertebral artery***. There is anastomosis between the branches of these arteries in the base of the brain, known as "***Circle of Willis***". The spinal cord receives reinforcements from regional arteries called ***radicular arteries***. The brain drains into specialized endothelium lined thin walled vessels called Dural venous sinuses. There is no lymphatic vessels in the nervous system.



PARTS OF BRAIN



CEREBELLUM



BRAIN STEM

1.4.2 PERIPHERAL NERVOUS SYSTEM

The bundles of nerve fibres that come out of central nervous system constitute the peripheral nervous system. The nerves that are attached to the spinal cord are called spinal nerves. The nerves taking origin from brain are called cranial nerves.

There are 12 pairs of cranial nerves namely, Olfactory, Optic, Oculomotor, Trochlear, Trigeminal, Vagus, Accessory and Hypoglossal. The cranial nerves are either sensory or motor or mixed.

There are 31 pairs of spinal nerves. They are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral & 1 coccygeal. The spinal nerve is a mixed nerve contains both sensory and motor fibres. There is segmental innervation to muscles and skin. ***Dermatome*** is the part of the skin which is supplied by a particular spinal nerve. The spinal nerves which supply the limbs form ***nerve plexuses***. There are five major nerve plexuses in our body i.e. cervical, brachial, lumbar, sacral and coccygeal.

Blood Supply

Peripheral nerves are supplied by special branches from nearest arteries called arteriae nervorum. The venae nervorum drains into nearby veins.

1.4.3 AUTONOMIC NERVOUS SYSTEM

The part of the central as well as the peripheral nervous systems which supply the viscera, blood vessels and smooth muscle are called autonomic nervous system. It has two parts:

a. The sympathetic system
b. The parasympathetic system

The sympathetic system has central connections with the thoracolumbar part of the spinal cord. The parasympathetic system has a cranial part which has connections with brain through cranial nerves 3, 7, 9 and 10 and spinal part which has connections with S2S3S4 sacral segments of spinal cord.

Activity D *1.A 60 year old man suddenly fell to the ground and unconscious for two hours. After examination, he was found to have had a cerebro vascular accident. The person had right sided hemiplegia and left sided hypoglossal nerve palsy.* *Where was the lesion and name the artery that was responsible?*

REVIEW QUESTIONS

Long Essay Question: (3 X 15 = 45)

1. Enumerate the parts of the nervous system. Describe the gross anatomical features of medulla oblongata. Add a note on its blood supply and applied anatomy.
2. Describe the cerebrum in detail.

Short Notes: - (3 X 15 = 15)

1. Cerebellum
2. Spinal Cord
3. Meninges

A.1.5 MUSCULO SKELETAL SYSTEM

The skeletal system is made up of just over 200 bones, joined together to provide a strong, movable, living framework for the body.

TYPES OF BONE TISSUE

Bone tissue is of two types, ***compact*** and ***spongy***. ***Compact*** bone appears to be solid but when it is examined under a microscope, it is found to consist of ***Haversian systems*** which have the following components:

a. A central canal, called a ***Haversian canal***, which contains blood vessels, nerves and lymphatics.

b. Plates of bone, called ***lamellae***, arranged around the central canal.

c. Spaces called ***lacunae***, between the lamellae, which contain bone cells, called ***osteocytes***, and lymph.

d. Fine channels, called ***canaliculi***, between the lacunae and the central canal, carry lymph, which brings nutrients and oxygen to the osteocytes.

Spongy bone is hard but has a spongy appearance to the naked eye. When examined under a microscope the Haversian canals are seen to be much larger and there are fewer lamellae. The spaces in spongy bone are filled with red bone marrow which consists of fat and blood cells.

TYPES OF BONES

There are three types of bones:

a. Long bones

b. Flat bones

c. Irregular bones.

***Long bones*:** A long bone consists of a shaft and two extremities. The shaft has an outer layer of compact bone surrounding a central cavity called the medullary canal which contains yellow bone marrow. The extremities consist of a mass of spongy bone containing red bone marrow covered by a thin layer of compact bone. The bone is covered by a tough sheath of fibrous tissue called the periosteum.

***Flat bones*:** Flat bones consist of two stout layers of compact bone joined by a layer of spongy bone.

Irregular bones: They consist of a mass of spongy bone covered by thin layer of compact bone.

***Surface Irregularities*:** The surfaces of bones show various depressions and projections.

***a) Articular projections*:**

1.Head – round, like a sphere or a disc.

2.Condyle – rounded but oval in outline, like the typical knuckle bone.

***b) Articular depression*:**

1.Socket – a depression into which another bone fits

2.Fossa – a shallow depression.

***Non-articular projections and depressions*:**

These give attachment to muscles or ligaments and are rough.

Non-articular projection:-

1. ***Spine*** – a pointed rough projection, 2. ***Tuberosity*** - a broad rough projection, 3. ***Trochanter*** – a broad rough projection, 4. ***Tubercle*** – a small tuberosity, 5. ***Crest*** – a long rough narrow projecting surface

***Non-articular depressions*:**

1. Fossa – a notch in the bone, 2. ***Groove*** – a long narrow depression.

1.5.1 BONES OF THE HEAD AND TRUNK

The bones of the head and trunk are also known as the axial skeleton, the main support of the body, while the bones of the extremities are known as the appendicular skeleton.

THE BONES OF THE HEAD

The skull may be divided into: 1. The bones of the cranium, 2. The bones of the face

THE BONES OF THE CRANIUM-

The cranium consists of fifteen bones:

1. One frontal bone, 2. Two parietal bones, 3. One occipital bone, 4. Two temporal bones, 5. One ethmoid bone, 6. One sphenoid bone, 7. Two inferior nasal conchae, 8. Two lacrimal bones, 9. Two nasal bones, 10. One vomer.

***The bones of the face*:** The bones of the face are: 1. The maxillae, 2. The mandible, 3. Two zygomatic bones, 4. Two palatine bones, 5. The hyoid bone

***The bones of the trunk*:** The bones of the trunk are: 1. The sternum, 2. 12 pairs of ribs, 3. The vertebral column

***The vertebral column*:** The vertebral column consists of number of irregular bones called the vertebrae. The vertebrae are divided into five groups:

1. Seven cervical vertebrae, 2. Twelve thoracic vertebrae, 3. Five lumbar vertebrae, 4. Five sacral vertebrae, 5. Four coccygeal vertebrae

1.5.2 BONES OF THE LIMBS

***Bones of the Upper limb*:** The bones of the upper limb are:

1. The scapula, 2. The clavicle, 3. The humerus, 4. The radius, 5. The ulna, 6. Eight carpal bones, 7. Five metacarpal bones, 8. Fourteen phalangeal bones.

***Bones of the Lower limb*:** The bones of the lower limb are:

1. The hip bone, which forms part of the pelvis, 2. The femur, 3. The patella, 4. The tibia, 5. The fibula, 6. Seven tarsal bones, 7. Five metatarsal bones, 8. Fourteen phalangeal bones.

The arches of the foot*:** The foot has two main functions: to support the weight of the body and to propel the body forward when walking. To fulfill these functions the foot has ***two longitudinal arches; the medial arch and the lateral arch and a series of transverse arches.

1.5.3 JOINTS OR ARTICULATIONS

A joint or articulation is formed wherever two bones meet. There are three types of joints:

1. ***Fibrous*** or fixed joints
2. ***Cartilaginous*** or slightly movable joints
3. ***Synovial*** or freely movable joints

Fibrous Joints*:** Fibrous joint occurs where the margins of two bones meet and dovetail accurately into one another, separated only by a thin band of fibrous tissue. They are found between the flat bones of the cranium and are called ***sutures.

***Cartilaginous Joints*:** A cartilaginous joint occurs where the two bony surfaces are covered with hyaline cartilage and are connected by a pad of fibro cartilage and by ligaments.

***Synovial Joints*:** A synovial joint consists of two or more bones, the ends of which are covered with articular hyaline cartilage. There is a joint cavity containing synovial fluid. The joint is surrounded by a fibrous capsule lined with synovial membrane which lines the whole of the interior of the joint.

TYPES OF SYNOVIAL JOINT

The synovial joints are divided into several classes according to the axis of movement.

- ***a. Hinge joints*** – allow movement in one direction only. Ex: elbow joint
- ***b. Pivot joints*** – allow rotation; e.g. Superior Radio Ulnar Joint
- ***c. Condylar joints*** –two pairs of articular surfaces allow movement in one direction only. E.g. Knee joint
- ***d. Ellipsoid*** - movements occur in two axes. E.g. Wrist joint
- ***e. Ball-and-socket joints*** – these are formed by a hemispherical head fitting into a cup-shaped socket; E.g.Hip Joint and Shoulder joint
- ***f. Plane joints*** – gliding movements are restricted by ligaments or bony prominences: e.g. carpal and tarsal joints

1.5.4 STRUCTURE OF MUSCLE

The muscular system consists of a large number of muscles through which the movements of the body are carried out. Voluntary muscles are attached to bones, cartilages, ligaments, skin or to other muscles by fibrous structures called ***tendons*** and ***aponeuroses***.

The Muscles of the Head: The muscles of the head are divided into two groups according to their function: (1) ***the muscles of facial expression*** (2) ***the muscles of mastication***.

Circular muscles, called orbicularis oculi and orbicularis oris, surround the eyes and mouth respectively, closing them. Small muscles raise and lower the eyebrows and upper lids, raise and lower the angles of the mouth and dilate the nostrils, causing a look of surprise, worry, happiness or sorrow.

The muscles of mastication move the lower jaw up and down in biting, and also both from side to side and backwards and forwards in chewing. They are the ***masseter***, ***temporalis***, ***medial*** and ***lateral pterygoids***.

The Muscles of the Neck**:** The neck contains two large muscles, the sternocleidomastoid and the trapezius.

The Muscles of the Trunk**:** The chief muscles of the trunk can be grouped according to their function.

Muscles moving the shoulder**:** The chief muscles moving the shoulder are the powerful muscles covering the back and front of the chest. They include ***the pectoralis major***, ***the trapezius***, ***the latissimus dorsi*** and ***the serratus anterior***.

Muscles of respiration**:** The chief muscles of respiration are:

1. The diaphragm, ***2. The external intercostals***, ***3. The internal intercostals***

Muscles forming the abdominal wall**:** The chief muscles of the abdominal wall are:

1.The rectus abdominis, 2. The external oblique, 3. The internal oblique, 4. The transversus abdominis, 5. The quadratus lumborum

***Muscles of the hip*:** The muscles in the trunk moving the hip are:

1. The iliopsoas, 2. The gluteal muscles: maximus, medius and minimus

***Muscles moving the spine*:** The muscles of the abdominal wall flex and turn the trunk, the rectus flexes and the Lateral muscles turn the thorax on the abdomen. The abdominal muscles also compress the internal organs. The spinalis muscles extend the spine.

Muscles of the pelvic diaphragm*:** The pelvic diaphragm consists of muscles which form the support of the pelvic organs. The pelvic diaphragm is composed of the ***levator ani and ***coccygeus*** muscles.

***The Muscles of the upper limb*:** The muscles of the upper limb may be divided into the muscles of the arm, the forearm and the hand.

***The Muscles of the arm*:** The muscles of the arm are: 1. The biceps, 2. The triceps, 3. The deltoid, 4. The brachialis

***The Muscles of the forearm*:** The forearm contains the flexors of the wrist, the common flexors of the fingers, the long flexor of the thumb and the pronator muscles of the wrist. The common flexors of the digits divide into four tendons, which run across the palm of the hand and up to the terminal phalanx of each digit, into which they are inserted. At the back lie the extensors of the wrist, the common extensors of the fingers, the extensor of the thumb and of the index finger, and the supinators of the wrist. The tendons of the muscles which cross the wrist are bound down by the flexor retinaculum anteriorly and extensor retinaculum posteriorly just above the wrist joint.

The Muscles of the hand*:** The hand contains the short flexor of the thumb, and the adductor and abductor muscles for the digits. The latter are termed the ***interosseous muscles. Muscles are only well developed at the base of the thumb and to a lesser extent at the base of the little finger. Here they form the ***thenar*** and ***hypothenar*** eminences, and give power to the grip.

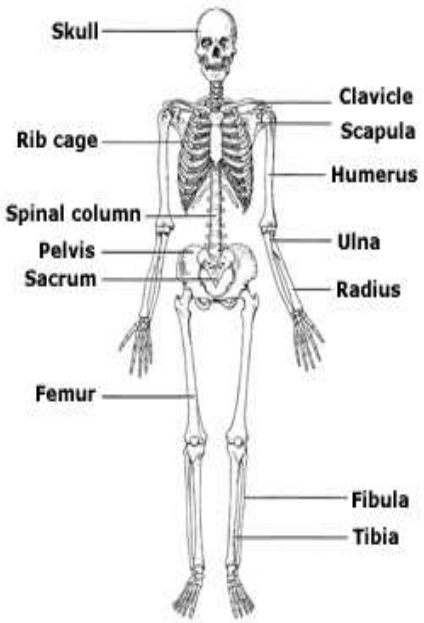
***The Muscles of the lower limb*:** The muscles of the lower limb are much larger and more powerful than those of the upper, as the limb carries the whole weight of the body.

***The Muscles of the thigh*:** The muscles of the thigh are particularly strong and include:

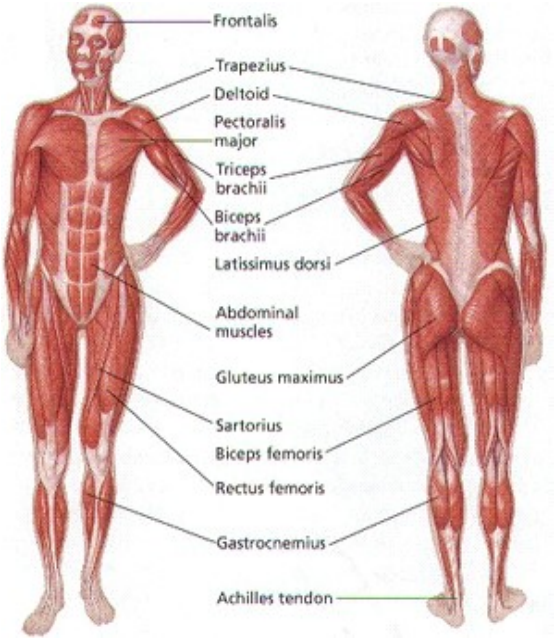
1. The quadriceps femoris, 2. The hamstrings, 3. The sartorius, 4. The adductors of the hip.

***The Muscles of the leg*:** The chief muscles are: 1. The gastrocnemius, 2. The Soleus, 3. The tibialis anterior, 4. The flexors and extensors of the digits

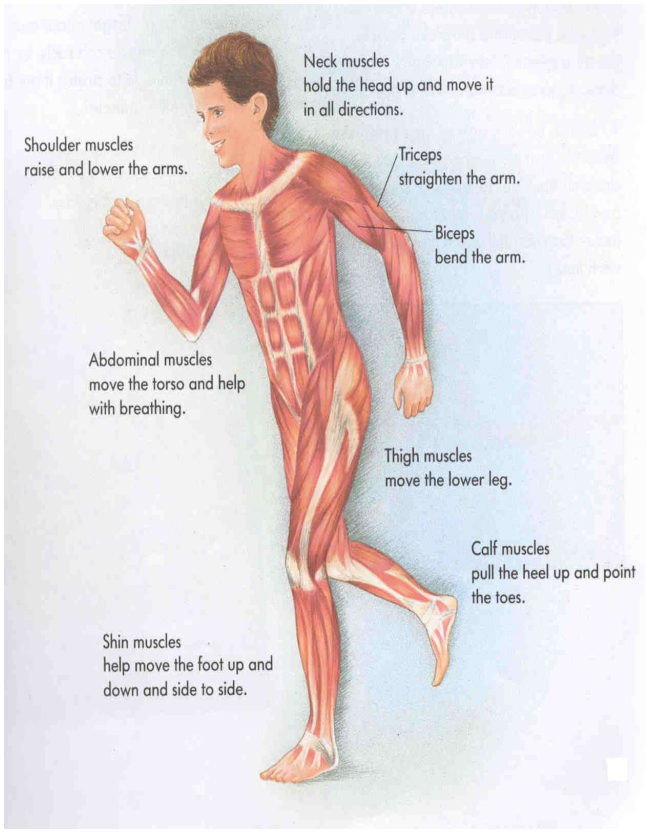
***The Muscles of the foot*:** The chief muscles moving the foot lie largely in the leg. The tendons of the extensors of the digits cross the dorsal surface of the foot, and the big toe having an individual muscle and tendon. The tendons of the flexors of the digits cross the sole and are strong and very important in helping to support the arch of the foot. There is a common flexor for the small toes and a flexor for the big toe. In addition, a short flexor of the toes crosses the sole from the calcaneum to the phalanages, and also gives support to the arch. Small interosseous muscles between the metatarsal bones abduct and adduct the digits.



THE SKELETON



MUSCLES OF THE BODY



FUNCTIONS OF THE MUSCLES

Activity E

An elderly woman with a history of fall on the outstretched hand developed localized pain and a swelling on the dorsal aspect of the wrist. When movements of wrist became painful she was brought to the hospital. X-ray findings confirmed the diagnosis of fracture of the lower end of radius.

1. Questions:

A. Give the name of the fracture of the lower end of the radius and the typical deformity of the hand as a result of this fracture?

REVIEW QUESTIONS

Long Essay Questions: (3 X 15 = 45)

1. Enumerate the muscles of the upper limb and describe briefly about deltoid.

2. Enumerate the muscles of the lower limb and describe gluteus maximus briefly.

3. Enumerate the bones of the lower limb and describe femur briefly.

Short Notes: (3 X 5 = 15)

1. Scaphoid.

2. Sterno cleiodomatoid.

3. Microstructure of striated muscle.

A.1.6 REPRODUCTIVE SYSTEM

In this chapter, we will be studying about the different parts and functions of male and female reproductive system.

1.6.1 MALE REPRODUCTIVE SYSTEM

The organs of male reproductive system include testes, epididymis, ductus deferens, ejaculatory duct and penis with accessory glandular structures, seminal vesicles, prostate and bulbo urethral glands.

TESTES

The testes are the primary reproductive organs in the male. They lie externally in a cutaneous-muscular pouch, the ***scrotum***.

The testis is invested by three coats from outside inwards, the tunica vaginalis, tunica albugenia and tunica vasculosa.

Internally the testis is made of 200 – 300 lobules. Each contains one to three highly convoluted ***seminiferous tubules***. These tubules contain ***germ cells*** which mature into spermatozoa and supporting cells called ***Sertoli cells***. In between the seminiferous tubules, there is loose supporting connective tissue which contains the ***Interstitial cells of Leydig***. These cells secrete testosterone, a hormone which is necessary for the maturation of sperms. The seminiferous tubules open into efferent ductules.

EPIDIDYMIS

It is a tortuous canal, folded and tightly packed and attached postero laterally to the testis in the scrotum.

The parts of the epididymis are head, body and tail. The head receives the efferent ductules of the testis which transports the spermatozoa from the testis. The tail continues as ductus deferens.

DUCTUS DEFERENS [VAS DEFERENS]

It is the distal continuation of epididymis. It starts at the tail of epididymis, ascends along the posterior aspect of the testis and travels in the inguinal canal. It enters the abdominal cavity through the deep inguinal ring. It

runs towards the posterior surface the urinary bladder crossing the major vessels of pelvis and ureter. Here, it unites with the duct of the seminal vesicle to form the ejaculatory duct.

EJACULATORY DUCT

It is formed by the union of the duct of the seminal vesicle with the ductus deferens. It runs through the prostate gland and opens into the prostatic part of urethra at colliculus seminalis.

PENIS

It is the male copulatory organ, comprises of an attached root to the perineum and a free body completely enveloped by skin.

The penis is made up of three masses of erectile tissue, a pair of crura and the bulb of the penis. The crus penis is attached firmly to the pelvic bone. The bulb of the penis lies between the two and contains the penile part of urethra which is the common passage for both urine and semen.

Accessory Glandular Structures

***Seminal Vesicles*:** The pair of seminal vesicles are highly coiled, sacculated tubes located between the bladder and the rectum in the pelvic cavity. 70% of the seminal fluid is secreted by them and poured into ejaculatory ducts. They help in the motility and capacitation of sperms and immuno suppression.

***Prostate*:** The prostate is a fibro musculo glandular structure which is situated around the beginning of the male urethra below the neck of the urinary bladder. It comprises of five lobes and covered by a true capsule and a false capsule. The glands of prostate secrete fluid rich in acid phosphotase and fibrinolysin. It also contributes to the bulk of the seminal fluid. The structure of prostate changes as age advances.

***Bulbo-Urethral glands*:** They are a pair of small glands lie in the deep perineal pouch. Their ductus pierce perineal membrane and open into the spongy part of male urethra.

Blood supply

Arterial Supply:

Testis & Epididymis: Testicular artery a direct branch from abdominal aorta.

Vas Deferens: Artery to vas, a branch from superior vesical artery.

Penis: Deep arteries of penis open into cavernous spaces.

Seminal vesicle: Inferior vesical and middle rectal arteries.

Prostate: Branches from internal pudendal, inferior vesical and middle rectal arteries.

Venous Drainage:

Testis & Epididymis: Testicular veins form a plexus around the vas deferens called pampiniform plexus. It ascends up along the spermatic cord and form a single testicular vein inside the abdomen. The right vein drains into the inferior vena cava and the left into the left renal vein.

Vas Deferens: Testicular vein

Penis: Deep dorsal vein of penis drain into prostatic plexus of veins.

Seminal vesicle: Drain into inferior vesical and middle rectal veins.

Prostate: Veins form a plexus called prostatic plexus and drain into internal iliac veins.

Lymphatic Drainage:

Testis & Epididymis: Lateral and pre aortic nodes.

Vas Deferens: External Iliac nodes.

Seminal Vesicle: Internal Iliac and External Iliac nodes.

Prostate: Internal Iliac & Sacral nodes.

Penis: Deep Inguinal and external iliac nodes. Deep lymphatics drain into internal iliac nodes.

Applied Anatomy:

1. Hydrocele: Accumulation of fluid between the layers of Tunica Vaginalis of Testes.
2. Torsion of Testis: rotation of testes around the spermatic cord. It is often seen in adolescent boys. It may lead to occlusion of testicular artery and necrosis of testes.

3. Testicular carcinoma arises from the germ cells.
4. Vasectomy: vas deferens is cut surgically and the ends are ligated. This procedure is used for family planning.
5. Benign hypetrophy of prostate is commonly seen in old men. It obstructs the urethra and patients will be complaining of difficulty in passing urine.
6. Carcinoma of prostate is the most common malignancy seen in men over 65 years of age.
7. Phimosis: The external opening of urethra at the prepeuce of penis is very small which results in difficulty in passing urine.

1.6.2 FEMALE GENITAL SYSTEM

The organs of female reproductive system consists of ovaries, uterine tubes, uterus and vagina which are situated in the lesser pelvis and are called as internal genital organs and mons pubis, labia majora, labia minora, clitoris and vestibule which are located at perineum and called as external genital organs.

OVARIES

The ovaries are a pair of almond shaped structures located on the lateral pelvic wall. They are covered with germinal epithelium. The ovaries comprise of a cortex which contains germ cells of different stages of maturation and supporting cells and highly vascular medulla which is made of connective tissue.

The maturation of germ cells depend on the hormones FSH and LH secreted by pituitary gland. In one ovarian cycle, one mature ovum is released into the peritoneal cavity and taken up by the fallopian tubes.

FALLOPIAN TUBE

The lie on either side of the uterus. It is about 10 cm long and opens into uterine cavity medially and peritoneal cavity laterally.

The parts of the tube from lateral to medial are fimbria, ampulla, isthmus and intramural. The fimbrial end helps to capture the unfertilized ovum after its release from the ovary.

The fallopian tubes are lined by ciliated columnar epithelium. The cilia help to move the ovum or zygote towards the uterine cavity. The peritoneal fold covering the tube is called broad ligament.

UTERUS

The uterus is a hollow, thick walled, muscular organ. It normally lies in the lesser pelvis between the urinary bladder and rectum.

The uterus is pear shaped and is normally anteverted and antiflexed. It has a fundus, body and cervix. The lumen of the uterus is flat anteroposteriorly, but it is round in cervix. The communication between the body and the cervix is called internal os and between the cervix and the vagina is called external os.

The uterus is made of three layers: Endometrium, Myometrium and Perimetrium. Endometrium undergoes changes during menstrual cycle. The phases are menstrual, proliferative and secretory. This occurs under the influence of hormones of ovary.

The uterus is connected to the bladder, rectum and pelvic walls by various ligaments. These ligaments and muscles of the pelvic walls support the uterus and keep it in position. The important supportive ligaments are uterosacral ligament, transverse cervical ligament and pubocervical ligament. The muscles which support the uterus are pelvic diaphragm and perineal body.

VAGINA

The vagina is the female copulatory organ. It is a fibro muscular tube extends from the uterus to the vestibule. The annular recess present between the cervix and vagina is called ***Fornix.*** Per vaginal examination is done to feel the organs of lesser pelvis through fornix.

EXTERNAL GENITAL ORGANS

The labia minora and the labia majora are a pair of cutaneous folds which enclose the vestibule. The vestibule is the part which contains the vaginal and external urethral orifices.

***Blood supply*:** Ovary is supplied by ovarian artery which is a branch of abdominal aorta. The ovarian vein from right side drains into inferior vena cava and from left drains into left renal vein. The fallopian tubes are supplied by both ovarian artery and uterine artery and are drained by the same veins.

The uterus receives blood supply from a pair of uterine arteries. The ovarian artery supplements the blood supply. The venous drainage is carried by uterine vein.

The vagina is supplied by multiple branches of internal iliac artery.

The female external genital organs are supplied by two external pudendal and one internal pudendal arteries and drained by internal iliac veins.

***Lymphatic Drainage*:** Ovaries and fallopian tubes drain into lateral aortic nodes.

The lymph vessels from the uterus travel all around and drain into lateral aortic and preaortic nodes, external iliac nodes and also into superficial inguinal nodes.

From female external genital organs lymph vessels drain into deep inguinal and internal iliac nodes.

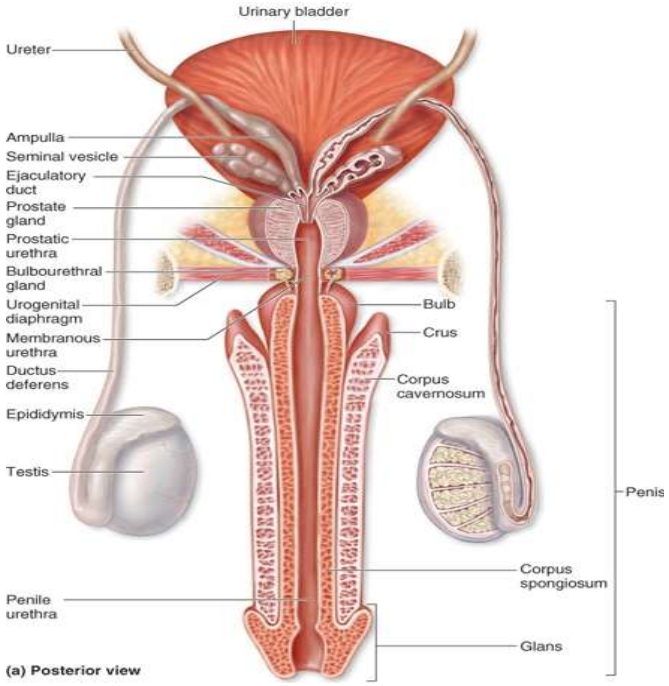
***Applied Anatomy*:**

a. Tumors are common in ovary. It may be a tumor of undifferentiated cells called teratoma or a secondary tumor.
b. ***Tubectomy*** is done to sterilize women for family planning.
c. Block in the fallopian tube due to inflammation may lead to infertility.
d. ***Hystero salphingography*** is the radiological method used to investigate female genital passages.
e. If supports of the uterus become weak, the uterus descends into the vagina. This is called ***prolapse of the uterus***.

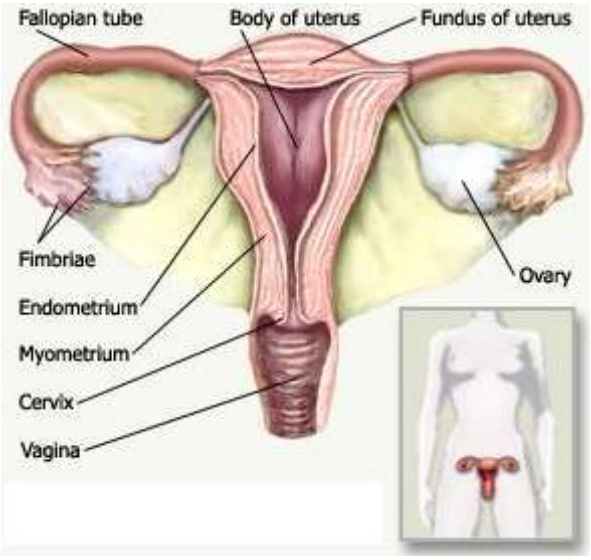
f. Myoma or fibroid is the commonest benign tumor involving the myometrium of uterus.

g. Cervical carcinoma is the commonest malignancy affecting the cervix.

MALE REPRODUCTIIVE SYSTEM



FEMALE REPRODUCTIVE SYSTEM



Activity F

1. A 75 year old man complained, difficulty in passing urine for one year. Per rectal examination revealed enlargement of prostate gland other investigations ruled out prostatic cancer.

What is the diagnosis?

2.A 50 year old woman came to the hospital with a history of feeling mass per vagina. On examination, a mass was felt in the vagina and the size increased when the patient coughed.

What is the diagnosis?

REVIEW QUESTIONS

Long Essay Question: (3 X 14 = 45)

1. Enumerate the male genital organs. Write in detail about testis.

2. Enumerate the female genital organs. Write in detail about uterus.

Short Notes: (3 X 5 = 15)

1. Prostate

2. Ovary

3. Vas deferens

A.1.7 EXCRETORY SYSTEM

The organs concerned with the formation and transport of urine constitute the excretory or the urinary system. This includes the ***Kidneys, Ureters, Urinary Bladder and Urethra***.

1.7.1 KIDNEYS

Each kidney is located in the posterior abdominal wall in the paravertebral gutter. It is ***retroperitoneal***. Each kidney has two poles, two surfaces and two borders. The lateral border of the kidney is smoothly convex while the concave medial border shows the depression of hilum at its middle. The hilum gives passage to the renal vessels and the pelvis of the ureter. The relations of the structures at the hilum in anteroposterior order are renal vein, renal artery and renal pelvis.

Coverings*:** Each kidney has four coverings. From within outward, they are, ***true capsule (fibrous capsule), ***fatty capsule*** (perinephric fat), ***fascial capsule (false capsule, renal fascia or fascia of Gerota)*** and ***paranephric fat***. The fascia of Gerota forms a common covering to the kidney and the suprarenal gland. Its anterior layer is called ***fasica of told*** and posterior layer is called ***fascia of zuckerkandl***.

***Relations of Kidney*:**

Anterior: Right suprarenal, right lobe of liver, II part of duodenum and coils of intestine form the anterior relations of right kidney. The anterior relations of the left kidney are left suprarenal, spleen, stomach, pancreas and coils of intestine.

Posterior: The posterior relations of kidneys are similar. Diaphragm, Psoas Major, Quadratus lumborum, Transversus abdominis muscles, subcostal nerve and vessels, iliohypogastric and ilio inguinal nerves form the posterior relations.

Cross Section of Kidney*:** The kidney is composed of outer ***cortex and inner ***medulla***. The sinus of the kidney is a large area lateral to the hilum and

surrounded by the kidney substance. The sinus contains the branches of renal artery, accompanying veins, ***major and minor calyces***, ***pelvis*** of kidney, nerve plexus and fatty tissue. The cortex is composed of about ***a million nephrons*** per kidney. The medulla consists of about ***6-12 pyramids***. The cortical tissue that extends in between the adjacent pyramids in the medulla is known as ***renal columns***. The apex of each pyramid extends in the minor calyx as a small projection called the ***renal papilla***. The major calyces are usually 2-3 in number and are formed by fusion of minor calyces. The major calyces unite to form the pelvis of kidney.

Microstructure*:** The cortex consists of nephrons, which are the structural and functional units of the kidney. The nephrons consist of four parts: ***Renal corpuscle, Proximal Convoluted Tubule (PCT), Loop of Henle, and Distal Convoluted Tubule (DCT). The renal corpuscle consists of central ***Glomerulus*** (lobulated tuft of capillaries) and ***Bowman's capsule***, which is the blind expanded end of the nephron. The Bowman's capsule has a parietal layer and visceral layer. The cells, lining the visceral layer are called ***podocytes***. ***Juxtaglomerular complex*** is also present in the nephrons.

***Blood Supply*:** The kidneys are supplied by renal arteries which are branches of abdominal aorta. Right and left renal veins drain the venous blood and empties into inferior vena cava.

***Lymphatic Drainage*:** The lymphatics accompany the renal vessels and drain into lateral aortic lymph nodes.

***Nerve Supply*:** Both sympathetic and parasympathetic innervations are provided to the kidney through the renal plexus.

***Applied Anatomy*:**

- The kidney is usually approached surgically through the lumbar region, the advantage being it is a retroperitoneal approach.
- Stone formation called ***renal calculus*** in kidney is a common cause of renal disease.

1.7.2 URETERS

Each ureter is a thick muscular tube which conveys urine from the renal pelvis to the urinary bladder. The average length of the ureter is 25 cm. It extends from the pelviureteric junction to the urinary bladder. The ureter shows **constrictions** at the pelviureteric junction, at the pelvic brim and in the wall of urinary bladder. The ureter is supplied by renal artery and gonadal arteries. Nerve supply to the ureter is by sympathetic innervation through the least splanchnic nerve from T_{12} and parasympathetic innervation is by pelvic splanchnic nerve (S_2 to S_4).

1.7.3 URINARY BLADDER

The urinary bladder is a hollow muscular organ which acts as a temporary reservoir of urine brought to it by ureters. The stored urine is passed out through urethra when the bladder is distended enough to feel the desire to micturate.

***Position, Shape and Capacity*:** In adult, the empty bladder is entirely in the pelvic cavity but a distended bladder rises into the abdominal cavity. The shape of the bladder is tetrahedral when empty and ovoid when distended. The maximum capacity of the bladder is 500 ml.

***Features of the Urinary Bladder*:** The urinary bladder has 4 triangular surfaces, 4 borders and 4 angles. The borders are anterior, right and left lateral (inferolateral) and posterior. The base or fundus is an inverted triangle with its narrow end pointed inferiorly and its broad end superiorly. The apex is the meeting point of superior and inferolateral surfaces. The neck is the lowest and most fixed part of the bladder. The urethra begins at the neck.

Relations*:** The apex points anteriorly and lies behind the upper margin of pubic symphysis. The two vasa deferentia lie side by side and separate the seminal vesicles from each other. The upper part of the posterior surface of the bladder is covered by peritoneum which forms the ***rectovesical pouch.

The superior surface of the bladder is covered with peritoneum and is related to the coils of ileum. The inferolateral surfaces are related in front to the retropubic pad of fat and the pubic bones. The neck of the bladder rests on the upper surface of the prostate.

Interior of the bladder*:** The mucous membrane is thrown into folds called ***Rugae. The mucous membrane covering the internal surface of the base of the bladder is called as the ***Trigone*** and is always smooth because it is firmly adherent to the muscular coat. The trigone is limited above by a muscular ridge called the ***interureteic ridge***. The ***uvula vesicae*** is a small elevation situated immediately behind the urethral orifice, produced by the underlying median lobe of the prostate.

The muscular coat of the bladder is composed of smooth muscle and is arranged as three layers of interlacing bundles known as the ***Detrusor*** muscle. At the neck of the bladder the muscle is thickened to form ***sphincter vesicae***.

***Blood Supply*:** The superior and inferior vesical arteries, branches of the internal iliac arteries supply the bladder. The veins form the vesical venous plexus and drains into the internal iliac vein.

***Lymph Drainage*:** The lymph vessels drain into the internal and external iliac nodes.

***Nerve Supply*:** The nerve supply is from the inferior hypogastric plexus. The sympathetic fibres inhibit contraction of the detrusor muscle and stimulate closure of the sphincter vesicae. The parasympathetic nerves stimulate contraction of the detrusor muscle and inhibit the action of sphincter vesicae.

***Applied Anatomy*:**

- ***Ureteric caluli*** are a very frequent condition.
- The interior of the bladder can be examined by a ***cystoscope***.
- The spinal cord injuries affect the function of the bladder giving rise to ***neurogenic bladder***.

1.7.4 URETHRA

The urethra is very long in male compared to female. It performs dual function of transmission of urine and semen in male.

MALE URETHRA

It begins in the neck of the urinary bladder and ends in the external urethral meatus at the tip of the glans penis.

Parts*:** The male urethra is divisible into four parts – ***Preprostatic, Prostatic, Membranous and ***Spongy or Penile***. The prostatic urethra is the widest and most dilatable part of the urethra, ***urethral crest, colliculus seminalis (Verumontanum)***, openings for ***prostatic utricle*** and ***ejaculatory ducts*** are present in the posterior wall of the prostatic urethra.

***Blood Supply*:** The inferior vesical, middle rectal and penile branches of internal pudendal arteries supply the male urethra. The prostatic venous plexus drain the urethra.

***Lymphatic Drainage*:** Lymph vessels drain into internal and external lymph nodes. The distal part drains into superficial inguinal nodes.

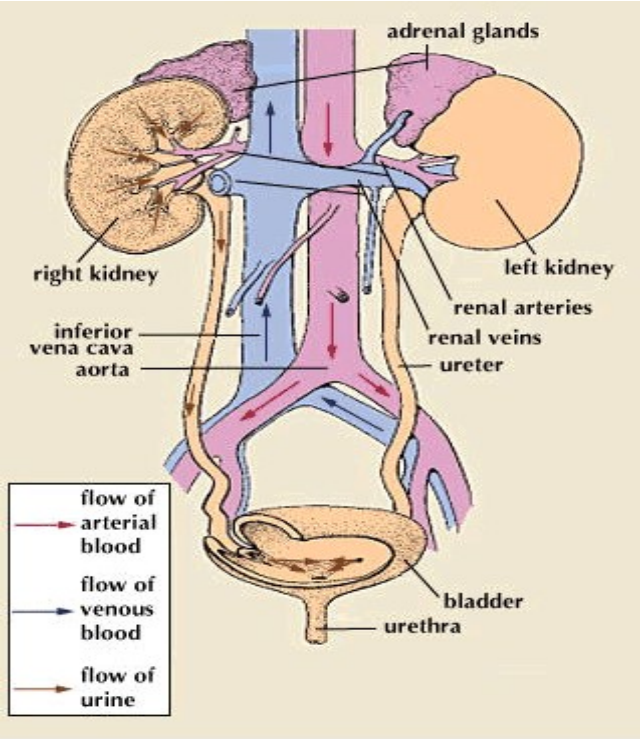
Female Urethra*:** The female urethra is about 4 cm long. It extends from the bladder neck to the external urethral meatus in the vestibule of vagina. The ***paraurethral glands of skene and urethral glands open in the urethra.

***Applied Anatomy*:**

a. In fracture of the pelvic bones, the functional area between prostatic and membranous urethra is ruptured. Extravasation of urine occurs in extra peritoneal tissue of pelvis.

b. ***Urinary stress incontinence*** is a common symptom in women after child birth. ***Kegel's*** exercises strengthen the perineal muscles and relieves the stress incontinence.

EXCRETORY SYSTEM



Activity G

A 30-year-old male, who was riding a bicycle, hit the bar forcibly in an accident. He did not pass urine after the fall. After some time he observed a swelling of the scrotum, penis and lower part of the anterior abdominal wall.

Question:

A. Name the structure that is ruptured and enumerate the parts of this structure in male.

REVIEW QUESTIONS

Long Essay Questions: (3 X 15 = 45)

1. Describe the gross structure of kidney in detail.
2. Describe the urinary bladder in detail.
3. Describe the course, relation and applied anatomy of ureter.

Short Notes: (3 X 5 = 15)

1. Prostatic urethra.
2. Microstructure of kidney.
3. Interior of the bladder.

A.1.8 ENDOCRINE SYSTEM

In this chapter, we will be learning about the different parts and functions of Endocrine system.

The internal environment of our body is regulated and maintained by the endocrine system and the autonomic nervous system. Both the systems are integrated and controlled by hypothalamus. The endocrine system is made of ductless glands and isolated cell clusters which secrete hormones.

The organs of this system are pituitary gland, pineal gland, thyroid and parathyroid glands, adrenal glands and islets of langerhans.

1.8.1 PITUITARY GLAND

Pituitary gland is situated inside the cranial cavity and hangs from the base of the brain. The pituitary stalk connects it with the brain. It is covered by meninges.

The gland has two parts**, *Adenohypophysis*** and ***Neurohypophysis***. The pituitary gland is also known as the “Master gland”. It secretes hormones which control the functions of other endocrine glands. The hormones secreted by Adenohypophysis are, Growth hormone, Mammotropin, Adrenocorticotropin, Thyrotropin, Gonadotropin and Melanocyte stimulating hormone.

Neuro hypophysis secretes vasopressin and oxytocin.

Blood Supply:

The pituitary gland is supplied by superior and inferior hypophyseal arteries. It drains into dural venous sinus.

1.8.2 PINEAL GLAND

The pineal gland is a small gland situated in the dorsal surface of mid brain between the superior collicui.The gland receives sympathetic nerve fibres and secretes neuroepiphysins. It regulates the activities of other endocrine glands.

***Blood supply*:** It is supplied by pineal arteries, branches from posterior choroidal arteries. The pineal veins drain into internal cerebral vein.

1.8.3 THYROID GLAND

Thyroid gland is highly vascular gland placed in the anterior part of lower neck. It is made of two lateral lobes connected by median isthmus. The gland is closely related to trachea and larynx. The gland is made of colloid filled follicles. It secretes hormones called thyroxine and thyrocalcitonin.

***Blood supply*:** Thyroid gland is supplied by superior and inferior thyroid arteries and drained by superior, middle and inferior thyroid veins. The lymph vessels drain into pre tracheal and deep cervical group of lymph nodes.

***Nerve supply*:**

Para sympathetic	:	vagus nerve
Sympathetic	:	cervical part of sympathetic chain

1.8.4 PARATHYROID GLAND

There are two pairs of parathyroid glands, a pair of superior and a pair of inferior, situated along the posterior border of thyroid glands.

They secrete parathormone.

***Blood supply*:** The parathyroids are supplied by twigs from anastomoses between the superior and inferior thyroid arteries.

Veins drain into thyroid veins.

***Nerve supply*:** Sympathetic fibres from superior and middle cervical sympathetic ganglia.

1.8.5 ADRENAL GLAND

The adrenal or suprarenal glands are a pair of yellowish bodies situated immediately anterosuperior to upper pole of kidneys. They are covered by renal fascia.

Each gland has a cortex and medulla. The cortex contains three cellular zones, the zona glomerulosa secreting mineralo corticoids, zona fasciculata secreting gluco corticoids and zona reticularis secreting sex steroids. The medulla secretes adrenaline and nor adrenaline.

***Blood supply*:** Three arteries superior, middle and inferior suprarenal arteries supply the gland.

There is a single suprarenal vein from each gland, which drains into inferior vena cava in right side and left renal vein in left side.

Lymph vessels end in lateral aortic nodes.

***Nerve supply*:** Sympathetic fibres supply both the cortex & medulla.

1.8.6 PANCREATIC ISLETS

The pancreatic islets or islets of Langerhans is part of the endocrine tissue which is embedded in between the exocrine glands of pancreas. There are more than one million islets found in human pancreas. The islets are numerous in the body and tail of the pancreas. There are three types of cells, alpha cells which secrete glucagon, beta cells secreting Insulin and delta cells secreting somatostatin. Glucagon and Insulin are important to maintain the blood glucose level.

***Applied Anatomy*:**

- Tumors of pituitary cause ballooning of pituitary fossa and lead to visual disturbances.
- Pineal gland is important to maintain “Circadian rhythm”.
- Swellings of thyroid gland are called “Goitre” which move with deglutition.

- Hypoparathyroidism results in tetany. Hyperparathyroidism causes softening of bones.
- Pheochromocytoma – is the tumor of adrenal medulla.
- Adenoma or carcinoma of adrenal cortex will cause cushing's syndrome.
- Deficiency of Insulin leads to Diabetes Mellitus.

Activity H   *1. A 30 year old woman had a nodular swelling in the lower part of the neck in the midline. The swelling moved with swallowing.*   *Name the gland that is responsible for midline swelling in the neck?*

REVIEW QUESTIONS

Long Essay Question: (3 x 15 = 45)

1. Enumerate the parts of the endocrine system. Describe the pituitary gland in detail.

2. Describe the Gross anatomical features of thyroid gland. Add a note on its blood supply, function and applied anatomy.

Short Notes: (3 X 5 = 15)

1. Suprarenal gland
2. Islets of Langerhans
3. Parathyroid gland

A.1.9 SPECIAL SENSES

The special sensations include ***Vision***, ***Hearing***, ***Taste***, ***Smell*** and ***Touch***. The organs concerned with these sensations such as ***Eye***, ***Ear***, ***Tongue***, ***Nose*** and ***Skin*** respectively will be dealt in this chapter.

1.9.1 EYEBALL

The ***eyeball*** lie embedded in a pad of fat inside the orbital cavities. Each eyeball has a fascial sheath called the ***Tenon's capsule***.

Coats of the eyeball: -

The eyeball has 3 coats.

I. Fibrous coat**:** The anterior 1/6 is transparent and called ***Cornea*** and posterior 5/6 is opaque and called ***Sclera***.

II. Vascular Coat**:** This coat is pigmented and consists of ***Choroid, Ciliary body*** and ***Iris***.

III. Nervous Coat: This coat is called ***Retina***.

FIBROUS COAT

Sclera**:** Outer convex surface of the sclera is covered by the Tenon's capsule and gives insertion to ***Recti*** and ***Oblique*** muscles of the eyeball. The inner surface is related to choroid from which it is separated by the ***supra choroidal membrane***. Posteriorly 3mm medial to the posterior pole it is pierced by the ***optic nerve***. Anteriorly the sclera is continuous with the cornea at the ***limbus*** or the ***sclerocorneal junctions***.

Cornea**:** It is transparent and avascular. It is made of a) Outer stratified squamous epithelium b) anterior elastic lamina c) substantia propria d) posterior elastic lamina and e) endothelium. It is supplied by ciliary branches of the ophthalmic nerve.

VASCULAR COAT (THE UVEAL TRACT)

Choroid**:** It is the posterior part of the vascular coat which lies deep to the sclera. It contains ***Pigment cells***.

Ciliary Body*:** It is situated at the limbus between the choroid and the iris. It consists of ***a) Ciliary ring, ***b) Ciliary processes*** and ***c) Ciliary muscles***.

***Ciliary Ring*:** It is the anterior continuation of choroid.

Ciliary Processes*:** They are 60 – 80 in number. Anteriorly it is continuous with the iris and posteriorly with the ***suspensory ligament of the lens.

***Ciliary Muscles*:** They consist of radially running outer fibres and inner circular fibres. It is supplied by occulomotor nerve.

Iris*:** It is the anterior part of the vascular coat. It is a thin circular diaphragm suspended in the ***aqueous humour between the ***anterior*** and ***posterior chambers***. There is an opening in the centre of the iris called ***pupil***.

NERVOUS COAT

Retina*:** It is purplish nervous membrane situated inside the choroid for the reception of the light stimuli. Its colour is due to the presence of ***rhodopsin or visual purple pigment. Its inner surface is related to the ***hyaloid membrane*** covering the ***vitreous humour***. In the centre of its posterior part is the ***yellow spot*** or the ***macula lutea*** where acuteness of vision is maximum. ***Fovea centralis*** is a depression in the centre. 3 mm to the nasal side of the macula lutea is the ***optic disc*** where the fibres of the retina converge into the optic nerve. It is insensitive to light and is called the ***blind spot***.

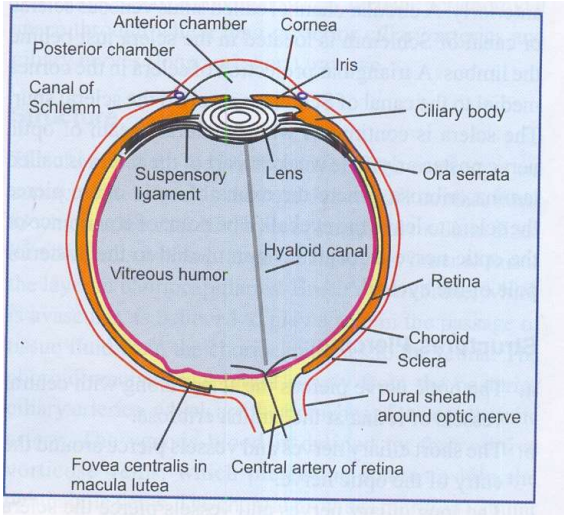
Contents of the Eyeball*:** The contents are ***1) Aqueous humour, ***2) Vitreous humour*** and ***3) Lens***

***Applied Anatomy*:**

1) ***Detachment of Retina*** is a very common clinical condition.

2) Opacity of the lens is called ***Cataract***. It is most common in elderly.

STRUCTURE OF THE EYEBALL



1.9.2 EAR

Ear is the organ of hearing and consists of 3 parts. ***External ear***, ***Middle ear*** and ***Inner ear***.

External Ear: It consists of ***(A) Auricle or Pinna*** and ***(B) External auditory meatus***.

AURICLE

It consists of ***1) Helix***, ***2) Auricular Tubercle***, ***3) Anti helix***, ***4) Triangular Fossa***, ***5) Scaphoid fossa***, ***6) Concha***, ***7) Tragus***, ***8) Antitragus***, ***9) Intertragic notch*** and ***10) Lobe***. The muscles of auricle are supplied by ***facial nerve***.

EXTERNAL AUDITORY MEATUS

It is a tubular passage extending from the bottom of the concha to the ***tympanic membrane***. It has a ***cartilaginous part*** (outer 1/3 of the canal) and a ***bony part*** (inner 2/3).

Middle Ear*:** The middle ear or ***tympanic cavity is situated within the petrous temporal bone between the external and internal ears.

***Boundaries*:** The middle ear has got a roof, floor, and four walls – anterior, posterior, medial and lateral walls.

Contents*:** The contents are auditory ossicles which are ***malleus, ***incus*** and ***stapes***, and the ***tensor tympani*** and ***stapedius*** are the muscles present in it.

Internal Ear*:** The internal ear consists of ***a) Bony Labrynth and ***b) Membranous Labrynth***.

a) Bony Labrynth: -

It consists of cavities situated inside the ***petrous temporal bone***, lined by periosteum and filled with ***perilymph*** in which the ***membranous labrynth*** floats. It consists of ***vestibule***, ***cochlea*** and ***semicircular canals***.

b) Membranous Labrynth: -

It consists of a series of intercommunicating fibrous sacs filled with endolymph. The branches of the ***vestibulocochlear nerve*** end on its walls. It comprises of I. ***Saccule*** and ***Utricle*** are sacs lodged in the vestibule. II. ***Cochlear duct*** situated inside the scala vestibuli of the cochlear canal. III. ***Three semicircular ducts*** situated inside the semicircular canals. The semicircular ducts open into the utricle. The saccule is connected to the utricle through the ***ductus utriculo saccularis***. The cochlear duct is connected to the saccule by the ***ductus reuniens***. The mucula of the saccule is an thickening in its anterior wall. The thickening present in the ampulla of the semicircular ducts are called crista ampullaris. These thickened portions receive the vestibular nerve fibers. **Organ of corti:** It is situated inside the cochlear duct.

***Nerve supply*:** The tympanic membrane is supplied by vagus and auriculotemporal nerves. Middle ear is supplied by the tympanic plexus.

1.9.3 TONGUE

The tongue is a mobile muscular organ located partly in the oral cavity and partly in the oropharynx.

PARTS OF THE TONGUE

The tongue consists of a tip, a root, inferior surface and curved dorsal surface. The tip of the tongue is directed forwards and it remains in contact

with the incisor teeth when the mouth is closed. The inferior surface is covered with mucous membrane. A midline mucosal fold called frenulum linguae connects the inferior surface to the floor of the mouth. The deep lingual vein is located on either side of the ***frenulum linguae***. The sublingual duct opens on the papilla present on either sides of the frenulum.

GROSS APPEARANCE OF THE DORSUM

The dorsum presents a V-shaped sulcus terminalis. At the apex of the V, there is a pit called ***foramen caecum*** which represent the site of origin of embryonic ***thyroglossal duct***, which develops into thyroid gland.

The sulcus terminalis divides the dorsum of the tongue into anterior two-third ***(presulcal or oral)*** and posterior one-third ***(post sulcal or pharyngeal)***.

Anterior Two Third*:** The mucous membrane contains lingual papillae which are projections of the mucosa. There are four types of papillae – ***Filiform, ***Fungiform***, ***Foliate*** and ***Circum vallate***.

a) The ***Filiform*** papillae are conical in shape and are arranged in rows parallel to the sulcus terminalis on either side of the midline.
b) The ***Fungiform*** papillae are found mainly on the margins of the tongue.
c) The ***Foliate*** papillae are present on the lateral margins of the tongue near the sulcus terminalis.
d) The ***Vallate*** papillae are largest in size about 10 – 12 in number and are located just in front of the sulcus terminalis.

Posterior One-Third*:** This part is located in the floor of oropharynx. The mucosa is devoid of papillae, but the ***lingual tonsils give this part a characteristic cobble stone appearance.

Muscles of the Tongue*:** The tongue contains extrinsic and intrinsic muscles. The extrinsic muscles are ***Genioglossus, ***Palatoglossus***, ***Styloglossus***, and ***Hyoglossus***. The right and left superior longitudinal muscles, the right and left inferior longitudinal muscles, vertical muscles and the transverse muscles are the intrinsic muscles of the tongue.

***Motor Nerve Supply*:** All the muscles of the tongue except the palatoglossus are supplied by the hypoglossal nerve. The palatoglossus is supplied by vago-accessory complex through pharyngeal plexus.

***Sensory Nerve Supply*:**

a) Anterior Two-Third: The lingual nerve carries the general sensation and the chorda tympani nerve carries the taste sensation. **b) Posterior One-third: -** Both the general and taste sensations are carried by glossopharyngeal nerve.

Arterial Supply: The lingual artery, a branch of external carotid artery is the main arterial supply of the tongue.

Venous Drainage: - The lingual vein drains the tongue and drains into the internal jugular vein or facial vein.

LYMPHATIC DRAINAGE

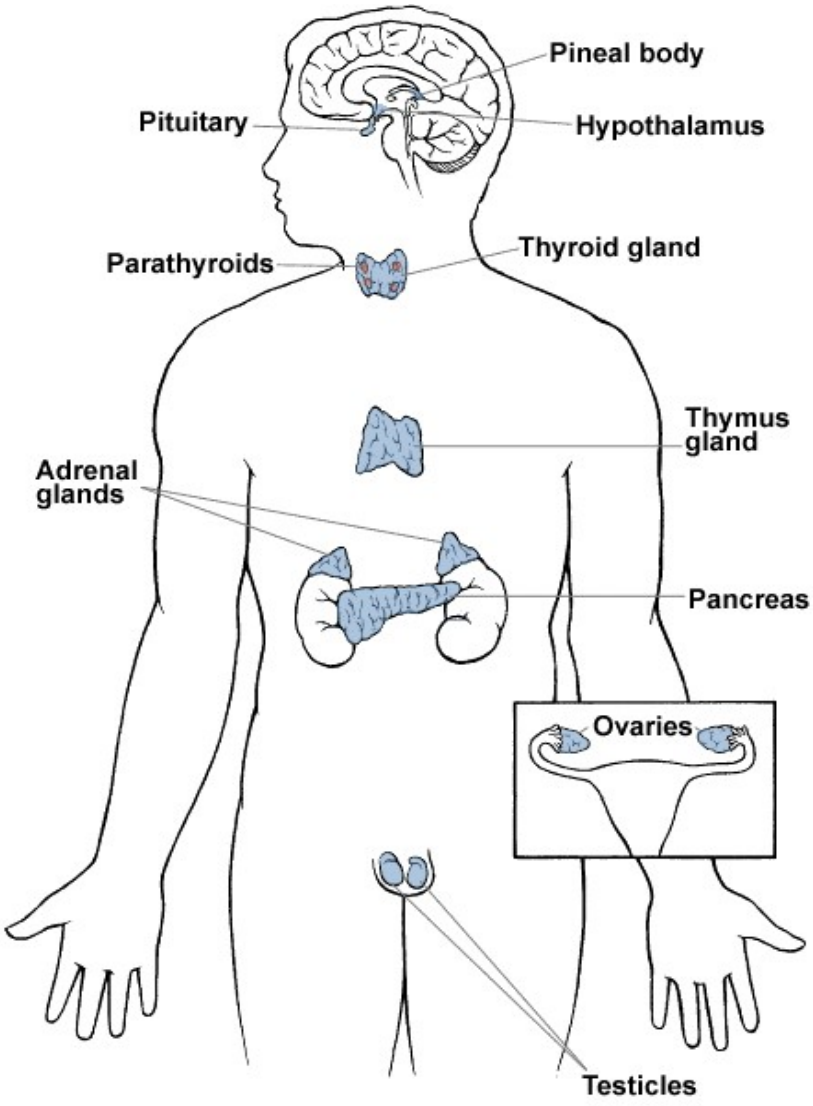
The lymphatic drainage of the tongue is of clinical importance because the cancer spreads via the lymphatics to the regional lymph nodes.

a) Lymphatics from the tip of the tongue drains bilaterally in submental nodes. A few reach to jugulodigastric nodes.
b) The central lymphatics from either side of the mid line drain into jugulodigastric nodes.
c) The lymphatics from the lateral part of the anterior two-thirds reaches the submandibular nodes.
d) The lymphatics from posterior one-third drains into jugulodigastric and jugulo omohyoid nodes.

APPLIED ANATOMY

a) Aphthous ulcer is a small painful ulcer usually on the tip or on the inferior surface of the anterior two-third of the tongue.
b) Congenital anomalies of the tongue include lingual thyroid which may present as a round and red swelling at the foramen caecum on the

ENDOCRINE GLANDS



1.9.4 THE NOSE

The external nose is the visible part of the nose. It is formed by two nasal bones and cartilage. It is both covered and lined by skin and inside there are hairs which help to prevent foreign material from entering. The nasal cavity is a large cavity divided by a septum. The anterior nares are the openings which lead in from without and posterior nares are similar openings at the back leading into the pharynx.

BOUNDARIES OF NASAL CAVITY

The roof is formed by the nasal cartilages, nasal and frontal bones, cribriform plate of ethmoid and body of sphenoid. The floor is formed by the hard and soft palates. The lateral walls are formed by the maxilla, the superior and middle nasal concha of the ethmoid bone and inferior nasal concha. The nasal septum is formed posteriorly by the ***perpendicular plate*** of ***ethmoid bone*** and ***vomer*** while anteriorly it is made of cartilage.

INTERIOR OF THE NASAL CAVITY

The cavity of the nose is lined by ciliated mucous membrane. The olfactory epithelium is situated in the highest part of the nasal cavity, a round cribriform plate of ethmoid bone.

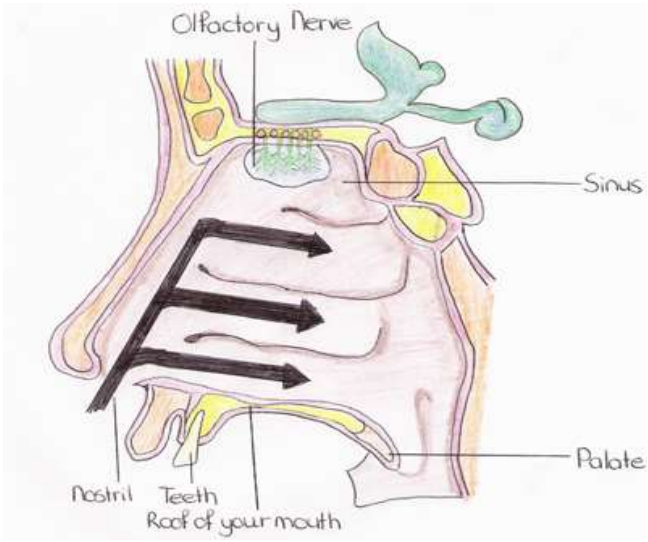
LATERAL WALL

The lateral wall has three bony shelf like elevations called ***superior***, ***middle*** and ***inferior concha***. They increase the surface area. Deep to the concha there are superior, middle and inferior ***meatuses***. The ***nasolacrimal duct***, the ***ethmoidal, maxillary***, ***frontal*** and ***sphenoidal*** air sinuses open into these meatuses.

Blood supply**:** The branches of the internal and external carotid arteries supply the nose. The veins accompany the arteries and drain into the pterygoid venous plexus and facial veins.

Nerve supply**:** The nasopalatine nerve, branches from the spheno palatine ganglion and anterior ethmoidal nerve supply the nose.

Applied Anatomy**:** The roof separates the nasal cavity from anterior cranial fossa. Therefore in fracture of the cribriform plate of ethmoid CSF leaks into the nasal cavity resulting in ***CSF Rhinorrhea***.



NASAL CAVITY SHOWING LATERAL WALL OF THE NOSE

1.9.5 THE SKIN

STRUCTURE OF SKIN

The skin has two layers: 1. The epidermis or outer layer, 2. The dermis.

The epidermis consists of ***Keratinised stratified squamous epithelium***. It is very thick, hard and horny on such areas as the palms of the hands and the soles of the feet and is much thinner and softer over other parts, such as the trunk and the inner sides of the limbs. The epidermis has two layers or zones: the outer is called the ***horny zone***; the inner is called the ***germinative zone***. The horny zone has three layers:

i. The horny layer ***(stratum corneum)*** is the most superficial layer: the cells are flat and have no nuclei.

ii. The clear layer ***(stratum lucidum)*** is composed of cells with clear protoplasm.

iii. The granular layer ***(stratum granulosum)*** is the deepest layer, and consists of several layers of cells with granular protoplasm and distinct nuclei.

The ***germinative zone***, which is deeper, consists of two layers:

i. The prickle cell layer contains cells having short processes, joining them together: the nuclei are distinct.

ii. The basal cell layer consists of columnar cells arranged on a basement membrane.

The corium is a tough elastic layer which is very thick in the palms of the hands and the soles of the feet and very thin in the eyelids. It consists of connective tissue with elastic fibres, blood vessels, lymphatic vessels and nerves. Numerous conical projections, called papillae, extend from the surface of the corium and protrude into the epidermis. The basal layer of cells in contact with the corium contains the pigments which give the skin its colour: yellow, white or black. The nerve endings in the skin are sensory, and of different varieties to give the various different sensations of which the skin is capable, namely, the sensations of touch, heat, cold and pain.

APPENDAGES OF THE SKIN

The skin carries four appendages: ***1. Sweat glands***, ***2. Hairs***, ***3. Nails*** and ***4. Sebaceous glands***.

The sweat glands are twisted, tubular glands which lie deep in the true skin. The hairs consist of modified epithelium. They grow from tiny pits in the skin, known as hair follicles. The nails are horny plates of modified epithelium which protect the tips of the digits. The sebaceous glands are small saccular glands which secrete an oily substance called sebum. They are situated in the angle between the hair follicle and the arrector pili muscle.

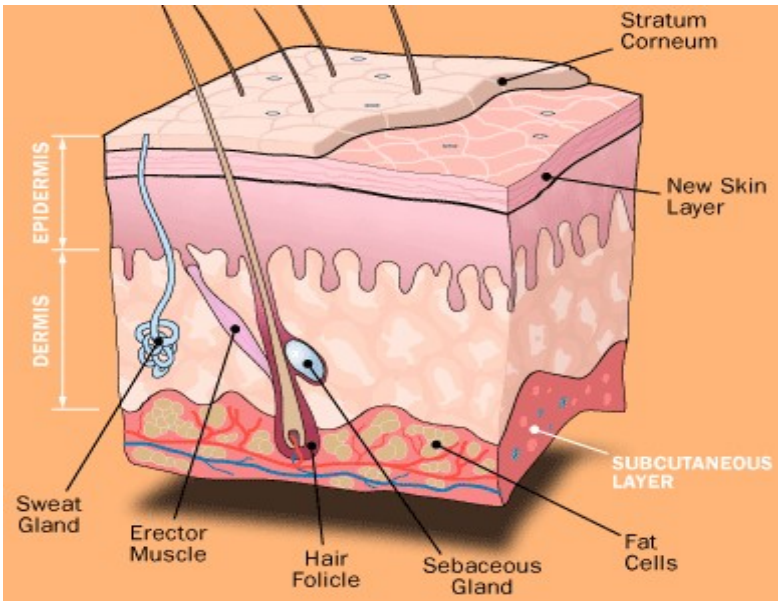
FUNCTIONS OF THE SKIN

The functions of the skin are:

a. to regulate body temperature

b. to secrete waste products

To make us aware of our environment, as the organ of touch and other senses.



STRUCTURE OF SKIN

Activity I

On speculum examination, it was noted that the external acoustic meatus (ear canal) was full of wax in a patient.

Question:

a. *Name the gland that secretes earwax.*

b. *Name the parts of the external acoustic meatus.*

c. *Give the nerve supply of the external acoustic meatus.*

REVIEW QUESTIONS

Long Essay Questions: (3 X 15 = 45)

1. Describe the middle ear in detail.
2. Describe the dorsum of the tongue in detail.
3. Describe the lateral wall of the nasal cavity in detail.

Short Notes: (3 X 5 = 15)

1. Structure of a skin.
2. Retina.
3. Organ of corti

SUMMARY

Human Anatomy is the scientific study of the morphology of adult human body. In this unit, we have gone through details regarding the digestive system, respiratory system, circulatory system, central nervous system, muscular skeletal system, reproductive system, excretory system, endocrine glands and special senses like eye, ear, tongue, nose and skin. The structure of each system has been explained along with their types which provides the reader an understanding of the various systems of Human Anatomy.

KEYWORDS

Blood supply	Nerve Supply
Subdural space	Subarachnoid space
Cerebro spinal fluid	Cerebrum

REFERENCES

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Activities Answers

A) Answer

A. The right kidney

B) Answer

1. Pleural Effusion

2. Injury to recurrent laryngeal nerve which supplies the intrinsic muscles of larynx.

C) Answer: B

D) Answer

Lesion was in the left side of medulla oblongata.The artery involved was posterior inferior cerebellar artery.

E) Answer:

A. Colles' fracture – dinner fork deformity.

F) Answers

1. Benign hypertrophy of the prostate.

2. Prolapse uterus

G) Answer

A. Urethra is ruptured. The parts of the male urethra are, preprostatic, prostatic, membranous and spongy.

H) Answer: *Thyroid gland*

I) Answer:

a. Ceruminous glands of external acoustic meatus are modified sweatglands.

b. The parts of external acoustic meatus are, lateral cartilaginous and medial bony parts.

c. The external acoustic meatus receives branches from auriculotemporal nerve.

Unit 2

MEDICAL TERMINOLOGY

Structure
Overview
Learning Objectives
2.1 Reasons for using Medical Terms
2.2 Glossary of Medical Terms
Summary
Keywords
Review Questions
Suggested Readings

OVERVIEW

Medical terminology is a specialized language used by health care practitioners. As like a foreign language, it has its own vocabulary and ways of stringing together words in an acceptable format that is understandable to everyone. But, unlike a foreign language, the medical terminology is used every day in magazines and newspapers with articles about new drugs, diets, new medical treatments and on television medical dramas. Therefore it becomes utmost important for a hospital administrator to know the meaning and context for every word that is being used.

LEARNING OBJECTIVES

Upon completion of this unit the candidate should be able to

- Find reasons for using medical terms
- List out the Glossary of medical terms

2.1 REASONS FOR USING MEDICAL TERMS

What follows is a mini-course in medical terminology which contains approximately 300 words. The purpose is to learn the basics of the medical terms to understand, recognize and learn new terms. Many medical terms have interesting, even weird meanings or stories behind their evolution as words.

MAJOR PARTS OF A MEDICAL TERM

PREFIX CHANGE

Myocarditis	=	muscle layer of heart inflamed
Pericarditis	=	outer layer of heart inflamed
Endocarditis	=	inner layer of heart inflamed

SUFFIX CHANGE

Cardiologist	=	a physician specializing in the heart
Cardiomyopathy	=	damage to heart muscle layer
Cardiomegaly	=	enlargement of the heart

TECHNICOLOR TERMS

Leuk/o	=	white leukemia (overabundance of white blood cells)
Melan/o	=	black melanoma (black tumor of the skin)
Cyan/o	=	blue cyanosis (blueness may be due to cold or not enough oxygen in blood)
xanth/o	=	yellow xanthoma (yellow tumor)

TUMOR TALK

Adding – oma (a swelling) to organ and tissue word roots names tumors. Not all tumors are malignant (cancerous). Many are benign (not life-threatening).

Aden/o	=	gland	adenoma
Lip/o	=	fat	lipoma
My/o	=	muscle	myoma
Lymph/o	=	lymph tissue	lymphoma
Carcin/o	=	malignant	carcinoma
Osteo/o	=	bone	osteoma

Endo	=	within, inside of	endoscopy (to inspect the inside of an organ or space with a lighted instrument)
Peri	=	around	perianal (around the anus)
Circum	=	around	circumcise (cut around)
Retro	=	behind	retrosternal (behind the breastbone)
Epi utermost	=	upon, on top	epidermis (the top or layer of skin)
Trans the	=	through	transurethral (through urinary exit duct)
Intra	=	within	intravenous (inside the veins, e.g. IV fluids)
Sub	=	below	subclavian (below the clavicle collar bone)

The word parts that make up medical terminology are prefixes, suffixes and word roots. The most typical sequence is prefix, word root, suffix with the word root being central but this is not always the case. In short, putting a hyphen in front of a suffix to indicate it is added to the end of a word, example, -itis. Prefixes and word roots are shown as freestanding word parts. At times slash and a vowel are added. Example, melan/o.

CIRCULATORY SYSTEM TERMS

Cardi/o	= heart	Endocarditis, myocarditis, pericarditis (inflammation of the lining, the muscle layer, the outer layer of the heart)

Brady/tachy tachycardia	= slow/fast	Bradycardi (rate<60) (rate>100)
Angi/o	= vessel	Angiography, angiogram (X-ray of artery)
Veno/phlebo	= vein	Venogram (X-ray of veins), Phlebitis (inflammation of veins)
-stasis	= to stop	Hemostasis (to stop bleeding), hemostat (a clamp-like instrument)
-cyte	= cell	Erythrocytes, leucocytes (red, white blood cells)
Hem/o, -emia	= blood	Hypoxemia (low oxygen) Hematosalpinx (blood in the uterine tubes)

NERVOUS SYSTEM

Cephal/o	Head	Cephalgia (a headache)
Encephal/o	Inside the head (brain)	Encephalitis (inflammation of the brain) Anencephalic (born without a brain)
Mening/o	Membranes surrounding the brain and spinal cord	Meningitis (inflammation of the membranes)
Myel/o	Spinal cord	Myelogram (X-ray of the spinal cord)
Neur/o	Nerve	Neuroma (tumor) Neuritis (inflammation)

Dys	Difficult, painful, abnormal	Dyslexia (difficulty reading)
-cele	Hernia, abnormal protrusion of structure out of normal anatomical position	Meningomyelocele (Protrusion of membranes and spinal cord)
pathy	Disease, abnormality	Encephalopathy (disease of the brain) Neuropathy (disease of the nerves)
-plasia	Development, formation, growth	Aplasia (no development) Hyperplasia (over development)
-plegia	Paralysis	Hemiplegia (paralysis of one side of the body Quadriplegia (paralysis of all four limbs)

DIGESTIVE SYSTEM

Gastr/o	Stomach	Gastritis, Gastrectomy
Chol/e	Gall, bile	Cholecystitis, Cholecystectomy inflammation of, removal of gallbladder)
Cyst/o	Bladder, sac	(see above)
Emes/o	Vomit	Emesis (vomiting), emetic (stimulating vomiting), antiemetic (stopping vomiting)
Lith/o	Stone	Cholelithotomy (removal of gall stones)
Lapar/o	Abdominal wall	Laparotomy (cutting into the abdomen)

-centesis	To puncture	Abdominocentesis (puncturing and draining)
-tripsy	To crush	Cholelithotripsy (smashing gall stones with sound waves)
-rrhea	Flow, discharge	Diarrhea
-iasis	Abnormal condition	Cholelithiasis (presence of gall stones causing (-osis) symptoms)

RESPIRATORY SYSTEM

Rhin/o	Nose	Rhinitis, rhinorrhea (inflammation of and “runny” nose)
Laryng/o	*Larynx, “voice box”	Laryngotomy, Laryngectomy (cutting into, surgically Removing the larynx)
Trache/o	Trachea, “windpipe”	Tracheotomy, tracheostomy (temporary and permanent openings)
Bronch/o	Lung air passageways	Bronchoscopy (looking into the Bronchi)
Pne/u, -pnea	Breath, air, lung	Tachypnea, dyspnea, apnea (accelerated difficult/painful, cessation of breathing)
Pulmo/o	Lung	Pulmonary artery
-ptysis	Spitting (coughing)	Hemoptysis (spitting or coughing up blood from lungs)
-plasty	Reconstruction	Rhinoplasty (surgical reconstruction of nose)

***ADAM'S APPLE**

Everyone is familiar with the bulge in the front of the neck we call an 'Adam's apple'. This structure, termed the laryngeal prominence, is a cartilage in the 'voice box' or larynx. Terstosterone, the male hormone, enlarges the larynx in males which also lengthens the vocal cords lowering the voice at puberty. Folklore has it that the "forbidden fruit" offered by Eve got stuck in Adam's throat. The fruit is not identified in Genesis. However, in art it is traditionally portrayed as an apple. The forbidden fruit was from the tree of knowledge of good and evil. The Latin word for evil, malum, also means apple. The Latin root is found in such words as malady and malignant.

URINARY SYSTEM

Nephro/o, ren/o	Kidney	Nephritis, renal artery
Hydro/o	Water	Hydronephrosis (abnormal condition involving back up of urine into the kidney)
Cyst/o	Bladder	Cystitis, cystectomy (inflammation of, removal of bladder)
Pyel/o	Renal collecting	Pyelogram (X-ray of the collecting ducts)
Ur/o, -uria	Urine	Polyuria, anuria (frequent urination, no urine formation)
Oilig/o	Scanty, less than normal	Oliguria (reduced urine formation)
-pexy	fix in normal position	To surgically reattach Nephropexy (surgically attach kidney in normal anatomical position)

REPRODUCTIVE SYSTEM – MALE

Orchid/o	Testes (male gonad)	Orchiditis orchidectomy Testicular artery, Testosterone (male sex hormone)
Balan/o	Head of the penis	Balanitis
Andr/o	Male	Androgenic stimulating maleness androgynous characteristics of male and female appearance
Prostat/o	Prostate	Prostatitis, prostatectomy
Vas/o	Vessel, duct	Vas deferens, vasectomy (duct carrying semen from testes, cutting the duct)
—rrhaphy	To suture	Herniorrhaphy (surgical correction of inguinal hernia

TESTIS

The testis, testify, testimonial and testament all share a common root meaning. Testis means “witness” in Latin. As the testis witnesses to manhood, you may witness to the truth at trial, proclaim your favorite brand of corn flakes or witness to your final wishes in your will. If you die without a will, you die “interstate”, without having witnessed.

REPRODUCTIVE SYSTEM – FEMALE

Hyster/o	Uterus	Hysterectomy, endometritis
Metr/o		(inflammation of the lining of uterus)
Salping/o	Uterine tube	Salpingitis, hematosalpinx (blood in

Salpinx		the uterine tube)
Colp/o	Vagina	Colporrhaphy (suturing a tear) Colpoplasty (surgical reconstruction) Colposcopy (viewing the interior)
Oophor/o	Ovary	Oophorectomy, oophoropexy (surgery fixation, reattachment)
Men/o	Menstruation	Menarche (first), dysmenorrheal (painful menstruation)
Mamm/o	Breast	Mammogram, mastectomy
Mast/o		
-pareunia, coitus	Intercourse	Dyspareunia (painful intercourse) precoital, postcoital (before and after intercourse)

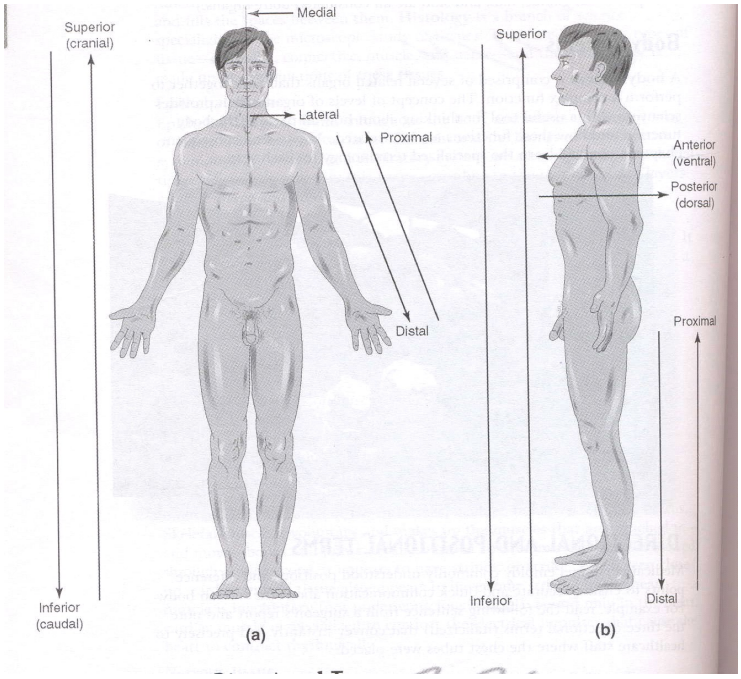
MUSCULAR SKELETAL SYSTEM

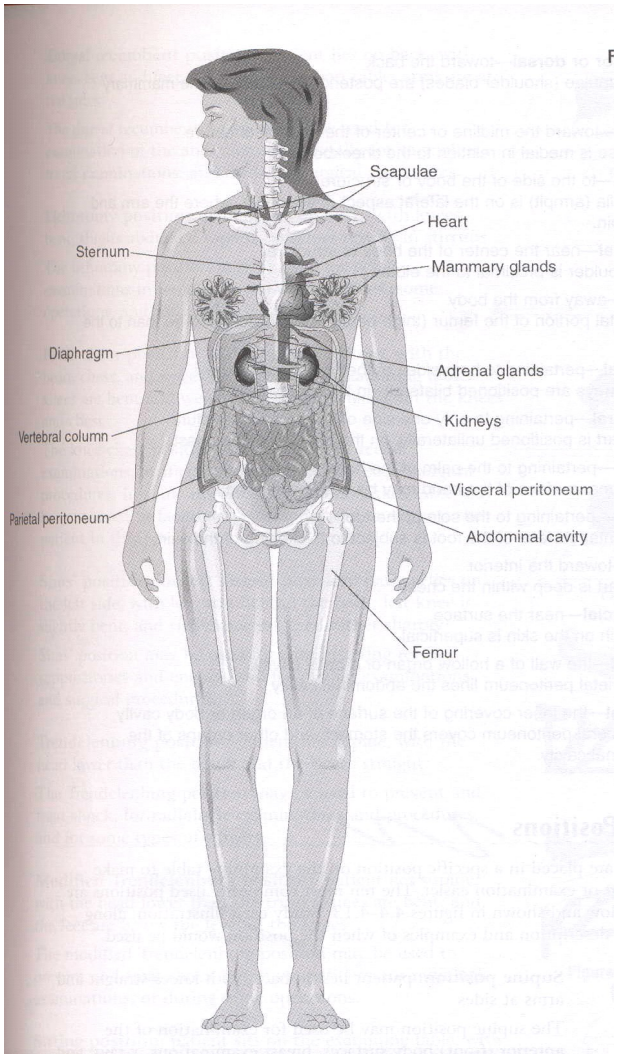
Oste/o	Bone	Osteitis, osteoma, osteocyte
Chondr/o	Cartilage	Chondritis, chondroma, chondrocyte
Arthr/o	Joint	Arthritis, arthroplasty
Myel/o	Bone marrow	Myeloma
Ten/o, tendin/o	Tendon (binds Muscle to bone)	Tendonitis, tenorrhaphy
Ligament/o	Ligament (binds bone to bone)	Ligamentous injury
Burs/o	Bursa,"bag",(shock absorber between tendons and bones)	Bursitis
My/o, Myos/o	muscle	Myoma, myositis

-malacia	Softening	Osteomalacia, chondromalacia
-porosis	Porous	Osteoporosis
-asthenia	Weakness, loss of strength	Myasthenia gravis
-trophy	Development, stimulation, maintenance	Atrophy (shriveling of muscles), hypertrophy (increase in size and strength of muscles)
-algia, algesia	Pain	Myalgia, arthralgia, analgesia (take away pain)

ANATOMICAL POSITION

Anatomical position is used as a reference position in medical communication and assumes that the patient is standing, facing forward, with arms at the sides, palms out, legs straight, and feet flat on the floor with toes pointing forward (figure 0.0 shows frontal and side views). Imagining a person in anatomical position gives uniform reference points for anyone describing areas of the body.





DIRECTIONAL TERMS

The following directional terms are part of the core medical vocabulary that is used to communicate about every body system. To learn the meaning of the directions, reach each term and the sentence that accompanies it. Then look at figures 0.0 and 0.0 and locate the anatomical parts mentioned, noting their positions relative to each other. Note that these terms are usually in pairs that have opposite meanings.

Superior or cephalic – toward the head, the surface, or the upper portion of the body.
The heart is superior to the diaphragm.

Inferior or caudal	–	toward the feet or lower portion of the body. The kidneys are inferior to the adrenal glands.
Anterior or ventral	–	toward the front of the body. The sternum is anterior to the vertebral column.
Posterior or dorsal	–	toward the back. The scapulae (shoulder blades) are posterior in relation to the mammary glands.
Medial	–	toward the midline or center of the body or structure. The nose is medial in relation to the cheekbone.
Lateral	–	to the side of the body or structure. The axilla (armpit) is on the lateral aspect of the chest, where the arm and chest join.
Proximal	–	near the center of the body or structure. The shoulder is proximal to the elbow.
Distal	–	away from the body. The distal portion of the femur (thigh bone) is closer to the knee than to the hip.
Bilateral	–	pertaining to both sides of the body or structure. The kidneys are positioned bilaterally in the lower back.
Unilateral	–	pertaining to only one side of the body or structure. The heart is positioned unilaterally, on the left side of the chest.
Palmar	–	pertaining to the palm of the hand. The palmar surface of the hand may be heavily creased.
Plantar	–	pertaining to the sole of the foot. The plantar surface of the foot is subject to thickening of the skin.

Deep – toward the interior. The heart is deep within the chest.

Superficial – near the surface. A scratch on the skin is superficial.

Parietal – the wall of a hollow organ or a body cavity. The parietal peritoneum lines the abdominal cavity.

Visceral – the inner covering of the surface of an organ or body cavity. The visceral peritoneum covers the stomach and other organs of the abdominal cavity.

TERMINOLOGIES IN ONCOLOGY

Oncology is the study field of cancer terms and an oncologist is a cancer specialist. The terms are grouped and defined in broad categories such as tumor types, causes and treatments.

CANCER TERMINOLOGIES

GOOD NEWS	BAD NEWS
Benign	Malignant
Low grade	High grade
Radiosensitive	Radioresistant
No metastases	metastases
Well differentiated	Poorly differentiated
Negative nodes	Positive nodes
In remission	Relapse
Surgically respectable	Inoperable

TUMOR TYPES

Malignant vs. **benign** (literally, “evil” versus “good”)

Tumors are masses of cells that have slipped the bonds of control of cell multiplication. Malignant tumors, cancers, are life-threatening because they

are invasive (spread into surrounding organs) and **metastasize** (travel to other areas of the body to form new tumors). Specifically, invasiveness results in penetration, compression and destruction of surrounding tissue causing such problems as loss of organ function (liver, kidneys), difficulty breathing (lungs), obstruction (intestines), possible catastrophic bleeding, and severe pain. Metastasis repeats the process recruiting other organs to the cancer.

Carcinoma

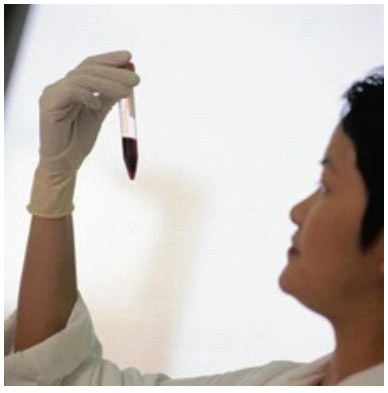
Carcinoma is the most common form of cancer. By definition, this type develops from epithelia (sheets of cells that cover a surface, example-skin, or line a body cavity, example-glandular lining of stomach). Some names for tumors of this type would be: carcinoma of the prostate, adenocarcinoma of the lung, hepatocellular carcinoma.

Sarcoma

A rarer form of cancer that arises from connective and supportive tissues, Examples: bone, bone marrow, muscle, lymphatics. Some names of this type of tumor would be: osteosarcoma (malignancy of bone), multiple myeloma (malignancy of bone marrow).

Grading and Staging

Tumor **biopsies** (tissue samples) are examined microscopically to determine type and degree of development A grading scale is used, Grade I to Grade IV, to describe tumor tissues as well differentiated (still look like the original source tissue which is good) to poorly differentiated (has taken on a more primitive structure and may not resemble its original tissue source which is bad).



Staging tumor biopsies evaluates whether they have invaded surrounding tissue, have involved lymphatics (drainage channels for cell fluids other than blood) and whether they have metastasized to other sites in the body.

Grading and staging tumors are important ways to predict the progress and outcome of the disease, called the “prognosis” and the type of treatments that may most likely succeed. In general low grade tumors that have not invaded tissues, have not involved lymph nodes (negative nodes) and have not metastasized would be expected to have a better prognosis than a high grade tumor that has invaded tissues, has invaded lymphatics (positive nodes) and has metastasized. However, the prognosis of any individual patient is much more complicated than described here. Complicating factors include the general health of the patient, the effectiveness of their immune system and what kinds of treatments are available for various tumor types. Also, some tumor types are very “aggressive” in spreading and highly resistant to treatment.

Causes of Cancer

Any injury to DNA (the genetic code) may result in loss of control of cell division and the cell population multiplying out of control. **Carcinogens** are cancer causing agents. Broad categories include radiation exposure, chemicals, drugs and viruses. Only certain types of chemicals, drugs and viruses are carcinogens and excessive radiation exposure. Common cold and flu viruses are not associated with cancer. The excessive radiation whether it is nuclear or ordinary sunlight can significantly increase the risk of malignancy. The Human Papilla virus is the major cause of cervical cancer. Environmental chemicals found in tobacco smoke and automotive exhaust, toxic emissions from factory smokestacks, and asbestos exposure can be carcinogenic.

MEDICAL TERMINOLOGIES

Brands are the proprietary names and trademarks of the pharmaceutical companies that make and distribute them. Names in parentheses are generic or chemical names that can be seen in the labels of the medicines.

CATEGORY	UNDERSTANDING TERMS	PURPOSE	SAMPLES
Analgesics	Pain pills	Headaches, Muscle aches And pains	Aleve (naproxen) Aspirin Celebrex (celecoxib) Codeine Motrin (ibuprofen) Tylenol (acetaminophen)
Antacids	Indigestion Pills	Heartburn	Prevacid (lansoprazole) Tums Zantac (ranitidine)
Antiarthritic	Rheumatism pills	Rheumatoid arthritis	Aspirin Aleve (naproxin) Celebrex (celecoxib) Humira (adalimumab) Remicade (infliximab)
Antibiotics	Bug killers	Microbial infections	Amoxil (amoxicillin) Erythromycin Keflex (cephalexin) Pen-Vee (Penicillin) Septra (sulfamethoxazole) Vibramycin (doxycycline)
Anticoagulants	Blood thinners	Preventing Blood clots	Coumadin (warfarin) Heparin
Anticonvulsants	Epilepsy Drugs	Prevent Seizures	Dilantin (phenytoin) Phenobarbital Neurontin (gabapentin)
Antidepressants	Uppers	Relieve Depression	Elavil (amitriptyline) Prozac (fluoxetine) Tofranil (imipramine) Zoloft (sertraline)
Antihistamines	Cold and Flu pills	Stops runny Nose, wheezing And itchiness	Allegra (fexofenadine) Benadryl (diphenhydramine) Claritin (loratadine)
Antihyperlipidemics	Cholesterol Pills	Lower Cholesterol Levels	Lipitor (atorvastatin) Niaspan (Niacin) Pravachol (pravastatin) Zocor (simvastatin)
Antihypertensives	Blood Pressure Pills	Lowers high Blood pressure	Norvasc (amlodipine besylate) Captopen (captopril) Inderal (propranolol) Lotensin (benazepril) Tenormin (atenolol) Zestril (lisinopril)
Cardiac drugs	Heart medicine	Treat abnormal heart rhythms, heart failure, angina pain	Cardizem (diltiazem) Cordarone (amiodarone) Inderal (propranolol) Lanoxin (digoxin) Nitrostat (nitroglycerin)
Diuretics	Water pills	Lower high blood pressure, treat congestive heart failure	Hydrodiuril (hydrochlorothiazide) Lasix (furosemide)
Erectile Dysfunction	Man's best friend	impotency	Cialis (tadalafil) Levitra(vardenafil) Viagra (sildenafil)
Hypnotics	sleeping pills	insomnia	Ambien (zolpidem tartrate) Lunesta (eszopiclone) Sonata (zaleplon)
Hypoglycemic agents	Diabetic drugs	Lowers high blood sugar	Diabeta (Glyburide) Glucophage (metformin) Glucotrol (glipizide) Insulin
Osteoporosis therapy	Mom's bone pills	Strengthens bones	Actonel (risendronate) Boniva (ibandronate) Fosamax (alendronate)
Tranquilizers	Downers	Anxiety	Valium (diazepam) Xanax (alprazolam)

2.2 GLOSSARY OF MEDICAL TERMS

The following information helps in understanding medical abbreviations.

1. There are numerous medical abbreviations. Only samples are given in this chapter.
2. The necessity to learn certain medical abbreviations is directly related to a student's health career plan. For example, laboratory abbreviations and terms are essential for students planning to be medical technicians.
3. Physician's handwriting, especially abbreviations, are difficult to read.

COMMON CHARTING TERMS

TERMS	MEANING
acute	a condition with severe symptoms and a short course - Example : Chickenpox is an acute illness of childhood.
benign	mild; Non cancerous Example: Even a benign tumor within the skull can cause severe symptoms.
chronic	a condition that develops slowly and persists over time. Example: Emphysema, a disease of the respiratory system, is often chronic.
degeneration or degenerative disease	gradual, progressive deterioration of body structure or function over time Example: Degenerative joint disease (DJD) can result in limited ambulation.
diagnosis	a physician's determination of the existence of disease based on objective and subjective findings (dia- = through; -gnosis = knowing)

	Example: A physician's diagnosis is found in the analysis section of the SOAP progress notes
etiology	cause of a disease (etio- = cause; -logy = study of) Example: In the 1700s the etiology of smallpox was not understood.
exacerbation	increase in severity Example: Stress from the automobile accident caused an exacerbation of the patient's hypertension.
febrile	having an elevated temperature Example: The patient was febrile upon arrival
gross	visible to the naked eye Example: On gross examination, the specimen container appeared to be contaminated.
Idiopathic	lacking a clearly defined cause Example: At present, Alzheimer's disease is an idiopathic illness.
localized	confined to a specific area Example: There is a localized area of edema of approximately 15 m on the dorsal aspect of the left forearm.
malignant	harmful, cancerous, or invasive Example: Rhabdomyosarcoma is a highly malignant form of cancer
marked	meaningful; noteworthy; important Example: There is marked improvement in the patient's condition.
microscopic	only visible with the use of microscope or other magnifying instrument

	Example: Microscopic bits of squamous epithelial tissue were found under the victim's fingernails.
morbidity	state or presence of disease Example: The morbidity rate in many of the underdeveloped countries is quite high.
mortality	death Example: The mortality rate in liver cancer is nearly 100 percent.
prognosis	knowledgeable prediction of the outcome of a disease (pro = before; -gnosis = knowing) Example: The patient's prognosis was discussed with his family.
progressive	continuing increase in the severity of signs and symptoms of a disease Example: The progressive course of the illness has left the patient completely unable to cope with personal care needs.
prophylaxis	measure that prevents (pro- = before ; -phylaxis = to guard) Example: Patients exposed to tuberculosis should receive rifampin prophylaxis,
recurrent	happening repeatedly after a period of inacitivity Example: Recurrent tonsillitis may indicate a need for tonsillectomy.
systemic	throughout the body Example: The effects of acetylsalicylic acid (ASA) are systemic.

unremarkable	unimportant; not meaningful; not abnormal or unexpected Example: Examination of the lower extremities is unremarkable.

ROUTES OF MEDICATION ADMINISTRATION

Route	Description
inhalation	vapor or gas inhaled through the nose or mouth and absorbed into the bloodstream through the lungs
oral	drug is taken by mouth and is absorbed into the bloodstream through the stomach or small intestine (may also be called enteral administration)
parenteral	drug is administered by injection using a needle and syringe or a needle and intravenous (IV) tubing
rectal	drug is in the form of a suppository or liquid and is inserted into the rectum
sublingual	drug is placed under the tongue and allowed to dissolve in the mouth drugs – generally lotions, ointments, and eye drops – are applied to a particular area for local action
transdermal	drug is absorbed into the bloodstream through the skin, usually by means of a patch

TYPES OF INJECTIONS (PARENTERAL ADMINISTRATION)

intradermal	injected within the layers of the skin
intramuscular	injected into the body of a muscle
intravenous	injected into a vein
subcutaneous	injected just beneath the skin into the subcutaneous layer

SUMMARY

As a hospital administrator it becomes in evitable for one to have a clear idea of the medical terminologies used in health care field. We have learnt a few medical terms which are used by medical practioniers in day today life. We have also learnt the reasons and stories behind the evolution of such terms. Definitions for commonly used abbreviations and explanations for symbols used in health care sector have also been highlighted.

KEYWORDS

Medical Terminology	Prefixes	Suffixes
Tumours	Terms	Circulatory
Digestive	Respiratory	Nervous
Endocrine	Urinary	Reproductive
Musculo	Skeletal	Routes of administration

REVIEW QUESTIONS

1. What are reasons for using medical terms.
2. Give a glossary of the important medical terms.

SUGGESTED READINGS

Text book of Medical Physiology	-	Guyton
Review of Medical Physiology	-	Ganong
Text book of Physiology	-	Jain
Text book of Physiology	-	Mahapatra

Unit 3

ROOTS, PREFIXES, SUFFIXES, ABBREVIATIONS AND SYMBOLS

Structure
Overview
Learning Objectives
3.1 Common Roots: Element Referring to, Usage and Definition
3.2 Common Prefixes and Suffixes
3.3 Common Abbreviations: Departments, Time, General Healthcare, Routes of Medication and Laboratory
Summary
Keywords
Rveview Questions
Suggested Readings

OVERVIEW

There are three basic parts to medical terms: a word root (usually the middle of the word and its central meaning), a prefix (comes at the beginning and usually identifies some subdivision or part of the central meaning), and a suffix (comes at the end and modifies the central meaning as to what or who is interacting with it or what is happening to it). This unit would focus on roots, prefixes, suffixes and abbreviations commonly used in health sector.

LEARNING OBJECTIVES

At the end of this unit the candidate should be able to understand and use these terminologies.

- Common Roots: Element Referring to, Usage and Definition
- Common Prefixes and Suffixes
- Common Abbreviations : Departments, Time, General healthcare, Routes of Medication, and Laboratory

3.1 COMMON ROOTS: ELEMENT REFERRING TO, USAGE AND DEFINITION

WORD ROOT

therm	= heat
hypothermia	(less heat)
thermometer	(measuring heat)

myocarditis

myo	= muscle
card	= heart
itis	= inflammation

COMMON ROOT WORDS AND COMBINING FORMS

Root Word	Combining Form	Meaning
abdomin-	abdomin/o	abdomen
angi-	angi/o	vessel
bacteri-	bacteri/o	bacteria
bio-	bio	life
carcin-	carcin/o	cancer;cancerous
cardi-	cardio/o	heart
cephal-	cephal/o	head
cyst-	cyst/o	sac or cyst containing fluid ; urinary bladder
cyt-	cyt/o	cell
electr-	electr/o	electricity
enter-	enter/o	intestines
fibrin-	fibrin/o	fiber
gnath-	gnath/o	jaw
gynec-	gynec/o	woman, female

hem-	hem/o	blood
hemat-	hemat/o	blood
hepat-	hepat/o	liver
irid-	irid/o	iris
kerat-	kerat/o	keratin (a protein)
lip-	lip/o	fat
mast-	mast/o	breast
necr-	necr/0	death
nephr-	nephr/o	kidney
onc-	onc/o	tumor
path-	path/o	disease
pelv-	pelv/o	pelvic
radi-	radi/o	x-rays
ren-	ren/o	renal, the kidney
sarc-	sarc/o	flesh
sial-	sial/o	saliva,salivary glands
thromb-	thromb/o	clot
trache-	trache/o	trachea
uter-	uter/o	uterus

3.2 COMMON PREFIXES AND SUFFIXES

COMMON PREFIXES

Prefix	**Meaning**	**Example**
a-	without, not	apnea – without breathing
an-		anhydrous – without water
ab-	away from	abnormality – away from normal
ad-	toward, to, near	adduction – toward the center
ambi-	both	ambidextrous – use of both hands
ante-	before	antepartum – before labor or

		childbirth
pre-		prenatal – before birth
pro-		procephalic – anterior part (before) of the head
anti-	against; opposed to	antibiotic – against bacteria
contra-		contraindication – opposed to a certain treatment
auto-	self	autoimmune – immunity to self
bi-	two; both	bilateral – both sides
di-		didactylism – condition of two digits on a hand or foot
bio-	life	biology – study of life
brady-	slow	bradycardia – slow heart rate
circum-	around; circular movement	circumorbital-around the orbit (eye)
peri-		pericardium-around the heart
con-	with or together	consanguineous – with blood (common ancestry)
sym-		symbiotic – with life
syn-		synergy-with energy
de-	not; from; down	decalcify-removal of calcium
dia-	across or through	diathermy – through heat

Prefix	**Meaning**	**Example**
trans-		transurethral – across the urethra
dis-	apart; separate	disease – separate from ease
dys-	faulty; painful; difficult	dysuria – painful urination
e-	out; away	efferent – conduction away
ec-		from ectomorphic – away from form

ex-		excrete-separate, cast out
ecto-	outside	ectoderm – outer layer of skin
exo-		exothermic-release of heat
extra-		extracellular – outside the cell
en-	inside; within	enclosed – contained within
endo-		endocardium – innermost layer (lining) of the heart
intra-		intra-abdominal – within the abdomen
epi-	upon	epigastric – upon (above) the stomach
eu-	normal or good	eupnea – normal breathing
hemi-	half	hemicardia - half of the heart (right or left)
semi-		semilunar – half moon
hyper-	above or excessive; extreme	hyperkalemeia – excess potassium (in the blood)
hypo-	deficient; below	hypoglycemia – (low blood sugar)
infra-	under; below	inframammary – below the breast
sub-		subdural – below the dura mater
inter-	between	intercellular – between cells
mal-	bad	malaise – bad comfort; discomfort
meso-	middie	mesophlebitis – inflammation of the middle layer of the wall of a vein

Prefix	**Meaning**	**Example**
meta-	beyond; after; change	metastasis – extension of disease from one part of the body to another

micro-	small	microcardia – small heart
mono-	one	mononuclear – one nucleus
uni-		unilateral – one side
neo-	new	neonatal – new birth
pachy-	thick	pachyderma – thick skin
pan-	all	panimmunity – immune to all diseases
para-	abnormal;	paracystic – alongside the bladder
	alongside; beside	
per-	through	percutaneous – through the skin
poly-	many	polycythemia – many (red) blood cell multi-disciplinary – many areas of study
post-	after	postmortem – after death
quadri -	four	quadriplegic – paralysis of all four limbs
tetra -		tetradactylism – condition of only four digits on a hand or foot
re-	again or back	resorb – absorb again
retro-	backward or behind	retrofelxion – backward bending
sub-	under, below	subvaginal – below the vagina
super-	above or excessive	superficial – near the surface
supra -	outside or beyond	suprascleral – outside the sclera
tachy -	fast	tachycardia – rapid heart rate
tri -	three	trigeminy – three abnormal heart beats

ultra-	beyond, excessive	ultrasonic – excessive sound

COMMONLY USED GENERAL SUFFIXES

Suffix	Meaning	Example
-ac	pertaining to	hemophiliac – pertaining to an individual with hemophilia
-al		temporal – pertaining to the temporal lobe of the brain
-ar		calvicular – pertaining to the clavicle
-ry		sensory – pertaining to the senses
-eal		esophageal – pertaining to the esophagus
-ic		gastric – pertaining to the stomach (gastrum)
-ose		adipose – relating to fat
-ous		cutaneous – pertaining to the skin
-tic		spermatic – pertaining to sperm
-blast	immature	osteoblast – immature bone
-cyte	cell	cell osteocyte – bone cell
-e	nun marker(indicates this form of the word is a noun)	melanocyte - pigment – producing skill cell
-gram	record	electroencephalogram – record of brain activity
-graph	instrument for recording	electroencephalogram – instrument for recordingbrain activity
-graphy	process of measuring	arthrometry – process of recording the electrical

		activity of the heart
-meter	instrument for measuring	arthrometer – instrument for measuring motion in a joint
-metry	process of measuring	arthrometry – process of measuring joint motion
-iatric	treatment	psychiatric – treatment of the psyche

Suffix	**Meaning**	**Example**
-iatry	study of	psychiatry – study of the psyche
-logy		urology – study of urine
-logist	one who specializes in	cardiologist – one who specializes
	the treatment or study of	of the heart
-icle	small	ventricle – small pouch or cavity, particularly within the heart or brain
-ole		arteriole – small artery
-ula		macula – small spot
-ule		pustule – small lesion (pimple) with pus
-ium/-eum	tissue or structure	periosteum – structure surrounding bone
-ize	make;use;subject to	anesthetize – subject to anesthesia
-ate		impregnate make pregnant
-or	one who	medicator – one who gives medicine
-poiesis	formation	erythropoiesis – formation of red blood cells
-scope	instrument for	cystoscope–instrument for

	examining	examining the bladder
-scopy	examination	cystoscopy – examination of the bladder
-stasis	stop or stand	hemostasis – stop bleeding

SUFFIXES RELATED TO CONDITIONS, SYMPTOMS, OR DIAGNOSES

Suffix	Meaning	Example
-algia	Pain	myalgia – muscle pain
-dynia		arthrodynia – pain in a joint
-cele	pouch,sac, or hernia	cystocele – hernia of the bladder
-emesis	vomit	hyperemesis – excessive vomiting
-emia	condition of blood	anemia – condition of insufficient iron in the blood
-form	like or resembling	vermiform – resembling vermin
-oid		osteoid – resembling bone
-genic	beginning, origin, or	pyogenic – production of pus
-genesis	production	pathogenesis – origin of disease
-ia	condition of	dysuria – condition of painful urination
-ism		hisutism –condition of excessive hair
-iasis	formation of; presence of	lithiasis – formation of stone
-it is	inflammation	tendinitis – inflammation of a tendon
-lysis	breaking down	hemolysis – breaking down of blood
-malacia	softening	osteomalacia – softening of bone

-megaly	enlargement	cardiomegaly – enlargement of the heart
-oma	tumor	osteoma – tumor of bone
-osis	condition	psychosis – condition of the psyche
-penia	abnormal reduction; lack of	leukocytopenia – abnormal reduction of white blood cells
-phage	eat; devour	macrophage – large cell that devours
-phagia		geophagia – eating dirt
-phagy		aerophagy – swallowing air
-phile	attraction for; love for	pedophile – abnormal adult attraction to children
-philia		hemophilia – attraction for blood

Suffix	**Meaning**	**Example**
-phobia	fear of	photophobia – fear of light
-plasia	formation	dysplasia – faulty formation
-pnea	breathing	apnea – without breathing
-ptosis	drooping; falling or downward displacement	mastoptosis – drooping breast
-rrhage	to burse forth	hemorrhage – bursting forth of blood
-rrhagia		hemorrhagia – condition of bleeding
-rrhagic		hemorrhagic – relating to condition of bleeding
-rrhea	discharge or flow	amenorrhea – absence of menstrual flow

-rrhexis	rupture or breaking	trichorrhexis – breaking of hair
-spasm	involuntary contraction	laryngospasm – involuntary contraction of the larynx
-trophy	development	hypertrophy – excess development (enlargement)
-y	condition or process of	ambulatory – process of ambulation (walking)

SUFFIXES RELATED TO PROCEDURES

Suffix	Meaning	Example
-centesis	puncture to remove fluid	amniocentesis – puncture of the amniotic membrane to remove fluid
-desis	binding	arthrodesis – binding of a joint
-ectomy	excision; surgical removal	splenectomy – removal of the spleen
-pexy	surgical suspension or fixation	uteropexy – surgical fixation of the uterus
-plasty	surgical repair or reconstruction of	hernioplasty – surgical repair hernia
-rrhaphy	suture	myorrhaphy – suture of muscle
-stomy	surgical creation of an artificial opening	colostomy – creation of an artificial opening in the colon
-tomy	incision	tracheotomy – incision into the trachea
-tripsy	crushing	ithotripsy – crushing of stones

3.3 COMMON ABBREVIATIONS: DEPARTMENTS, TIME, GENERAL HEALTHCARE, ROUTES OF MEDICATION, AND LABORATORY

ABBREVIATIONS FOR SERVICES OR UNITS IN A HEALTH – CARE FACILITY

Abbreviation	Definition
A & D	Admitting and Discharge
CS	Central service (or Supply)
OR	Operating, Room, surgery (MOR, minor surgery)
RR	Recovery Room
PT & OT	Physical Therapy and Occupational Therapy (May be under PM & R, Physical Medicine and Rehabilitation)
X-ray	Radiology
Lab	Medical laboratory
MR	Medical Records
Peds	Pediatrics
Med-Surg	Ward for medical and surgical patients (may be combined or separate)
OB	Obstetrics (includes labor and delivery rooms, postpartum ward, and newborn nursery for healthy babies)
ICN or NICU	Intensive Care Nursery, or Newborn Intensive Care Unit, for premature or unhealthy babies
OPD	Out Patient Department
ER	Emergency Room ; ED : Emergency Department

ENT	Ear, nose and throat
GU	Genitourinary
NP	Neuropsychiatric
SS	Social Service
CCU or ICU	Coronary Care Unit or Intensive Care Unit
DOU	Definitive Observation Unit (less than intensive care, but more than "floor" care)
Dietary (FS)	Food Service
Housekeeping	Janitorial service
Pharmacy	Drugstore
Morgue	Unit for autopsies / holding the deceased
Pathology (Path)	Laboratory for study of diseased tissues, including blood

ABBREVIATIONS FOR FREQUENCIES

Abbreviation	**Definition**
q	every
qd	once a day
qod	every other day
q_h	every _ hours (insert hours)
bid	twice a day
tid	three times a day
qid	four times a day
hs	at bedtime (hour of sleep)
ac	before meals
pc	after meals
prn	when needed
ad lib	as desired

ABBREVIATIONS FOR UNITS

Abbreviation	Definition
tabs.	Tablets, pills
g or gm	grams
gr	grains
cc	cubic centimeters or
mL or ml	milliliters
L	Liter (1000 cc or ml)
mEq	milliequivalent
U	units
gtt	drops
oz	ounces
dr.	drams

ROLE OF HEALTHCARE WORKERS

Professional or Paraprofessional		Contribution to Healthcare Team
Physicia	-	Gathers information through medical history taking, physical examination, laboratory data, and test result
	-	Make diagnoses
	-	Makes treatment decisions based on information and clinical judgement
	-	Explains treatment options and expected results may counsel patients on lifestyle changes for enhanced health
Nurse	-	Assesses patient status and monitors patient progress
	-	Administers treatments, particularly drug therapies, as prescribed by physician

	- May assist with some treatments and tests, as prescribed by physician
	- Documents patient progress
	- Teaches patients and families about diseases and treatments
	- Supervises duties of patient care assistants
Patient care technician or Nursing Assistan	- Assists patient with activities of daily living: bathing, dressing, personal care measures, toileting, eating, and drinking
	- Maintains clean environment for patient: changes or straightens bed linens, provides clean gown or clothing, and organizes bed area
	- Takes patent's vital signs
	- Documents vital signs and patient activities
	- Assists nurse with patient observations
Physical therapist	- Assesses patient's need for various types of physical therapy
	- Provides physical therapy and related treatments
	- Helps patients obtain and use some types of medical appliances such as splints and braces
	- Documents observations and therapy provided
	- Provides information to patient and family regarding physical therapy interventions
Occupational therapist	- Assesses patient's ability to benefit from occupational therapies
	- Provides therapy designed to increase patient's level of functioning in daily living activities and job related activities
	- Helps patients to obtain and use certain assistive devices, such as reaching and grasping

	-	implements, hand splints, and specialized tools for handicapped persons
	-	Documents observations and therapy provided
	-	Provides information to patient and family regarding occupational therapy interventions
Social worker	-	Assesses patient's need for medical social service
	-	Assists patient with financial concerns
	-	Documents observations and interventions provided
	-	Provides information to patient and family regarding services and resources available in the community
Dietitian	-	Assesses patient's nutritional status
	-	Plans program of nutritional care
	-	Documents observations and interventions
	-	Provides information to patient and family regarding nutritional therapy
Pharmacist	-	Dispenses drug therapies for patient
	-	Documents activities
	-	Counsels patients, nurses, and families regarding drug interactions and implications of drug therapies

ABBREVIATIONS FOR MEANS OF ADMINISTERING SUBSTANCES INTO THE BODY

Abbreviation	Definition
PO	by mouth (*per os*)
IV	intravenously (into a vein; usually a peripheral vein)

IM	intramuscularly (into a muscle)
H	hypodermically (with a needle)
subcu, subq	subcutaneously (through the skin into the fattytissue)
subling	sublingually (under the tongue)
R	rectally (by rectum)
parenteral	a solution given intravenously
enteral	tube feeding (into stomach or small intestine)
D_5W	5% glucose in distilled water used IV
caps.	Capsules
supp	suppository
ss	one-half
mg	milligrams
N.S.	normal saline solution: isotonic solution
Clyssi	fluids given by needle, under skin (not in vein)
TKO	to keep open (vein)
KVO	keep vein open

ABBREVIATIONS FOR DIET ORDERS

Abbreviation	Definition
NPO	nothing *per os* (nothing to eat or drink orally)
I & O	intake and output (measured)
Cl Liq	clear liquids only: ginger ale,tea, broth, Jell-O, 7-Up, coffee
F Liq	full liquid: addition of milk and milk products; liquid at body temperature
Lo Salt, Low Na, Salt Free	restricted in sodium: ordered by mg or g of sodium desired, i.e., 2 g Na, 500 mg Na
NAS	no added salt; usually 4-6 g Na (mild restriction)
Reg	regular diet (“house” or “normal” sometimes used). A balanced diet without restrictions so as to type of food texture, seasoning, or preparation method

Mech soft	mechanical soft; a regular diet with alteration in texture only. Sometimes called “edentulous”
Med soft	medical soft; alterations in texture, preparation methods, and seasonings
Bland	a medical soft diet further altered to omit acid producing beverages, and restrict seasonings. Altered feeding intervals
Lo res	low residue; alteration in texture, and a limited food selection to yield little intestinal residue
High fiber	a regular diet with increased amounts of food containing dietary fiber
FF or PF	force or push fluids; increasing the liquid intake by addition of extra fluids
Int fdg or int nour	interval feeding; supplemental nourishment served between meals
DAT	diet as tolerated
ADA diet	American Dietetic Association diet; refers to calculated diet plans used primarily for diabetics
AHA diet	Amercian Heart Associaiton diet; refers to calculated diet plans used primarily to reduce risk of heart disease.

COMMON ABBREVIATIONS IN PRESCRIPTIONS

Abbreviation Meaning	Latin	Term
-a	before	ante
a.c.	before meals	ante cibum
AD	right ear	auricle dexter
ad lib	as desired	d libitum
A.M.	before noon	ante meridiem
amt.	amount	
aq	water	aqua

AS	left ear	auricle sinister
AU	both ears	auricle unitas bilateral
b.i.d.	twice a day	bis in die
C	Celsius, centigrade	
C	with	cum
d.	day	die
F	Fahrenheit	
>	greater than	
h.	hour	hora
h.s.	hour of sleep	hora somni
i	one	uni
ii	two	bis
iii	three	ter
<	less than	
OD	right eye	oculus dexter
ss	one-half	simis
OS	left eye	oculus sinister
OU	both eyes	oculi unitas
p	after	post
p.c.	after meals	post cibum
per	by or through	
P.M.	after noon	post meridiem
p.o.	by mouth	per os
p.r.n.	as needed	pro re nata
q.	each or every	quaque
q.d.	every day	quaque die
q.h.	every hour	quaque hora
q2h	every two hours	quaque bis hora
q.i.d.	four times a day	quarter in die
q.o.d.	every other day	quaque altera die
q.s.	quantity sufficient	
Rx	recipe or prescription	

sig.	label; instructions	signa
STAT	Immediately	statim
t.i.d.	three times a day	ter in die
w.a.	while awake	
S	without	sine
wk	week	
yr	year	
X	times or for	

ABBREVIATIONS FOR LABORATORY, X-RAY STUDIES, AND PULMONARY FUNCTION

Abbreviation	Definition
AP and Lat	routine x-ray picture of chest (front to back and side view)
Up	upright x-ray picture
Decub	decubitus (lying) position
IVP	intravenous pyelogram (kidney)
BE	barium enema (colon)
2 GI series	upper (barium swallow): x-ray of stomach / duodenum; lower (same as BE): x-ray of lower bowel / colon
GB series	gallbladder x-ray picture
MRI	magnetic resonance imaging; noninvasive procedure using a magnetic field that yields images for dx
RAI, RAIU	radioactive iodine (uptake) for diagnosing thyroid function
SCAN	CT, CAT: computed tomography, computerized axial tomography
CBC	complete blood count
UA	urinalysis
VC	vital capacity (lungs)

LABORATORY ABBREVIATIONS

Abbreviation	Definition
AFB	acid-fast bacillus (tuberculosis organism)
C & S	culture and sensitivity
CBC	complete blood count
Crit, Hct	hematocrit
diff	differential
ESR	erythrocyte sedimentation rate
FBS	fasting blood sugar
GTT	glucose tolerance test
Hb, Hbg	hemoglobin
RBC	Red blood (cell) count (erythrocytes); red blood cells
RA	rheumatoid arthritis
STS	serologic test of syphilis
VDRL	venereal disease research laboratory
WBC	white blood (cell) count (leukocytes); white blood cells

3.4 SYMBOLS

+	**Positive**
–	**Negative**
=	**Equal**
#	**Pound or Problem**
↑	**Increase**
↓	**Decrease**
ø	**None /No**

1º	**Primary**
2º	**Secondary**
△	**Change**
△'d	**Changed**
'	**Feet**
"	**Inches**
○—	**Lying**
	Sitting
)o	**Standing**
	**Blood Pressure**
	**Ambulance**
	**Thermometer**
	**Female**
	**Male**
	**Handicapped**
	**Medical**
Rx	**Pharmacy**
	**Resuscitation**
	**Weight Scale**
	**First Aid**

SUMMARY

This unit gives a clear understanding to the students about Common Roots, Elements Referring to the Usage and Definition of Common Prefixes and Suffixes, Common Abbreviations relating to departments, Time, General healthcare, Routes of Medication and Laboratory.

KEYWORDS

myocarditis	cancerous	efferent	hemophiliac
keratin	trachea	exothermic	calvicular
uterus	apnea	mesophlebitis	cutaneous
anhydrous	adduction	percutaneous	osteoblast
ambidextrous	antepartum	polycythemia	spermatic
procephalic	didactylism	quadriplegic	melanocyte
consanguineous	decalcify	tetradactylism	arthrodynia
diathermy	transurethral	retrofelxion	peiosteum
hyperkalemeia	inframammary	suprascleral trigeminy	pustule

REVIEW QUESTIONS

1. Write down the Common Root words and combining forms related to digestive system.
2. List out the suffixes related to conditions, symptoms, or diagnoses.

SUGGESTED READINGS

1. William F. Ganong, Review of Medical Physiology (McGraw Hill, Boston) ISBN 007 - 144040-2
2. Stedman's Medical Dictionary (Williams & Winlkins, Baltimore) ISBN 0-683-07922-0

Unit 4

ILLNESS

Structure
Overview
Learning Objectives
4.1 Defining Illness: Direct & Indirect Causes
4.2 Classification & Description
4.2.1 Inflammation
4.2.2 Tomours
4.2.3 Hypersensitivy (Allergy)
4.2.4 Thrombosis, Embolism and Infarction
4.2.5 Degeneration
4.2.6 Genetic Abnormalisites
Summary
Keywords
Review Questions
Suggested Readings

OVERVIEW

Many different illnesses, disorders and diseases are known, which vary from minor, but often very troublesome conditions, to the very serious. The study of abnormalities can be made much easier when a systematic approach is adopted. Causes (aetiology) are outlined first when there are clear links between them and the effects of the abnormality (pathogenesis) also explained.

LEARNING OBJECTIVES

Upon completion of this unit the candidate should be able to

- Explain the definition of illness, direct and indirect causes.
- Write down the classification and description of Inflammation
- Hypersensitivity (allergy)
- Thrombosis, Embolism and Infarction
- Degeneration
- Genetic Abnormalisites

4.1 DEFINING ILLNESS: DIRECT & INDIRECT CAUSES

AETIOLOGY

Diseases are usually caused by one or more of a limited number of factors that may include:

- Genetic abnormalities, either inherited or acquired
- Infection by microbes or parasites, e.g. viruses, bacteria or worms
- Chemicals
- Ionizing radiation
- Physical trauma
- Degeneration, e.g. excessive use or ageing.

In some diseases more than one of the aetiological factors listed above is involved, while in others, no specific cause has been identified and these may be described as essential, idiopathic or spontaneous. Although the precise cause of a disease may not be known, predisposing (risk) factors are usually identifiable. Iatrogenic conditions are those that result from healthcare interventions.

PATHOGENESIS

The main processes causing illness or disease are outlined below.

Acute : a disease with sudden onset often requiring urgent treatment (compare with chronic)

Acquired : a disorder which develops any time after birth (compare with congenital)

Chronic : a long-standing disorder which cannot usually be cured (compare with acute)

Congenital : a disorder which one is born with (compare with acquired)

Sign : an abnormality seen or measured by people other than the patient.

Symptom : an abnormality described by the patient.

Syndrome : a collection of signs and symptoms which tend to occur together.

4.2 CLASSIFICATION & DESCRIPTION

The main processes causing illness or disease are outlined below.

4.2.1 INFLAMMATION

This is a tissue response to damage by e.g. traum, invasion of microbes. Inflammatory conditions are recognized by the suffix – it is, e.g. appendicitis.

Inflammatory response : This is the physiological response to tissue damage and is accompanied by a characteristic series of local changes. It most commonly takes place when microbes have overcome other non-specific defense mechanisms. Its purpose is protective; to isolate, inactivate and remove both the causative agent and damaged tissue so that healing can take place.

Inflammatory conditions are recognized by the Latin suffix '-itis'; for example, appendicitis is inflammation of the appendix and laryngitis is inflammation of the larynx.

Causes of inflammation : The numerous causes of inflammation may be classified as follows:

a) Microbes, e.g. bacteria, viruses, protozoa, fungi
b) Physical agents, e.g. heat, cold, mechanical injury, ultraviolet and ionizing radiation
c) Chemical agents
d) Organic, e.g. microbial toxins and organic poisons, such as weedkillers
e) Inorganic, e.g. acids, alkalis

Acute inflammation : Episodes of acute inflammation are usually of short duration, e.g. days to a few weeks, and may range from mild to very severe. The cardinal signs of inflammation are:

- redness
- heat
- pain
- swelling
- loss of function

Most aspects of the inflammatory response are hugely beneficial, promoting removal of the harmful agent and setting the scene for healing to follow.

The acute inflammatory response is described as a collection of overlapping events: increased blood flow, accumulation of tissue fluid, migration of leukocytes, increased core temperature, pain and suppuration.

Chronic inflammation : The processes involved are very similar to those of acute inflammation but, because the process is of longer duration, considerably more tissue is likely to be destroyed. The inflammatory cells are mainly lymphocytes instead of neutrophils, and fibroblasts are activated, leading to the laying down of collagen, and fibrosis. If the body defences are unable to clear the infection, they may try to wall it off instead, forming nodules called granulomas, within which are collections of defensive cells. Tuberculosis is an example of an infection that frequently becomes chronic, leading to granuloma formation. The causative bacterium, Mycobacterium tuberculosis, is resistant to body defences and so pockets of organisms are sealed up in granulomas within the lungs.

Chronic inflammation may either be a complication of acute inflammation or follow chornic exposure to an irritant.

4.2.2 TUMOURS

These arise when the rate of cell production exceeds that of normal cell death causing a mass to develop. Tumours are recognized by the suffix –oma, e.g. carcinoma.

A tumour or neoplasm (literally meaning ‘new growth’) is a mass of tissue that grows faster than normal in an uncoordinated manner, and continues to grow after the initial stimulus has ceased.

Tumours are classified as benign or malignant although a clear distinction is not always possible. Benign tumours only rarely change their character and become malignant. Tumours may be classified according to their tissue of origin. For example, an adenoma is a benign tumour of glandular tissue whereas

an adenocarcinoma is a malignant tumour of glandular or secretary epithelial tissue. Malignant tumours are often named according to the tissue they arise from, for example a carcinoma originates in epithelial tissue whereas a sarcoma arises from connective tissue.

Causes of neoplasms : Some factors are known to precipitate the changes found in tumour cells but the reasons for the uncontrolled cell multiplication are not known. The process of change is carcinogenesis and the agents preceipitating the change are carcinogens. Carcinogenesis may be of genetic and / or environmental origin and a clear – cut distinction is not always possible.

CARCINOGENS

Environmental agents known to cause malignant changes in cells do so by irreversibly damaging a cell's DNA. It is impossible to specify a maximum 'safe dose' of a carcinogen. A small dose may initiate change but this may not be enough to cause malignancy unless there are repeated doses within a limited period of time that have a cumulative effect. In addition, there are widely varying latent periods between exposure and evidence of malignancy. There may also be other unknown factors. Environmental carcinogens include chemicals, irradiations and oncogenic viruses.

Chemical carcinogens

Some chemicals are carcinogens when absorbed; others are modified after absorption and become carcinogenic. Examples include:

- aniline dyes, which predispose to bladder cancer
- asbestos, which is associated with malignant pleural tumours
- cigarette smoke, which is the main risk factor for lung cancer

Radiation carcinogens

Exposure to ionizing radiation including X-rays, radioactive isotopes, environmental radiation and ultraviolet rays in sunlight may cause malignant changes in some cells and kill others. The cells are affected during mitosis so those normally undergoing continuous controlled division are most susceptible. These labile tissues include skin, mucous membrane, bone marrow, lymphoid tissue and gametes in the ovaries and testes.

Oncogenic viruses

Some viruses are known to cause malignant changes in animals and there are indications of similar involvement in humans. Viruses enter cells and incorporate their DNA or RNA into the host cell's genetic material, which causes mutation. The mutant cells may be malignant. Examples include hepatitis B virus, which can cause liver cancer and human papilloma virus, which is associated with cervical cancer.

Host factors

Individual characteristics can influence susceptibility to tumours. These include race, diet, age and inherited factors. Tumours of individual tissues and organs are described in the appropriate chapters.

GROWTH OF TUMOURS

Normally cells divide in an orderly manner. Neoplastics cells have escaped from the normal controls and they multiply in a disorderly manner forming a tumour. Blood vessels grow with the proliferating cells, but in some malignant tumors the blood supply does not keep pace with growth and ischaemia (lack of blood supply) leads to tumour cell death, called necrosis. If the tumour is near the surface, this may result in skin ulceration and infection. In deeper issues there is fibrosis; e.g. retraction of the nipple in breast cancer is due to the shrinkage of fibrous tissue in a necrotic tumour. The mechanisms controlling the lifespan of tumour cells are poorly understood.

Abnormal immune mechanisms – these are responses of the normally protective immune system that cause undesirable effects.

4.2.3 HYPERSENSITIVITY (ALLERGY)

Allergy is powerful immune response to an antigen (allergen). The allergen itself is usually harmless (e.g. house dust, animal dander, grass pollen). It is therefore usually the immune response that causes the damage to the body, not the allergen itself. Upon initial exposure to the allergen the individual becomes sensitized to it, and on second and subsequent exposures the

immune system mounts a response entirely out of proportion to the perceived threat. It should be noted that these responses are exaggerated versions of normal immune function. Sometimes symptoms are mild, if annoying, e.g. the running nose and streaming eyes of hay fever. Occasionally the reaction can be extreme, overwhelming body systems and causing death, e.g. anaphylactic shock.

There are four mechanisms of hypersensitivity, which are classified according to what parts of the immune system are involved.

Type I, Anaphylactic hypersensitivity

This occurs in individuals who have inherited very high levels of immunoglobulin E (IgE). When exposed to an allergen, e.g. house dust, these high levels of antibody activate mast cells and basophils, which release their granular contents. The most important substance is released is histamine, which constricts some smooth muscle, e.g. airway smooth muscle, causes vasodilatation and increases vascular permeability (leading to exudation of fluid and proteins into the tissues). Examples of type I reactions include the serious situation of anaphylaxis. There is profound bronchoconstriction and shock due to extensive vasodilatation. The condition can lead to death.

Type II, Cytotoxic hypersensitivity

When an antibody reacts with an antigen on a cell surface, that cell is marked for destruction by a number of mechanisms, e.g., phagocytosis, or destruction by lytic enzymes. This is the usual procedure in the elimination of, for example, bacteria, but if the antibodies are directed against self-antigens the result is destruction of the body's own tissues (autoimmune disease). Type II mechanisms cause other conditions, e.g. haemolytic disease of the new born and transfusion reactions.

Type III, Immune-complex-mediated hypersensitivity

Antibody-antigen complexes (immune complexes) are usually cleared efficiently from the blood by phagocytosis. If they are not, for example when there is phagocyte faiculre or an excessive production of immune complexs

(e.g., in chornic infections), they can be deposited in tissues, e.g., kidneys, skin, joints and the eye, where they set up an inflammatory reaction. The kidney is a common site of deposition because it receives a large proportion of the cardiac output and filters the blood. Immune complexes collecting here lodge in and block the glomeruli, imparting kidney function (glomerulonephritis). Sensitivity to penicillin is also a type III reaction; antibodies bind to penicillin (the antigen), and the symptoms are the result of deposition of immune complexes in tissues – rashes, joint pains and sometimes haematuria.

Type IV, Delayed type hypersensitivity

Unlike types I-III, type IV hypersensitivity does not involve antibodies, but is an overreaction of T-lymphocytes to an antigen. When an antigen is detected by memory T-lymphocyte and large numbers of cytotoxic T-lymphocytes are released to eliminate the antigen. Usually this system is controlled and the T-lymphocyte response is appropriate. If not, the actively aggressive cytotoxic T-lymphocytes damage normal tissues.

An example of this is contact dermatitis, Graft rejection is also caused by T-lymphocytes; an incompatible skin graft, for instance, will become necrotic and slough off in the days following application of the graft.

4.2.4 THROMBOSIS, EMBOLISM AND INFARCTION

These are the effects and consequences of abnormal changes in the blood and / or blood vessel walls.

EMBOLUS

This is a mass of any material carried in the blood. It is usually a fragment of a thrombus (an intravascular blood clot) from elsewhere in the vascular system, but other materials include:

- fragments of atheromatous plaques
- fragments of vegetations from heart valves, e.g. infective endocarditis
- tumour fragments, which may cause metastatses
- amniotic fluid, during childbirth

- fat, from bone fractures
- air, from puncture of a blood vessel by a broken rib or during a clinical procedure
- nitrogen bubbles in decompression sickness (the 'bends')
- pus from an abscess

THROMBUS FORMATION

The risk of a thrombus developing within a blood vessel is increased by any condition that slows blood flow, damages the smooth intimal lining of blood vessels or increases blood coagulability.

Blood flow is slowed. This may happen in immobility, e.g. prolonged sitting or in bed rest, or if a blood vessel is compressed by an adjacent structure such as a tumour, or if blood pressure is low for a prolonged period, as in shock.

Damage to the intimal lining of blood vessels. This may be caused by atherosclerosis or trauma.

Increased blood coagulability. Factors here include oestrogen (either naturally produced or taken in oral contraceptive drugs), dehydration, pregnancy and child-birth, the presence of an intravenous cannula, some malignant diseases and some disorders of blood clotting.

Emboli originating in an artery travel away from the heart until they reach an artery too narrow to let them pass, and lodge there, partly or completely blocking blood supply to distal tissues. Emboli originating in veins travel towards the heart, and from there travel to the lungs in the pulmonary artery. They then lodge in the first branch too narrow to let it pass. Lung tissue supplied by the blocked vessel becomes ischaemic and dies. There may be multiple small emboli or one or more large ones. Massive pulmonary embolism blocks a main pulmonary artery and usually causes sudden collapse and death.

INFARCTION

This is the term given to tissue death because of interrupted blood supply. The consequences of interrupting tissue blood supply depend on the size of

the artery blocked and the function of the tissues affected. Ischaemia means tissue damage because of reduced blood supply.

EMBOLISM

Embolism occurs when a traveling embolus, whatever its nature, lodges in and obstructs a blood vessel. The most serious consequences include pulmonary embolism, or blockage of a coronary artery (myocardial infarction) or a cerebral artery (cerebral infarction).

4.2.5 DEGENERATION

This is often associated with normal ageing but may also arise prematurely when structures deteriorate causing impaired function.

METABOLIC ABNORMALITIES

These cause undesirable metabolic effects, e.g. diabetes mellitus

Diabetes mellitus

This is due to deficiency or absence of insulin or, rarely, to impairment of insulin activity (insulin resistance) causing varying degrees of disruption of carbohydrate and fat metabolism. This incidence of type 1 and, especially, type 2 diabetes is increasing worldwide.

Type I, Insulin-dependent diabetes mellitus (IDDM)

This occurs mainly in children and young adults and the onset is usually sudden. The deficiency or absence of insulin is due to the destruction of â-islet cells of the pancreas. The exact cause remains unknown although, in most people, there is evidence of an autoimmune mechanism involving auto antibodies that destroy the â-islet cells. Genetic predisposition and environmental factors, including viral infections, are also thought to be involved.

Type II, Non-insulin-dependent diabetes mellitus (BIDDM)

This is the most common form of diabetes, accounting for about 90% of cases. The causes are multi factorial and predisposing factors include:

- obesity
- sedentary lifestyle
- increasing age: affecting middle-aged and older people
- genetic factors

It often goes undetected until signs are found on routine investigation or a complication occurs. Insulin secretion may be below or above normal. Deficiency of glucose inside body cells may occur despite hyper-glycaemia and a high insulin level. This may be due to insulin resistance, i.e. changes in cell membranes that block the insulin-assisted movement of glucose into cells.

Secondary diabetes

This may develop as a complication of:

- acute and chronic pancreatitis
- some drugs, e.g. corticosteroids, phenytoin, thiazide diuretics
- secondary to other endocrine disorders involving hypersecretion of e.g.growth hormone, thyroid hormones, cortisol, adrenaline (epinephrine).

Gestational diabetes

This develops during pregnancy and may disappear after delivery; however, diabetes often recurs in later life. Raised plasma glucose levels during pregnancy predispose to the birth of large birth weight and stillborn babies and deaths shortly after birth.

4.2.6 GENETIC ABNORMALISITES

These may be either inherited (e.g.phenylketonuria) or caused by environmental factors such as exposure to ionizing radiation.

CANCER

Cancer (malignant growth of new tissue) is caused by mutation of cellular DNA, causing its growth pattern to become disorganized and uncontrolled.

INHERITED DISEASE

Gene mutation **:** Many diseases, such as cystic fibrosis and haemophilia are passed directly from parent to child via a faulty gene. Many of these genes have been located by mapping of the human genome, e.g. the gene for cystic fibrosis is carried on chromosome 7. Other diseases, e.g. asthma, some cancers and cardiovascular disease, have a genetic component. In these cases, a single faulty gene has not been identified, and inheritance is not as predictable as when a single gene is responsible.

Phenylketonuria **:** In this disorder, which is an example of an inborn error of metabolism, the gene responsible for producing the enzyme phenylalanine hydroxylase is faulty, and the enzyme is absent. This enzyme normally converts phenylalnine to tyrosine in the liver, but in its absence phenylalanine accumulates in the liver and overflows into the blood. In high quantities, phenylalanine is toxic to the central nervous system and, if untreated, results in brain damage and mental retardation within a few months. Because there are low levels of tyrosine, which is needed to make melanin, depigmentation occurs and children are fair skinned and blonde. The incidence of this disease is now low in developed countries because screening of newborn babies detects the condition and treatment is provided.

CHROMOSOMAL ABNORMALITIES

Down syndrome **:** In this disorder, there are three copies of chromosome 21 (trisomy 21), meaning that an extra chromosome is present, caused by failure of chromosomes to separate normally during meiosis. People with Down syndrome are usually short of stature, with pronounced eyelid folds and flat, round faces. The tongue may be too large for the mouth and habitually protrudes. Learning disability is present, ranging from mild to severe. Life expectancy is shorter than normal, with a higher than average incidence of cardiovascular and respiratory disease. Down syndrome is associated with increasing maternal age, especially over 35 years.

Cri-du-chat syndrome **:** Cri-du-chat (cat's cry) refers to the characteristic meowing cry of an affected child. This syndrome is caused when part of chromosome 5 is missing, and is associated with learning disabilities and anatomical abnormalities, including gastrointestinal and cardiovascular problems.

SUMMARY

This unit has elaborated on illness, its direct and indirect causes. The main processes causing illness have been classified under the following heads: as Inflammation, Hypersensitivity (allergy) Thrombosis, Embolism and Infarction, Degeneration and Genetic Abnormalities and described thoroughly.

KEYWORDS

aetiology	neutrophils	cytotoxic
pathogenesis	mycobacterium	haemolytic
latrogenic	papilloma	phagocytosis
congenital	ischaemia	faiculre
appendicitis	necrosis	glomerulone
protozoa	anaphylactic	atheromatous
coagulability	cannula	infarction

REVIEW QUESTIONS

1. Define illness.
2. Describe degeneration.

SUGGESTED READINGS

1. K. Park, Textbook of Preventive and Social Medicine
(M/s. Banarsidas Bhanot Publishers, Jabalpur)
2. Stedman's Medical Dictionary (Williams & Winlkins, Baltimore)
ISBN 0-683-07922-0

Unit 5

INFECTION CONTROL

Structure
Overview
Learning Objectives
5.1 Medical Asepsis, Nosocomial Bacteremia
5.1.1 Infection Control
5.2 Reservoir, Carrier & Mode of Transmission
5.3 Infection Control Measures
5.3.1 Infection Control Program Elements
5.4 Sterilization and Aseptic Techniques
5.4.1 Definitions of Useful Terminology
5.4.2 Solutions and Procedures for Cleaning, Disinfection and Sterilization
5.4.3 Role of the Infection Control Practitioner in Cleaning, Disinfection and Sterilization Practices
5.5 Infection Control Committee
Summary
Keywords
Review Questions
Suggested Readings

OVERVIEW

This chapter discusses primary nosocomial bacteremias that are associated with intravascular devices such as IVs and intraarterial monitors. Secondary bacteremias can be reduced by attention to prevention and control of the nosocomial primary sites. Such a focus has been chosen rather than a general discussion of all bacteremias, because of the ICP's responsibility for monitoring practices related to intravenous catheter insertion and management and also because of the potential for a reduction in the incidence of this infection by adherence to infection control polices and procedures.

LEARNING OBJECTIVES

Upon completion of this unit the candidate should be able to,

- Discuss about medical asepsis and nascomial bateremia infection
- Discuss about the carrier and mode of transmission of infections
- Explain the infection control measures
- Describe the sterlisation and aseptic techniques
- Highlight the role of infection control committee

5.1 MEDICAL ASEPSIS, NOSOCOMIAL BACTEREMIA

Bacteremia can be a primary infection or a secondary complication of an infection at another site. The incidence of bacteremia in hospital varies from reports of 20 cases per 10,000 hospital admissions (1) to over 200 cases per 10,000 admissions (2).

Nosocomial bacteremia is defined as the isolation of any organisms from a properly obtained blood culture specimen in a patient with clinical signs of sepsis who was admitted with no signs or symptoms of infection nor a positive blood culture. Nosocomial primary banteremia develops in 6 of every 1000 hospital admissions, producing infection in approximately 120,000 patients per year (3). These infections can add 7-14 days to the hospital stay and cost more than $1.5 billion annually (4-5).

Two-thirds of all nosocomial bacteremias are caused by aerobic gram negative bacilli (3), and in the last decade deaths attributed to gram-negative bacilli bacteremia have increased at a faster rate than all other causes (6).

Bacteremia occurs more frequently in patients with severe underlying diseases, and mortality varies from 20 to 80% depending on whether shock is present (7). Outbreaks of infection with associated nosocomial bacteremias can be detected quickly when bacteremias are used as sentinel ineicators of the problem.

Intravenous cannulas, arterial monitoring devices and Swan-Ganz catheters are the most frequent causes of primary nosocomial bacteremias. Dissemination of bacteria from other mosocimial sites such as surgical wounds, pneumonias, and urinary tract infections cause the remainder (3).

INTRAVENOUS CATHETERIZATION

The plastic catheter for intravenous infusion was introduced in 1945, and the first reports showed no complications from its use. Shortly after the more widespread use of these catheters, however, more reports appeared citing serious complications, especially thrombophlebitis and septicemia.

Maki and his colleagues, Goldmann, and Rhame (8,9) provide an excellent review of the history of intravenous cannulation, showing a report as early as 1957 associating the length of time of catheterization and the occurrence of infection (10). The authors indicate, however, that intravenous catheterization was not considered a significant source of nosocomial infection until much later, and prospective studies did not begin to appear until 1973.

Problems associated with intravenous catheterization have been identified and continue to be significant in in terms of patient morbidity and mortality. The use of catheterization for the total nutritional support of a patient has been associated with a high frequency of complications; this problem will be discussed later.

SITES, KINDS AND USES OF INTRAVENOUS CANNULATION

Intravenous catheters can be inserted into a number of body sites. Originally the site of choice was the femoral vein; however, now peripheral placement in upper extremities, surgical placement (cutdown) of subclavian catheters, and catheters inserted into the umbilical vein of newborns are common IV catheterization areas and techniques.

Materials used for IV infusion include plastic and steel. The steel needle (scalp vein needle) has been used extensively in pediatrics; because of problems with infiltration, these needles need frequent replacement. Plastic catheters provide a more secure route for administration of fluids.

Intravenous infusion serves several purposes in the care of the hospitalized patient. First, fluids and electrolytes can be restored quickly ; moreover, total nutrition can be provided for patients who cannot otherwise be fed or who need supplemental nutrition. An IV catheter provides a route for the continuous or emergency delivery of medications. Last, a catheter provides a means of monitoring central venous pressure or other changes in the vascular status in the critically ill patient. The benefits of intravenous cannulation are clear; the problems are based on a break in the integrity of the skin and in the direct access to the sterile bloodstream via a foreign body, the catheter. The risks must be weighed against the benefits in determining the need for IV catheterization.

PRIMARY NOSOCOMIAL BACTEREMIA

Intravascular devices carry an inherent risk of infection. The increased use of these devices for hemodynamic monitoring, parenteral nutrition, chemotherapy, and venous access has increased the potential for primary bacteremia. Since catheter-associated infections are the most common types of primary bacteremia, these catheters should be placed aseptically and closely monitored.

Intravenous infection sets should always be suspected when the patient appears to be bacteremic. Symptoms include fever, shaking chills (rigors), sweating, abrupt onset, and hypotension. Phlebitis at the IV site is present in more than half of the IV-associated bacteremias (8). Bacteremia in a patient with an indwelling IV catheter can be most closely associated with the catheter if the blood culture and the IV tip culture correspond, the febrile episode is resolved after removal of the catheter, and other primary sites of infection have been ruled out (11).

Gram-positive skin organisms such as staphylococci, Candida, and corynebacterium sp. can colonize the catheter site and subsequently the catheter. Bacterial colonization of the IV catheter appears to be an important factor in the development of primary bateremia (12).

Organisms of the tribe Klebsielleae (Klebsiella, Enterobacter, Serratia) have been associated with contaminated IV fluid (13).

SUPPURATIVE PHLEBITIS

One of the must serious complications of IV therapy is suppurative phlebitis which can be fatal, especially in burn patients. Local signs of infection may be absent, and signs of sepsis may not appear fro 2-10 days after the catheter has been removed (14). Suspicious of this complication requires immediate antimicrobial therapy and quite frequently surgical intervention to excise the purulent segment of vein.

SEPTIC SHOCK

Septic shock is caused in most cases by gram-negative enteric bacteria. It generally occurs in persons with severe underlying diseases (diabetes, chronic liver disease, blood dyscrasias) or immunosuppressive drug therapy and is often preceded by a manipulative procedure.

Septic shock is characterized by inadequate tissue perfusion as a consequence of tissue anoxia, pooling of blood, diminished cardiac output, and increased peripheral vascular resistance. Along with shaking chills, the patient has fever and warm extremities; cardiac output is increased in this early phase, which is followed by arterial vasoconstriction and a reduction in cardiac output, pooling of blood, and decrease in effective blood volume, Symptoms of shock then follow: hypotension, tachycardia, tachypnea, confusion, progression of shock leads to respiratory insufficiency, heart failure, coma, and death. Treatment is based on support of body systems and immediate surgical intervention to remove or incise and drain the source of infection. Prevention is based on early recognition and treatment of primary infection or of septic shock when it occurs, including the monitoring of intravenous devices.

SPECIMEN COLLECTION

The methods by which blood specimens are obtained and processed are critical for valid results. The recovery of a microorganism from a blood culture in a patient without clinical signs of bacteremia may indicate contamination at some point in the system of collecting, culturing, or processing blood (16,17). Unlike a urine specimen, for example, where the microbiology laboratory can detect and rule out contamination (e.g.,<1000 diphtheroids), it is difficult to interpret the results of cultures positive for normal skin flora which may be causing certain patients infections.

Specimens first of all should be taken by personnel trained in venipuncture. The contamination risk is much higher, as would be expected, when personnel are not well trained in the aseptic method of obtaining a blood culture specimen.

The skin prep is very important, in order that skin flora do not contaminate the specimen. As with other preps, mechanical friction is the most important factor; there is no instant antisepsis by wetting the site with a solution. Alcohol followed by a vigorous prep with an iodophor, or an iodophor alone, remaining for at least a minute, will provide good antisepsis. Tincture of iodine, followed by removal with alcohol, is an excellent prep.

Specimens should be drawn if possible during the febrile episode; the physician needs to make decisions concerning when and how many blood cultures should be drawn (18).

Solutions thought to be contaminated should be cultured. If the IV is suspected as the primary site of infection, it should be removed. Reports conflict on the value of culturing the catheter tip. The CDC recommends a thorough skin prep, aseptic removal of the catheter, and sterile removal of the tip for culture. Maki also recommends catheter culture, and outlined a method for culturing catheter tips that was semiquantitative and correlated well with the development of complications. Cooper et al. describe Gram staining of the distal catheter tip as a simple, inexpensive, accurate, and rapid method of diagnosing colonization of intravascular catheter tips.

Other state, however, that the presence of an organism on a catheter tip does not indicate the presence of bacteremia; a catheter tip can be colonized but not in enough numbers to seed the bloodstream. Alternately, the bloodstream can be primarily infected and subsequently seed the catheter; therefore, a positive culture from both blood and the tip does not necessarily indicate that the bacteremia was caused by the IV catheter and should be evaluated with clinical symptoms. A positive catheter tip without a positive blood culture may well be an indication, however, of impending bacteremia, especially if the IV has been in place longer than 48 hours.

PORTALS OF ENTRY

Epidemics have been traced to a variety of sources and sites in the IV and arterial set up. Intravenous solutions can become contaminated during the manufacturing process. In one instance, a large outbreak involving solutions

contaminated during production led to the recall of the implicated product. Other outbreaks from intrinsically contaminated IV solutions have also been reported.

Hairline cracks in IV bottles or minute punctures in plastic bags can allow bacteria to enter the solution. Contamination can occur at almost any time during the IV set up; when additives are mixed with the solution; when the bottle or bag is attached to the administration set; during manipulation of a stopcock; during injection of medications into the system; and when manipulation of the insertion site occurs, during regular care or IV site care.

Insertion of the IV catheter can be the source of a bacteremic episode, if the insertion is performed under emergency conditions or using poor technique. The catheter can also become contaminated secondarily, as previously mentioned, by bacteremia that originated at another site; the colonized catheter can then lead to a local infection or can itself become a source of recurring bateremia.

5.1.1 INFECTION CONTROL

The ICP must ensure that the hospital has specific written guidelines for the insertion and care of intravascular needles and catheters. Additionally, the ICP should monitor the use of IV and other intravascular devices for outbreaks of infections as well as breaks in technique. Teaching is again important, to reinforce the practices that are vital to minimize the risk of IV associated infections.

Specific referenced guidelines for the prevention of intravascular infections are available from the CDC. They include hyperalimentation, arterial pressure monitoring devices, and insertion and care of IV catheters. First, intravascular devices should not be placed unless clinically indicated; if oral therapy can be used, IVs should be avoided and the use of keep-open IVs should be discouraged. Meticulous aseptic technique during IV insertion should be maintained. Lines inserted during emergency situations should be removed and restarted, if needed, when the patient's condition stabilizes. The insertion should follow handwashing by a person trained in intravenous insertion, and a

good skin prep. The skin should be clean (washed with soap and water) and then prepped with tincture of iodine (2% iodine in 70% alcohol). After at least 30 seconds of drying time, the tincture should be removed with 70% alcohol. The prep should be done using friction and moving in concentric circles, from the center outward. Alcohol followed by the use of an iodophor is an acceptable alternate. In patients who cannot tolerate tincture of iodine or an iodophor, vigorous rubbing with 70% alcohol for at least 1 minute is acceptable.

Insertion of an IV catheter is a sterile procedure, requiring use of a sterile field, drapes, and sterile gloves. Steel (scalp-vein) needles should be used whenever possible and practical. Shaving is not indicated, since very small infections can begin in irritated skin and lead to a greater risk of IV site infection; cutting the hair when necessary is adequate. After insertion, the catheter should be anchored and a dressing applied. Because of the possibility that skin flora or organisms will be deposited at the site of insertion and gain access at the point of entry of the catheter, the use of an antiseptic or antibacterial ointment at the insertion site is sometimes recommended and appear to be of greatest value for catheters that remain in place longer than 72 hours and catheters placed by cutdowns. Because some studies have indicated that antibiotic ointments may favor the selected growth of fungi and resistant bacteria, the use of an antiseptic ointment such as an iodophor should be considered, if any is used. The date of catheter insertion should be charted.

Once started, all parenteral solutions should be completely used or discarded within 24 hours. The IV site should be evaluated daily for catheter related complications. This can be accomplished by gently palpating the insertion site through the gauze dressing or palpation and visual examination through transparent polyurethane dressings. Pain or tenderness at the insertions site or unexplained fever warrants removal of the dressing and inspection of the site. Sites should be rotated and dressings changed every 48-72 hours. The tubing setup from the bottle to the needle or catheter hub should be changed every 48 hours. New data show that it may be safe and more cost-effective to

change tubing every 72 hours. Careful charting or labeling of the setup is necessary to determine how long each IV has been in place on a busy ward.

The use of membrane filters has been suggested to eliminate any bacteria in the IV system; a 0.45-µm filter removes almost all bacteria and fungi except some *Pseudomonas,* and a 0.22-µm filter will block all bacteria. The use of filters, however, has not yet been shown to be effective in reducing infection and may require pumps in order to insure flow of the solution.

Solutions that are suspected to be contaminated from the manufacturer should be held and the name and lot number noted. Rather than wasting time culturing IV solutions, suspected solutions should be routinely inspected for cracks and plastic bags gently squeezed to detect punctures. Any fluid that is visibly turbid should not be used.

Programs within the hospital for adding materials to IV solutions hould follow strict policies and procedures. Mixtures, such as those used for parenteral hyperalimentation, that are made up in the hospital pharmacy should be prepared under a laminar airflow hood to reduce airborne contamination. Techniques in the handling and preparation of these solutions should be closely reviewed by the ICC. Many solutions, from manufacturers, after admixture, and following manipulation during setup or care, become contaminated with microorganisms. The practice of routinely changing the entire setup every 24 hours ensures that those organisms present will not have enough time to multiply to numbers large enough to cause infection. Breaks in technique at any stage, however, can allow contamination or growth or organisms that may lead to a catheter-associated infection. Hyperalimentation or total parenteral nutrition (TPN) is included in the CDC hyperalimentation and admixture section of the vascular-related infection guidelines. The TPN solution, if containing crystalline amino acids, does not support the growth of microorganisms except Candida, but a variety of gram-negative bacilli grow rapidly when the solution contains lipids.

The placement of the catheter should be performed as a sterile procedure using sterile gloves and drapes. The solution should be used within 6 hours of preparation or refrigerated. Solutions may be refrigerated up to 1 week as long as refrigeration is continuous and initiated immediately after admixing. Catheter sites need not be changed except as necessary, as long as they are subclavian or jugular. Dressing and tubing changes are the same as those governing non-TPN vascular devices, but greater emphasis is placed on sterile technique to control skin and catheter colonization.

The ICP has the responsibility for monitoring the use of IV catheters as potential sources of nosocomial infection. Although in most cases there is prompt resolution of IV-associated bacteremia following removal of the catheter, in some instances complications occur, with serious results. Through monitoring, developing and reviewing policies and procedures, and teaching, the ICP can minimize the risk of infection associated with this vital procedure.

5.2 RESERVOIR, CARRIER & MODE OF TRANSMISSION

In the course of running an infection control program, the ICP will have a close relationship with the microbiology laboratory of the hospital. Some ICPs enter the position with a background or specific education in microbiology, but most have not had much formal or even informal education in this area. The ICP must understand microbiology to be able to review and examine cases of infections intelligently and also to serve as a liaison between the laboratory and the rest of the hospital.

During surveillance activities, or special studies of infections, the ICP should be able to interpret results from the microbiology laboratory. In addition to the specific criteria for determining infections, the ICP should know normal body flora and what organisms are or can be pathogens in a certain body site, as well as the course of disease for the microorganism, treatment, and prognosis.

To make the best use of the microbiology laboratory, the ICP should know how to take specimens properly from the appropriate body site and how to handle them in order to obtain the best results for the money and time spent.

The ICP will give classes on proper specimen collection techniques and therefore must have a good understanding of growth patterns of organisms, including the best methods of culture, how long to wait before results can be expected, and the different tests available to screen for particular organisms.

This chapter includes a discussion of microbiology for the ICP should know during practice. Those ICPs who have not had any education or experience in microbiology should spend some time working in the microbiology laboratory; if this is not possible, the ICP should attend courses that are periodically offered on the subject. Because microbiology is the key to infection control practice, formal or informal education is essential to the ICP.

A discussion of microorganisms from the laboratory's standpoint follows, including some definitions, groupings and characteristics of microorganisms, and certain laboratory tests. The study of microbiology can be divided into four major groups: bacteriology, mycology, parasitology, and virology.

BACTERIOLOGY

Various staining techniques are available for the identification of certain characteristics or groups of microbes. The Gram stain and the acid-fast stain techniques are probably the most important to the ICP.

The Gram stain is the most common technique; it rapidly identifies bacteria as gram-positive or gram-negative and shows the shape and size of the organisms when viewed under the microscope. There are variations in the Gram stain method; this is one example:

- Heat-fix specimen to slide
- Pour crystal violet or gentian violet on slide for 10 seconds, then rinse with water.
- Carefully decolorize with 95% ethanol, then rinse with water.
- Pour safranin on slide for 10 seconds, then rinse with water.
- Air-dry or blot with paper towels.

Organisms that are gram-positive retain the crystal violet and iodine and resist decolorization; the organisms stain purple. Organisms that are gram-negative lose the crystal violet-iodine stain pick up the counterstain (safranin) after decolorization; these organisms stain pink or red.

Organisms then can be viewed under the microscope and are described as gram-positive or gram-negative; organisms are further described by their size, shape, and grouping, such as rods, cocci, grouped in chains or in pairs, lancet-shaped and so on. Certain organisms have characteristic shapes and groupings that, with the clinical picture, can lead the physician to an early presumptive diagnosis and prompt therapy.

The acid-fast stain is a technique using carbolfuchsin, acid alcohol, and methylene blue in succession.

- Heat-fix specimen to slide
- Cover smear with filter paper and pour carbolfuchsin over slide
- Steam for 3-5 minutes; let stand for 5 minutes; then rinse with water (discard filter paper).
- Pour acid alcohol onto slide until no more color appears, then rinse with water.
- Pour counterstain (methylene blue) over slide for 20 seconds, then rinse with water.
- Sir-dry; examine with 100 x oil-immersion lens.

Some mycobacteria are aicd-fast; they retain the cabolfuchsin (red) and resist decolorization by the acid alcohol. Organisms that are nonacid-fast are decolorized and pick up the counterstain, methylene blue. The particular value of this technique is for the patient with suspected tuberculosis, since M.tuberlosis (and all other members of the genus Mycobacterium) is acid-fast. Since this organism can take weeks to grow in culture, a positive stain combined with clinical signs and symptoms is most helpful to the clinician and to the patient, whose therapy can then begin.

Organisms are also grouped by their need for and survival in oxygen. Anaerobes are organisms that in some way are harmed by oxygen, although there is much variability in the degree of toxicity of oxygen present, but many bacteria categorized as anaerobes are obligate anaerobes, that is, they do not grow in cultures incubated aerobically. Facultative bacteria have wider range: facultative anaerobes can grow in the presence of small amounts of oxygen (microaerophilic); facultative aerobes can grow in conditions of diminished oxygen. Another useful term in describing microorganism growth characteristics is fastidious: organisms that are fastidious are difficult to grow without specific and sometimes special nutrients or conditions set up for culture.

NORMAL FLORA, PATHOGENS, AND CULTURE TECHNIQUES

Normal flora are microorganisms that reside in many areas of the body without causing infection. These organisms vary from one geographic area to another, and also from one host to the next, based on such individual host factors as age, presence of chronic disease, temperature, and acidity. The microorganisms that normally reside on the body help to prevent colonization by pathogenic organisms and thus participate in the host's defense against invasion. When host factors are altered, however, or if these "normal" organisms are introduced into another body area, they can cause infection.

Transient organisms are picked up during patient care, for example, on a nurse's hands. These organisms can become part of the normal flora of the nurse's skin during care for that patient. After the nurse is no longer caring for the patient, these organisms usually are no longer found colonizing that nurse's hands. The acquisition of transient flora can be important during outbreak investigations, when an organism not normally carried on hands can become transient normal flora and thus be transmitted from patient to patient.

RESPIRATORY TRACT

The nasal passages are colonized predominantly with gram-positive organisms, including Staphylococcus aureus (20-80% of the population) and S.epidermidis; streptococci, including streptococcus pneumoniae (5-15% of the population); Neisseria sp. (N.meningitidis in 0-4% of the population), Hemophilus influenzae (5-10% of population), and diphtheroids.

The naso pharynx can be colonized with some of the same microorganisms as the nose, such as streptococci (S. pyogenes (Group A), in 5-15% of the population), Neisseria sp. (N. meningitides in 5-20% of the population), H. influenzae, and in fewer numbers, S.aureus and gram-negative bacilli such as Escherichia coli, Proteus sp., and Pseudomonas aeruginosa.

The trachea, bronchi, lungs, and sinuses are normally sterile. Possible pathogens include Group A streptococci, although, since these can be upper respiratory normal flora, clinical sings and symptoms are necessary to complete the diagnosis. Corynebacterium diphtheriae is the pathogen responsible for diphtheria, and Bordetella pertussis is the causative agent in shooping cough. Other microorganisms in pure culture or that occur in great numbers matched with the clinical picture can lead to a diagnosis of upper or lower respiratory tract infection.

Nose and nasopharyngeal cultures should not be taken to determine the etiology of acute or chronic sinusitis, but they may be taken to rule out a carrier of an organism implicated in an outbreak or to identify C.diphtheriae. Cultures of the nareas are taken with a swab, extended as far back as possible in the nostril, and left in place long enough to obtain nasal secretions. Nasopharyngeal cultures are taken by using a nasal speculum. A special swab on a flexible wire is inserted through the speculum to the nasopharynx and is rotated and left in place for 30 seconds. It is important to transport these specimens immediately to the laboratory. The use of a transport medium will prevent the swab from drying out.

Throat cultures are taken in patients with acute tonsillitis or pharyngitis. The specimen is taken with a sterile swab; by depressing the tongue with an applicator, the posterior pharynx is swabbed, including any areas of purulence. The swab must not touch any other part of the oral cavity. Transport media are not needed in cultures for Group A beta hemolytic streptococci.

Sputum is cultured when a patient has clinical sings or symptoms of lower respiratory tract infection. A coughed specimen is best obtained in the early morning, since the paitent's secretions have pooled overnight. After rinsing the mouth out with water, the patient is instructed to cough as deeply as possible. Induction by nebulizer is sometimes used to stimulate coughing and loosen secretions. Nasotracheal suctioning and transtracheal aspirates are better for sputum specimens, since there is likely to be little or no oropharyngeal contamination of the sputum. A culture may also be taken directly during bronchoscopy.

Sputum is Gram-stained when it reaches the laboratory, to determine the quality of the specimen. Some labs, after examining the smear of the specimen, will reject sputum that has a predominance of epithelial cells, an indication of oral contamination. The presence of polymorphonuclear cells in the smear suggests that the specimen may be from the site of infection and therefore of good quality.

EYE

The eye is normally colonized with organisms including diphtheroids, S. epidermidis, nonhemolytic streptococci, saprophytic fungi, and Neisseria sp. Pathogens can be S.aureus, Moraxella lacunata, Neisseria gonorrhoeae, S. penumoniae, and certain gram – negative bacilli such as Pseudomonas sp. Eye cultures are taken in patients with clinical evidence of purulent conjunctivitis or ulceration. Sterile swabs can be used for obtaining discharge, but there is frequently not enough material to collect. Direct scrapings of the cornea can be taken after application of a topical anesthetic. Transport media are necessary for swabs; scrapings can be directly inoculated into appropriate laboratory media.

EAR

Normal flora of the outer ear includes common skin flora such as S. epidermidis, diphtheroids, and alpha hemolytic streptococci. The middle and inner ear are normally sterile. Pathogens include P. aeruginosa, pathogenic fungi (Aspergillus sp. In particular), S. Pneumoniae, H. influenzae, and other gram- negative bacilli.

Ear cultures are taken or tympanocentesis is performed in patients with purulent otitis media. If the tympanic membrane has ruptured, cultures can be taken with a sterile swab after cleansing the external ear with an antiseptic. Purulent discharge is swabbed, and the specimen is placed in transport media.

GASTROINTESTINAL TRACT

The mouth is colonized with a variety of aerobic organisms, with anaerobic organisms in the gums and tooth pockets. The organisms include alpha and nonhemolytic streptococci, staphylococci (usually S. aureus), diphtheroids, Candida albicans and other yeasts, Bacteroides sp., Fusobacterium sp., Peptostreptococcus sp., and others.

The stomach and duodenum contain minimal numbers of bacteria; if there is obstruction, more bacteria will be present in retained stomach contents, and gall bladder infection may result in more bacteria in the duodenum. The jejunum and upper ileum contain $10^5 - 10^8$ bacteria per gram. The lower ileum contains more microorganisms, including Clostridium perfringens, enterococci, staphylococci, and lactobacilli. The large intestine is heavily colonized with microorganisms, with anaerobic bacteria outnumbering facultative bacteria by a factor of 300 (8). Included in these anaerobes are Bacteroides sp., Peptostreptococcus sp., and Clostridium sp. The common aerobes in the large intestine, often called coliforms, include E.Coli, Enterobacter sp., and Klebsiella sp.

Organisms that are pathogenic to the gastrointestinal tract include Salmonella sp., Shigella sp., Arizona sp., Yersinia sp., Edwardsiella sp., and Campylobacter sp., Staphylococcus aureus and C. albicans, which are normal flora, may be pathogens if found in pure culture or if they predominate (>50% of organisms).

Clostridium difficile, an organism found in 2-4% of the population, is the major cause of pseudomembranous colitis and antibiotic associated colitis. This organism has been implicated in nosocomial infections. Parasites are also included among gastrointestinal pathogens.

Stool cultures are indicated in patients with prolonged diarrhea or other clinical signs of enteric infections. Samples may also be taken in the investigation of an outbreak, where rectal carriage among patients or personnel is suspected. Feces or a rectal swab in transport media are acceptable; fecal material is better for the isolation of Salmonella sp.

URINARY TRACT

The anterior third of the urethra can be colonized with microorganisms such as S. epidermidis, diphtheroids, enterococci, alpha streptococci, and lacto bacilli. The urinary tract above the anterior portion of the urethra is normally sterile, including the bladder, ureters, and kidneys.

Pathogens include the coliform bacteria and other gram-negative organisms, especially E.coli. Other possible pathogens, if found in numbers greater than 1,00,000/ml of urine, include c.albicans, enterococci, S. aureus, and, occasionally, S. epidermidis.

NOSOCOMIAL URINARY TRACT INFECTIONS

Specimens of urine should be obtained in a sterile cup or syringe (suprapubic aspiration or aspiration from a Foley catheter) and transported promptly to the lab. If transport and inoculation onto media cannot occur within 2 hours, the specimen should be refrigerated or put into special transport media.

Urethral specimens are taken in patients with suspected gonorrhea, or, in males with nonspecific urethritis, a swab may be used to obtain urethral discharge after milking the urethra toward the orifice.

BODY FLUIDS

Blood and cerebrospinal fluid are normally sterile. Nearly all common microorganisms already mentioned can primarily or secondarily infect these sites. Additionally, specimens may become contaminated by skin flora during collection. The more common organisms found in blood cultures include

staphylococci; gram-negative organisms such as E. coli, Klebsiella sp., and Pseudomonas sp.; streptococci; and Bacteroides sp. Subacute bacterial endocarditis (SBE) can be caused by alpha hemolytic streptococci (S. viridans), enterococci, staphylococci, gram-negative organisms, fungi, yeasts, or anaerobes.

Cultures of the cerebrospinal fluid are taken by the physician, after hand washing, gloving, draping, and a good skin prep. These specimens should be transported immediately to the laboratory. Since the pathogens are often fastidious, they may not survive refrigeration.

FEMALE GENITAL TRACT

The lower female genital tract is colonized with a variety of microorganisms, including anaerobic and aerobic streptococci, E.Coli, S.; epidermidis, and C. albicans. A definite pathogen is N. gonorrhoeae, and possible pathogens include Hemophilus vaginalis and C. albicans. Indications for culture are purulent vaginitis and postpartum endometritis, as well as investigation of contacts of people who have venereal diseases. A swab of vaginal secretions or needle aspiration for endometrial cultures is taken with the patient in lithotomy position, after insertion of the speculum. Specimens should be delivered as soon as possible to the lab, or inoculated immediately, if N. gonorrhoeae is suspected.

SKIN

The skin is colonized with microorganisms such as S. epidermidis, dpitheroids, alpha streptococci, and Propionibacterium acnes. Additionally, areas of skin near colonized body sites, such as the nose, mouth, and rectum, will be colonized with some of the normal flora from those sites. The common skin pathogens are S. aureus and S. pyogenes (Group A). Other microorganisms can cause superficial skin infections; subcutaneous infections can be caused by anaerobic organisms such as Clostridium sp.

Cultures should be taken of the skin when the patient has boils, furuncles, carbuncles, or other eruptions. In addition, skin cultures may be taken in an outbreak investigation, such as before and after hand washing to detect skin

colonization with the responsible pathogen. The best culture method is aspiration of vesicles with a needle and syringe. After a gentle skin prep, taking care not to rupture the lesion, as much material as possible is aspirated. If lesions are open and draining, a sterile swab can be used to obtain a specimen. If fungal infection is suspected, dry skin scrapings are an adequate specimen.

WOUNDS OR ABSCESSES

Normal postoperative wounds are sterile, although they may be superficially contaminated by surrounding skin flora. Many organisms can become pathogens in a wound; most commonly isolated are S. aureus, S. pyogenes (Group A), Pseudomonas sp. And other gram-negative bacilli, and anaerobes such as Clostridium sp. And Bacteroides sp. Abscesses are frequently caused by anaerobes or a combination of aerobic and anaerobic organisms.

Specimens are indicated if the patient develops purulence in a wound or signs and symptoms of an abscess. The best method is needle aspiration after a skin prep or after cleaning an open wound with saline. Fresh pus from an open wound will give the best indication of the responsible pathogens.

Other body sites may be cultured, and there are specific protocols for culturing certain suspected pathogens. The microbiology laboratory personnel should be consulted for any unusual specimen or particular technique needed.

The ICP spends a lot of time investigating the means of transmission of various diseases or microorganisms and working to prevent or minimize the transmission within the hospital. Certain diseases may have known means of transmission, and precautions to prevent this from occurring are clear-cut. The transmission of certain microorganisms, however, may be less clear, as well as the mechanism of patient colonization or disease during an outbreak. The ICP must be concerned about both the transmission of communicable diseases and the mechanism by which patients within the hospital are colonized by a common organism that later results in endogenous infections.

COMMON DISEASES OR INFECTIONS AND THEIR MEANS OF TRANSMISSION

Disease	*Means of Transmission*
Chickenpox	*Contact:* direct, indirect, droplet
Diarrhea	*Contact*: direct, indirect
Rubella	*Contact:* droplet
Hepatitis	*Contact:* direct, indirect
Rubeola	*Contact*: droplet
Wound infection	*Contact*: direct, indirect
Tuberculosis	Airborne
Urinary tract infection	*Contact:* direct, indirect

Transmission can be broken into four main categories: contact, airborne, vehicle, and vector. Some diseases or microorganisms can be spread by more than one route, and preventive or control measures can differ for each route.

TRANSMISSION BY CONTACT

Contact is the most common way infectious agents are transmitted from one person to another. There are different ways within the contact route that infections are spread and each is controlled somewhat differently.

Direct Contact

Direct contact occurs whenever one person touches another. During this contact, organisms colonizing each person can be transmitted, or active infectious material (such as secretions from draining lesions) can be spread from one to the other. Within the hospital, direct contact is an ongoing process: daily care is done by nursing personnel directly touching patients; in pediatric units, outpatient areas, and psychiatric units there may be direct contact between and interact with each other. In an intensive care unit, a nurse may have prolonged, close contact with more than one patient in a short period of time. There is a great potential for transmitting organisms – those causing infections as well as normal flora – from one patient to another via the hands.

Since hands can provide adequate survival and even growth requirements for microorganisms, nurses can become colonized with those organisms that have colonized or infected the patient with whom the nurse comes into contact with the patient, as long as the patient remains under that nurse's direct care.

The best means of preventing transmission by direct contact is through hand washing, since the hands have the most contact with patients. Gowning and gloving are more strict precautions to prevent transmission, either to the patient, from the patient, or the health care giver through the use of a protective covering that is discarded after use. The use of antiseptic soaps with residual action against microorganisms has been suggested for intensive care areas. This is intended to prevent transient colonization of employees' hands with potential pathogens when hand washing cannot be accomplished after each and every contact. Antiseptic soaps have also been suggested for use before invasive procedures, such as surgery or before intravenous or Foley catheter insertion.

Cohorting of nursing personnel is another means of limiting spread through direct contact. Certainly if there were one nurse for each and every patient, spread from patient to patient via the hands would not occur (although spread of disease from the patient to the nurse or vice versa would still be possible by the contact route). The idea of grouping patients with similar organisms or diseases, consistently cared for by the same nurse or nurses, has merit during an outbreak. These nurses would not have direct contact with noncolonized or noninfected patients; therefore, if the infectious material were picked up and carried by personnel, it could not be transmitted to patients who were not already positive for the organism or disease.

Indirect Contact

Indirect contact occurs when a person touches an inanimate object that has been contaminated by another person. In the hospital environment there is a multitude of objects shared by patients: common toys in a pediatric outpatient department; a stethoscope and sphygmomanometer, beds, and other pieces

of equipment used for one patient after another. The importance of the inanimate environment in the spread of disease-causing agents should be evaluated.

Preventive measures include isolation techniques: double bagging of contaminated laundry and dressings to ensure that they do not contact other patients or susceptible personnel, gowning and gloving of personnel while handling linen and equipment in an isolation room, and special disposal of needles; the list covers the entire range of cleaning, disinfection, and sterilization techniques and the handling of infectious waste in the hospital environment. It is important that certain pieces of equipment, such as instruments and devices that break the skin, always be handled with care before or after patient use. It is also important, however, that other parts of the inanimate environment be examined carefully during outbreaks when the indirect contact route of spread is suspected; for example, the common use of a playroom and toys should be restricted during a suspected outbreak of chickenpox in a pediatric unit.

DROPLET SPREAD

The droplet route of spread involves contact with infectious upper respiratory secretions. Infections spread in this manner require proximity between the infected and the non infected persons. When a person coughs, talks, or sneezes, relatively large (> 5 μm in size) droplets are disseminated from the upper respiratory tract. Because of their size, most travel about 3 ft before settling to a horizontal surface such as furniture or the floor. Infections spread via the upper respiratory tract, although these large droplets require that the non infected person come in contact with the particles within this 3-ft range, before they fall. Infections occur when the susceptible host inhales the particles and that person’s mucous membranes come in contact with the infectious particles.

Masks may help to prevent contact with infectious droplets from a person who is communicable through this route. Physical distance may also be a

control, for example, by placing the person alone in a room. Additionally, infected people may wear masks to decrease the number of droplets that they disseminate.

AIRBORNE TRANSMISSION

Some particles from a person's upper respiratory tract are smaller than the droplets, that is, less than 5 µm in diameter. In addition, the moisture in some droplets evaporates before they fall, and these particles, called droplet nuclei, are small enough to get into air currents in an environment and remain suspended. Although many organisms cannot survive in this nearly dry state, some do, in particular the tubercle bacillus, staphylococci, and streptococci. In this situation, organisms can be spread from one patient to next without direct or indirect (via inanimate objects) contact between the patients or even without the actual presence of the disseminating person. An example of this is seen in the report of an outbreak of postoperative wound infections by S. pyogenes (Group A), during which the carrier-disseminator had just left the operating room and the subsequent patient became infected. These organisms survived long enough in the environment to infect the next surgical case via the airborne route.

Additionally, organisms can become aerosolized from contaminated inanimate objects and will then be transmitted via the air. Procedures such as sweeping, using dry dust mops or cloths, and shaking out linen can aerosolize particles that may contain, for example, the tubercle bacillus. Legionella pneumophila, the organism responsible for legionnellois (Legionnaires' disease; Pontiac fever), has been isolated from water in air-conditioning cooling towers. The mode of transmission of this organism appears to be airborne, during evaporation of water droplets from the cooling tower, which are then drawn into air intakes.

Preventive measures include good ventilation system; ideally, air is supplied from outside and is exhausted directly to the outside. If air is re circulated in high-risk areas such as the operating room, it should be filtered with a 90%

efficiency filter. The operating room should be under positive pressure relative to the surrounding area. Control of patients with tuberculosis and other diseases where the airborne route is of concern includes a private room with negative pressure, the door kept shut, and the use of masks when entering the room.

TRANSMISSION BY VEHICLES

Specific infections can be spread through contaminated blood, drugs, food, or water. Blood is routinely tested for HB_sAg and HIV in an attempt to prevent transmission of these diseases through the vehicle of blood. Accurate donor histories and the reduction of use of blood from paid-donor centers can reduce the risk of infection transmission via this route.

Periodically drugs and intravenous solutions are recalled by the Food and Drug Administration (FDA) because of contamination. A large outbreak related to contaminated intravenous solutions is an example of spread of infection via this vehicle. Prevention and control of transmission from contaminated drugs or other commercial products mainly include a high level of awareness and prompt action if a product is suspect. Withdrawing the product from patient use, saving the product for investigation, and notifying the proper authorities are essential activities. Time will be wasted if the hospital attempts to culture suspected material; the responsibility for investigating including culturing, commercially prepared items in hospitals rests with the FDA. The ICP's responsibility is to investigate up to the point of determining the likelihood that a product is contaminated, withdrawing and saving the product, and notifying the proper authorities.

Drugs and solutions can become contaminated after being opened in the hospital and can then serve as a vehicle in the transmission of infection. This is a problem within the hospital, and the ICP should investigate to determine the source of the problem. A review of the procedures used in the handling of drugs, IV and irrigating solutions, and blood may be helpful in preventing or controlling transmission.

Food and water can also be vehicles in the transmission of infecting organisms. Although not common in the hospital setting, there is potential for food borne outbreaks resulting from improper handling or storage techniques in the Dietary Department. The ICP's role in reviewing policies and procedures and in teaching personnel in this Department will serve to minimize the risk of transmission by this route.

TRANSMISSION BY VECTORS

Infections spread by the vector route have an animal or insect as an intermediate host between two persons. Although this type of infection transmission is generally not significant within the hospital, patients with plague or rabies, for instance, can become directly communicable to other persons. Isolation precautions and a high level of suspicion in geographic areas where these infections are more common will help to minimize the risk to other patients and personnel.

Infections and potentially pathogenic microorganisms are spread within the hospital by a variety of routes. The ICP must determine the route of spread in each case and recommend procedures or precautions to break the chain of infection by stopping its transmission. The range of precautions, from hand washing, to housing of patients, to disinfection and sterilization, to isolation precautions, all contribute in different ways to stop transmission of organisms. The ICP must evaluate the source's degree of infectivity, determine the means of transmission, and institute appropriate steps to prevent transmission of a sufficient number of organisms to a susceptible host.

HOST SUSCEPTIBILITY

Healthy people have several mechanisms for fighting infection: (1) mechanical barriers such as intact skin and mucosal lining of body cavities, (2) appropriately functioning white blood cells, (3) cellular immunity, and (4) cells capable of manufacturing antibodies (humoral immunity). An infection or disease occurs when a microorganism of significant virulence or colony size is able to

circumvent, inactivate, or overwhelm the normal host defenses. Organisms that are capable of doing this in a healthy person are known as pathogens. Organisms that are part of a healthy person's normal flora rarely cause infection but can cause infection when the host's defenses break down. These organisms are called opportunistic.

Many hospitalized patients have one or more broken or deficient defense mechanisms, thus predisposing them to acquiring an infection. Additionally, people with active infections may be hospitalized, so that severely compromised hosts may be housed in the same area, perhaps, as severely infected persons.

The ICP must have an understanding of normal host defenses, deficiencies or breaks in the normal defenses, and how each defense (or lack of it) affects a person's risk of acquiring an infection.

Immunologic factors in host defense

Three types of cells are involved in the host immunologic defense system that prevent infection: cells capable of phagocytosis, cell-mediated immunity (CMI) and humoral immunity (HI). Additionally, complement is involved in antigen-antibody reactions that inactivate and destroy the microorganisms. All of these cells originate in the bone marrow as basic stem cells and when subjected to micro chemical stimuli maturate and perform specific immunologic functions. These cells acting singly and together provide the host with a competent immunologic system.

i) Phagocytosis

Phagocytosis is the capture and killing of microorganisms. There are two overlapping categories of phagocytic cells: the circulating granulocytes known as neutrophils or polymorphonucleocytes (polys) and the macrophage, which is a highly specialized monocytic cell. The first type, the polys, are capable of traversing intact capillary walls, moving in response to a chemical stimulus (chemotaxis), attaching and engulfing the microorganism, and releasing toxic

substances that kill the organism. Only mature polys, which are released from the bone marrow, are capable of phagocytosis. The immature forms are called bands. An increase in polys and bands in the peripheral blood is an indication of infection.

By contrast, macrophages emerge from the bone marrow and circulate as immature or relatively undifferentiated cells (monocytes) capable of clearing particulate matter and invading microbes from the blood. Differentiated, these cells become fixed and wandering phagocytic cells. Macrophages have greater phagocytic capacity, engulfing particles, debris, and dead polys.

Another important function of the macrophage is its ability to process antigens and secrete interleukin 1 (formally known as lymphocyte-activating factor) which activates T and B lymphocytes.

Polys are short-lived and usually succumb within a few hours after a phagocytic event, while macrophages are long-lived and can sustain a chronic long-term relationship with pathogens. Macrophages are capable of self-proliferation in a local lesion, whereas polys are dependent on the bone marrow and circulating blood for a fresh supply to the lesion. Macrophages have greater phagocytic capacity for engulfing particles, debris, and damaged cells than polys-an important activity in wound healing.

ii) Cell-Mediated Immunity

T lymphocytes are the immunologic cells responsible for CMI. They originate in the bone marrow and maturate and differentiate in the thymus gland. These thymus-derived lymphocytes are helper, effector, and suppressor cells. Helper T cells stimulate B lymphocytes to produce antibody and help to differentiate effector T cells into two distinct cell types. One type of effector T cell can gather macrophages and produce delayed hypersensitivity reaction at an intradermal infection site. A PPD skin test for tuberculosis is a delayed hypersensitivity reaction. Other effector T lymphocytes produce lymphokines, which are chemical substances that kill certain viruses, fungi, parasites, and tumor cells. Interferon is a lymphokine. Both types of effector cells can attack and destroy tissue grafts that they perceive as foreign substances.

Suppressor T cells act as immunologic regulators and turn off hypersensitivity reaction and the inflammatory response before an unacceptable level of healthy tissue is destroyed. These regulator cells also stop antibody production when an adequate supply has been produced to eradicate the bacteria. T Lymphocytes are preprogrammed to recognize only one antigen. Cell-mediated immunity occurs when T lymphocytes are sensitized by contact with bacterial antigens at the site of infection or in the lymph nodes. These sensitized T cells have immunologic memory and are capable of self-proliferation to increase their numbers to destroy that particular microbial antigen when it is again presented to the host. The T cells also release lymphokines that are macrophage inhibitory factors (MIF). This causes immobilization and accumulation of the macrophages to kill more quickly or at least to contain the pathogen, giving rise to such defenses as the granuloma that forms around tubercle bacilli.

iii) Humoral Immunity

The third part of the immunologic defense system is antibody production and complement activity. The B lymphocyte is the cell responsible for antibody production. When a macrophage takes up a foreign antigen, it produces interleukin 1, which stimulates helper T cells to produce interleukin 2, which, in turn, activates B lymphocytes to produce plasma cells to secrete immunoglobulins (antibodies). There are five classes of immunoglobulins: IgG, 1gM, IgA, IgD, and IgE. These antibodies have three main functions: opsonization , agglutination, and neutralization. IgA and IgM are involved in opsonization and complement fixation. Opsonization occurs when the antibody coats a bacterium, making it more attractive to the poly and facilitating phagocytosis. Polys have receptor sites on their surfaces. The binding of complement and antibody to the surface of microorganisms allows the poly to attach its receptor sites, especially to heavily encapsulated organisms such as S. pneumoniae and H. influenzae, which are particularly resistant to binding to polys and macrophages. IgA is the predominate immunoglobulin in mucosal secretions of the gut and respiratory tract. The primary function of IgA is to bind to viruses and protozoa.

This interferes with their ability to adhere to membrane surfaces and thus reduces their capacity to invade underlying tissue. The immunoglobulin E initiates allergic responses with release of histamine and other vasoreactive substances.

Agglutination occurs because antibodies have more than one combining site and agglutinate bacteria by combining and branching. This makes a complex that is more easily phagocytized and more easily filtered in the lymph system. Neutralization occurs when the antibody coats the membrane of a host cell and prevents virus from attaching, therefore preventing invasion of the cell by the virus.

At birth, infants have antibodies from the mother; within the first month, the child begins to make its own antibody; the adult level of antibody is reached at about 12 years of age.

The complement system is the other part of humoral defense. It involves nine proteins and some enzymes, which act on one another in a cascade, often activated by the presence of antibody. Activation of the complement pathway results in opsonization, immune adherence, chemotaxis, and lysis of the bacterium.

OTHER GENERAL HOST DEFENSES

Other host defenses include the skin, lung, and gastrointestinal anatomy. The integrity of the skin is an important bacterial barrier for the host. Skin secretions also provide a barrier, as do normal flora. Respiratory tract defenses include the cough and sneeze reflex, mucociliary escalator, and alveolar macrophages.

The gastrointestinal tract provides defenses against bacterial and viral invasion by its normal motility, immunoglobulins in the gut, and gastric acid.

5.3 INFECTION CONTROL MEASURES

In the practice of infection control, there is more than one agency governing the activities and monitoring the results of program efforts. Some of these agencies, briefly discussed or referred to previously, will be covered in more depth here to give the ICP a view of the overall responsibility for infection control within an institution and between the institution and the community.

Health care institutions must be accredited or licensed in order to receive Medicare and Medicaid funding and to participate in other federal programs. Most hospitals are accredited by the Joint Commission on Accreditation of Hospitals (JCAH). Extended care facilities, including rehabilitative and psychiatric institutions, are generally licensed by state health departments. Additionally, departments within an institution may be reviewed and approved by other agencies, such as the review of a microbiology laboratory by the College of American Pathologists. Because the JCAH regulations are broad in scope and affect the majority of ICPs in the country, they will be described in more depth; although state regulations for licensure tend to parallel JCAH standards closely, pertinent regulations should be obtained by those individuals reviewed and licensed by state health department officials.

5.3.1 INFECTION CONTROL PROGRAM ELEMENTS

Surveillance, Reporting, and Analysis of Infections : The JCAH requires that each facility have written definitions of nosocomial infections as well as a surveillance system to collect and review data and to perform follow-up studies as needed. The JCAH also requires input into the employee health program relating to infections. In addition, there must be a system for monitoring and following up problems identified in the inanimate environment of the hospital. All these systems must be in writing and carefully outlined to show that patients, personnel, and the environment are being monitored adequately.

In-Service Education : Education in infection prevention and control must be provided to all personnel in the health care facility through orientation and continuing education programs. Documentation of this educational program must be available to the review team.

Laboratory Support : The infection control program must include written evidence that there is microbiologic and serologic support for any activities related to the surveillance, prevention, and control of infections within the hospital.

Policies and Procedures : There must be hospitalwide or facilitywide policies and procedures regarding the handling of patients in isolation. These rules should cover any personnel having contact with a patient in isolation. There should be documentation that the hospital will provide safe and adequate patient care that will not be compromised by the need to isolate the patient. These policies and procedures should be available in every department and area of the hospital as hospitalwide documents; they should not form part of a specific document's manual, such as that used only in the nursing service.

Approval of Adequate Patient facilities : The JCAH-accredited hospital must provide adequate facilities to house infectious patients, including negative-pressure rooms for respiratory isolation.

INFECTION CONTROL COMMITTEE

The JCAH requires that a standing committee of the medical staff be responsible for the infection control program and activities in the facility. Required membership includes representatives from the medical staff, administration, nursing service, microbiology laboratory (if available), and the ICP or any person responsible for the implementation of the infection control program. The chairperson of the committee must be a person with knowledge or special interest and experience in infection control, preferably a physician. Meetings must take pace at least bimonthly. Documentation of the existence of the committee, its members and meeting dates, its minutes, and the scope of its authority in routine and emergency situations within the administrative structure must be available for review.

The ICC must design and direct the infection control program, including the determination of the kind of surveillance and reporting program that is needed and the approval of definitions and criteria related to surveillance. Activities of the ICC required by the JCAH include the review of the results of any pertinent studies or collection of data, including nosocomial surveillance data, findings from reviews of antibiotic use, and special studies of infections or related procedures. The committee must document these reviews, as well as the ongoing review and approval of policies and procedures for all hospital areas.

INFECTION CONTROL ACTIVITIES

The ICC directs the activities of the ICP and therefore determines the structure and functioning of the infection control program. Some specific activities are required by the JCAH and are spelled out in their guidelines. These activities include the provision of documented policies and procedures, as well as the inservice orientation and continuing education for all departments within the hospital. Specifically named departments are:

- Nursing service
- Anesthesia and postanesthesia care units
- Blood bank
- Cafeteria, coffee shops, canteens
- Food service
- Emergency service
- Nuclear medicine
- Newborn nurseries
- All obstetric services – labor, delivery and postpartum
- Outpatient areas and services
- Pathology
- Pharmacy
- Physical medicine
- Radiology
- Respiratory care service
- Special care units
- Central service
- Housekeeping
- Linen and laundry
- Engineering and maintenance
- Operating rooms

In addition to policies and procedures regarding the handling of isolated patients in these areas, the JCAH requires documentation of policies for handling waste,

use of disposables, and all personnel and equipment procedures that are associated with the occurrence of nosocomial infections. These policies and procedures must be specific for the area, patients, and personnel involved and must be available for review and accessible to people working in the department. The ICC must review and, if needed, revise these policies and procedures on an annual basis. Suggested departmental policies and procedures for infection control are available commercially and offer at least a base from which modifications can be made to fit individual facility specifications.

Additionally, certain procedures in patient care that transcend departmental or area lines, such as intravenous catheter and Foley catheter insertion and care, and the selection, handling, and disposal of disposable items must be documented and reviewed annually by the ICC.

In summary, the JCAH requires that any hospital seeking accreditation have an active infection control program, designed and monitored by an ICC. It suggests that an ICP implement the program directly. The committee must report directly to the executive committee of the medical staff and must have the authority to intervene as necessary in infection control emergencies such as outbreaks. The committee, by its authority and through review functions, ensures that all areas and departments within the hospital are covered by adequate infection control policies and procedures and can show proof of their ongoing education programs in infection prevention and control.

5.4 STERILIZATION AND ASEPTIC TECHNIQUES

Cleaning, disinfection, and sterilization are activities in which ICPs are frequently involved, from the selection of products to the development of specific procedures. Often, ICPs have little formal background or training in the concepts of cleaning, disinfection, and sterilization; yet they are viewed as experts in the use of antiseptics and disinfectants in a health care facility.

5.4.1 DEFINITIONS OF USEFUL TERMINOLOGY

Cleaning is the physical removal of visible dirt and debris. Sanitization renders an item clean, generally by the use of a chemical agent. Decontamination refers specifically to the removal of potentially pathogenic microorganisms, using a process that renders the item safe for handling, usually before further treatment of the item is done.

Disinfection is defined as the reduction in the numbers of disease-producing microorganisms, or potential pathogens, by physical or chemical means. This process generally does not include the destruction or removal of spores. There are different levels of disinfection, both because of the different "potential pathogens" on pieces of equipment and the body sites the equipment contacts.

Sterilization can be defined as the complete destruction of all microorganisms, leaving no viable microbial forms, including spores. In reality, this is most difficult to achieve, and a more practical definition is that the possibility of any microorganisms surviving the process is remote, and that those subsequently found on the item will be nonpathogenic.

In general, the level of disinfection selected will depend on three factors.

1. The type and amount of contamination suspected

Example: The countertops in a hemodialysis unit laboratory area may be disinfected with an agent thought to be effective against hepatitis viruses. By contrast, the countertop in the nursing station of a general medical floor may be cleaned with a general housekeeping agent, such as a quaternary ammonium chloride. It is likely that a hemodialysis unit will have blood spills in the laboratory area that may be contaminated with the hepatitis virus. Therefore, the use of a strong agent to remove or kill these organisms is warranted. By contrast, a nursing station is an unlikely place for heavy contamination with the hepatitis virus or any other pathogen, therefore the use of a general disinfecting agent is adequate.

2. The type and degree of contact the object has with the potential host.

Example: Instruments that enter a sterile system, such as the bloodstream should be rendered sterile. Objects having contact with skin or mucous membranes, such as thermometers and respiratory therapy equipment, require a high level of disinfection.

3. Susceptibility of the host who will have contact with the object

Example: For certain patients with combined immunodeficiency diseases and who are thus highly susceptible to infection, attempts are made to sterilize everything that enters the patients' closed environment.

5.4.2 SOLUTIONS AND PROCEDURES FOR CLEANING, DISINFECTION AND STERILIZATION

The ICP should understand some basic characteristics about the various solutions available for cleaning, disinfecting, and sterilizing the environment, both animate and inanimate.

Soap **:** Soap is made by combining animal or vegetable fats and a caustic agent such as lye. Its action is based on the splitting of molecules into electrically charged ions when dissolved in water. These particles then cause the formation of lather that emulsifies fats, lifting off dirt and other material from the area washed. Soap's action is mainly mechanical.

Alcohol **:** Isopropyl alcohol in 70-90% concentrations will kill many vegetative gram-positive and gram-negative bacteria, including Mycobacterium tuberculosis. Isopropyl alcohol is more effective than ethyl alcohol in its ability to degerm the skin. With constant friction, the skin can be adequately prepped by this antiseptic, but the effect is transient. Alcohol evaporates quickly and leaves no residual effect. It is not sporocidal or virucidal.

Tincture of Iodine **:** Tincture of iodine is a combination of iodine and isopropyl or ethyl alcohol; the solution is used as an antiseptic. Iodine is highly active against microorganisms and continues to be one of the best antiseptic agents. It is effective against both gram-positive and gram-negative organisms and is tuberculocidal, sporocidal, and fungicidal.

When used as an antiseptic skin prep, however, it must be washed off after 30 seconds with alcohol; otherwise, burning and chapping of the skin results. Additionally, patients with allergies to iodine cannot come in contact with this solution. It may also stain the skin and fabrics.

Iodophor **:** Povidone-iodine, known as iodophor, is a widely used antiseptic; it is a polyvinyl-pyrrolidone-iodine complex. Povidone is a polymer that, when combined with iodine, has the following qualities: it retains the germicidal activity of iodine; it liberates iodine slowly, thereby prolonging its activity; and it has a lower toxicity than free iodine.

Although allergic reactions to iodophor are possible, they are greatly reduced compared to those resulting from the use of tincture of iodine. An iodophor is not generally washed off; it remains on the skin and has some residual effects.

Hexachlorophene **:** Hexachlorophere is a halogenated bisphenol that acts as a bacteriostatic, preventing growth, rather than a bacteriocidal agent; it is more effective against gram-positive than gram-negative organisms. Its minimal effect against gram-negative organisms is shown by the fact that gram-negative organisms can grow in hexachlorophene preparations. Peak bacteriostatic effect occurs after multiple washings; this effect can be interrupted by the use of alcohol.

Hexaachlorophene bathing was once widely used as an effective prophylactic measure in nurseries to prevent outbreaks of staphylococcal skin infections. In 1971, a study of 50 newborns showed blood levels of 0.009-0.646 µg/ml at the time the babies were discharged from the hospital, following a daily bathing with a 3% hexachlorophene product. In December 1971, the FDA and the Amercial Academy of Pediatrics concluded that routine bathing with hexachlorophene was not recommended, because of the possible neurotoxicity resulting from absorption through the skin of infants, burned or denuded skin, or mucous membranes.

Following this recommendation and the termination of the use of hexachlorophene, staphylococcal outbreaks in nurseries occurred, and the FDA,CDC and AAP suggested that, in addition to other control measures, a

once-daily prophylactic bathing with 3% hexachlorophene, followed by through rinsing, be considered. In March of 1973, based on further data, the CDC recommended that this temporary use of hexachlorophene be restricted to personnel handwashing and infants weighing more than 2500g, for two washings only. Other recommendations to control staphylococcal infections in the nursery did not include the use of hexachlorophene. Currently, hexachlorophene solutions of 0.75% or greater concentration require a prescription, and solutions containing 0.75% or less hexachlorophene must have precautionary labeling.

Chlorhexidine Gluconate **:** Chlorhexidine gluconate is an antiseptic that is effective against both gram-positive and gram-negative organisms. It has persistent residual activity, increasing its effectiveness after repetitive use. Skin reactions may be rare, but the product is relatively new in the United States and data are not available. Currently chlorhexidine gluconate's use in the United States is restricted to handwashing and surgical scrubbing; it is not used at this time as an antiseptic wound care product, although it has shown good results abroad for this antiseptic use.

Mercurial Compounds **:** Mercurial compounds are poor antiseptics that are only weakly bateriostatic and are inactivated by protein. These compounds are generally not recommended for use in the hospital as antiseptics.

Quaternary Ammonium Compounds **:** There is one quaternary ammonium compound (quat) that was widely used as an antiseptic, benzalkonium chloride. Because of the ability of gram-negative organisms, Pseudomonas in particular, to grow in these solutions, the CDC recommended in 1974 that aqueous benzalkonium chloride be replaced by other solutions for antisepsis. The other quats are used for general housekeeping as disinfectants; they are cationic, anionic, or nonionic groups of detergents. Their activity covers a wide range, depending on the specific chemical composition of each agent in each group. In general, however, they are ineffective against M. tuberculosis or spores, are relatively nontoxic, and can be inactivated by soap.

Phenolic Compounds **:** Phenolics other than hexachlorophene are used as disinfectants and are broad-spectrum germicides that kill M.tuberculosis, viruses, and, sometimes, spores. Generally they are relatively irritating and toxic to the skin but are relatively stable and are not inactivated by organic matter or soap. Reports of cases of hyperbilirubinemia related to the inappropriate use of phenolics in bassinets led to their discontinuation in the nurseries in many hospitals.

Chlorine Compounds **:** Sodium hypochlorite, a common chlorine product, although corrosive can be useful as a disinfectant in dialysis areas because of its reported activity against the hepatitis virus. It is, in addition to being corrosive, irritating to skin and mucous membranes.

Glutaraldehyde **:** Aqueous activated glutaraldehyde is an effective solution for achieving high level disinfection or chemical sterilization. It has the ability, when used over the appropriate time period, to kill all vegetative bacteria, fungi, viruses, and spores. It has low protein coagulability and can be used when steam or ethylene oxide is not possible or practical. However, it is toxic to the skin and mucous membranes.

Pasteurization **:** Pasteurization is a disinfecting process whereby heat is used to kill certain microorganisms and reduce the numbers of others, so that bacteria are kept under control within acceptable limits. The item is heated to a certain temperature for a certain period of time; this method has been suggested as a process for the disinfection of certain pieces of respiratory therapy and anesthesia equipment, although it does not guarantee sterility or even cleanliness if the equipment is not washed first.

A hot-water bath at 60-70ºC for 20-30 minutes is though to be effective against gram-positive, gram-negative and tubercle bacilli but not against spores.

Ethylene Oxide **:** Ethylene oxide is a colorless gas used to sterilize (or to achieve high level disinfection) equipment that would be harmed by moisture or heat. Ethylene oxide can penetrate plastic, rubber, cotton, and other substances but cannot sterilize liquids because it is absorbed and not released

by them. Products that have absorbed EO must be aerated before they can be used; this includes rubber products, plastic, muslin, and paper. Aeration times differ based on the temperature and air flow. A heated aeration cabinet, used according to manufacturer's recommendations, will result in the fastest aeration times.

The Environmental Protection Agency (EPA) expressed concern for the health of workers constantly exposed to EO, and in January 1978, released a report outlining the potential problems. Data are not available on long term effects of exposure to this agent, which is widely used as an alternative to steam sterilization.

***Steam* :** Steam under pressure remains the most effective means of destroying microorganisms on a piece of equipment. High-vacuum and gravity-displacement sterilizers are in use throughout hospitals. Although this is the best and quickest means of sterilization, it cannot be used on an increasing number of delicate pieces of equipment being developed for health care today. Its efficacy, in addition, is based on care in following manufacturer's instructions, including time, temperature, pressure, wraps, load size and load placement, variation in any of which can affect the results.

CLEANING

There are many areas of the health care facility that must be rendered clean, for esthetic as well as infection control reasons. They include, in the general environment, walls, floors, countertops, and furniture. Additionally, cleaning must precede any disinfection or sterilization of an object. All practical methods for disinfection or sterilization can be overchallenged by grossly dirty and heavily contaminated materials. Also, certain chemical disinfectants are inactivated by protein. Therefore, cleaning is essential in nearly all areas of the hospital, whether or not further steps are taken to achieve disinfection or sterilization.

Perhaps the most important component of the cleaning process is friction. In order to physically remove protein material such as blood, tissue, pus, and dirt, mechanical rubbing or scrubbing is necessary.

Cleaning the Inanimate Environment **:** Floors, walls, and furniture in a health care facility may be cleaned with a disinfectant germicide solution and clothes or mops for scrubbing. Wet mopping and dusting are more efficient than dry and are the preferred techniques. Quats, phenolics, or iodophors can be used. The environment should be kept aesthetically clean; those areas in direct contact with patients or patient secretions need additional attention and more specific procedures.

In a typical patient room, the bed mattress and pillow should be covered with plastic, since these items are difficult to clean if they become wet with secretions. Since the patient has prolonged contact with the bed, it should be cleaned between patient use with fresh solution and cleaning clothes. Next, surfaces that receive less patient contact, such as overbed tables, and other pieces of furniture are rendered visibly clean, and walls are spot cleaned as necessary. Such cleaning is best done, either concurrently (during a patient's stay in the room) or for terminal cleaning (after the patient has been discharged), with a spray bottle of cleaning solution, so that the solution does not become dirty from rinsing out the cleaning cloth. The bathroom should be cleaned last, since the toilet and sinks are likely to be the most contaminated, and the moisture in these areas will harbor or even foster the growth of microorganisms. The cleaning clothes used in this area should not be used subsequently on a patient bed mattress or overbed table. Separate cleaning supplies for bathrooms are best.

Mopping also should be done often enough to keep the patient's room or general environment visibly clean. Methods for cleaning the floor include a spray-down, wet-vacuum pick-up machine, which can be used in larger open areas such as hallways, or mopping by hand. There is no evidence that floors contribute directly to infections in hospitals, but they may contribute in an indirect way: a generally dirty environment may be a subtle encouragement to personnel to be lax in their patient-care techniques, or it may reflect a general problem in adherence to good techniques. A visibly clean environment is certainly a better place to work and will probably make most patients more comfortable during their stay.

All areas of the hospital should be maintained as needed; specific procedures for the Housekeeping Department are available elsewhere. Cleaning isolation rooms is the same as any other area, except that the materials used should not be used in another area afterward. Additionally, personnel may need to use isolation techniques while in the area. Disinfectant fogging has been shown to be ineffective and is not recommended as part of the cleaning procedure for terminal and isolation cleaning.

Cleaning the Animate Environment **:** The patient's skin, as well as the hands of nursing and other personnel, must be cleaned regularly. It is important to remove secretions and keep the skin dry to prevent skin breakdown in the immobilized patient. Removal of dirt or contamination from the hands is important to prevent transmission of possible disease-producing microorganisms from a patient to an employee or from one patient to another via the hands of health care personnel.

A soap with the following characteristics should be used for hand washing: it should be mild to avoid irritation; it should make a good lather, since emulsification of surface oils is part of the action necessary to remove contamination. It is best to wash the hands with warm, running water, so that the material is rinsed away with the soap lather. Friction, as with cleaning of other materials, is probably the most important aspect of the procedure of hand washing.

Mallison and Steere have summarized and presented detailed information on hand washing techniques and the appropriate solutions to use. Although bar soap has been shown to become contaminated with microorganisms, it has also been shown that personnel do not pick up these microorganisms on their hands after the procedure has been done. A soap dish that allows water to drain freely and the use of small (hotel size) bars will minimize microbial growth and ensure frequent change of soap. Soap solutions and powders are acceptable and should be chosen for ease of use, non irritability and cost.

Hands should be washed between the routine care of patients, before eating, and after using the bathroom. Often, nursing personnel admit that it is impossible to wash each and every time they make a patient visit. Hand washing

is not necessary, for example, when patient trays are delivered (except as needed before the process of delivering starts), if the patient and the immediate environment will not be touched. There are several instances when health care personnel have little direct contact with the patient; when contact does occur, however, hands should be washed.

Similar considerations apply to keeping the patient clean; the product used should be a nonirritating soap, and the skin should be cleaned as often as necessary to prevent maceration of the tissues from secretions or soilage.

DISINFECTION

Certain pieces of equipment and areas of a health care institution require more than cleaning or sanitization. There are several ways to disinfect the inanimate environment. Similarly, in certain disinfection of skin or tissue is needed during patient care, antiseptics are chemicals used to disinfect live tissue.

Disinfecting the Inanimate Environment

Objects that have extensive contact with patients or areas where survival and transmission of pathogens could occur may need disinfection in addition to cleaning to ensure that potential pathogens are not transmitted. Countertops in dialysis units and laboratories, for instance, need a higher level of disinfection than those at a nursing station. For disinfection to be successful, the object must have been adequately cleaned earlier and the contact time must be long enough for the solution to work. To minimize the growth of microorganisms, equipment such as bedpans, urinals, and thermometers should be stored dry between patient uses; in addition, a thermometer used for one patient should be washed carefully before and after each use and stored dry in the patient's room. Fiberoptic endoscopy equipment should be disinfected according to manufacturer's directions.

Disinfecting the Animate Environment

Antisepsis of the hands is recommended before performing invasive procedures such as IV catheterization or surgery. The hand washing procedure

is the same in terms of running water and friction; the scrub may be required for 2 minutes or longer, and the hand washing solution may differ. Antiseptic soaps such as those containing hexachlorophene, in iodophor, or chlorhexidine gluconate have a certain amount of residual bactericidal action that may be helpful in lowering the number of microorganisms on the hands. Since it is nearly impossible to produce a glove without minute holes in it, this action may reduce the number of microorganisms on the skin that could penetrate a glove and contaminate a sterile body area.

Similarly, the skin of patients going into surgery is treated with an antiseptic scrub. The prolonged action of the solution, as well as its bactericidal activity during the scrub, may eliminate more microorganisms and prevent recolonization during the surgical procedure.

STERILIZATION

In most cases, pieces of equipment that are invasive and that enter sterile body cavities require high-level disinfection or sterilization. This process can be done by steam autoclave, ethylene oxide, boiling water, or chemicals such as activated glutaraldehyde. Items that should be sterilized range from IV fluids, which enter the bloodstream directly, to surgical instruments, which disrupt blood flow and the integrity of skin and body tissues, to the sterile environment created for certain patients with combined immunodeficiency diseases.

5.4.3 ROLE OF THE INFECTION CONTROL PRACTITIONER IN CLEANING, DISINFECTION, AND STERILIZATION PRACTICES

The ICP alone, as a member of a products committee, or as a screen for the ICC, may make many decisions about product selection and the determination of appropriate procedures to render a patient care item safe and reusable.

The ICP must understand fully the type of procedure and equipment in question and be able to determine the level of cleaning or disinfection necessary. Thus the ICP must not only understand the nature of the procedure or contact a patient or employee will have with an object but also realize the limitations and frailties of the piece of equipment itself, since in many cases very fragile equipment requires high-level disinfection.

The choice of an antiseptic for skin or tissues can be based on these ideal characteristics:

i) It should be effective against resident and transient microorganisms on the skin

ii) It should be applied quickly and have effects that last throughout a procedure.

iii) It should be effective against all microorganisms.

iv) It should be able to be used on any part of the human body, at any age, without toxic effects.

v) It should not be inactivated by protein such as organic matter, by soaps, or by other materials.

The ICP must consider these ideal characteristics when considering a product for use on patients or personnel in the hospital.

Spaulding set up criteria for the ideal disinfectant, and these still stand as useful considerations in the selection of a product. An ideal product

- Produces rapid killing of microorganisms, including vegetative bacteria, spores, and viruses
- Will not corrode metal, damage rubber parts, or dissolve cement in lens systems
- Will not discolor or stain
- Is not inactivated or coagulated by the presence of body proteins such as secretions, tissue, or blood
- Is nonirritating to the skin and is nontoxic
- Is tasteless and odorless
- Is heat stable
- Is stable over a wide pH range
- Does not alter electric conductivity
- Remains active over a long period of time
- Can be diluted without losing its activity
- Is inexpensive

- Is a good wetting agent
- Is miscible with water in any proportion
- Will not produce a residue or buildup after use

Each of these characteristics must be considered by all those involved in the purchase of disinfectants. The ICP will be called upon to address those criteria that pertain to the killing of microorganisms, in-use life, and use factors that might affect the product's ability to perform as a disinfectant. With information about the desired level of disinfection and the characteristics of the product, the ICP can recommend acceptable alternatives that can be considered from other standpoints, such as cost and toxicity.

PRODUCT SELECTION

The EPA evaluates labels on products that are classified as pesticides. Disinfectants come under this classification, and the product label must include the following: brand name; chemical formula, including all active ingredients and the proportion of inert chemicals; name and address of the manufacturer; information to alert user to toxic side effects; first aid; warnings; disposal of container; directions for use; EPA registration number; and establishment number.

Any other information on the label is the choice of the manufacturer, but it must be approved by the EPA. Included might be results of the Association of Official Analytical Chemists (AOAC) Use-Dilution Confirmation Test. This test is based on the product's ability to kill selected organisms, Salmonella cholerasuis, S. aureus, and P. aeruginosa. Although this testing must be true, it is done under laboratory conditions and may not be exactly the same as that of the hospital environment.

Manufacturers frequently supply brochures with test results that stimulate in-hospital use. However, since the label claims are carefully controlled by the EPA and the additional information brochures may come from a variety of sources, the ICP may choose to look at the label only for determining the qualities of a product. Some manufacturers encourage in-use microbiologic

testing of products. This is not recommended for the selection of a product for use in the hospital, since the tests when done correctly are costly, time consuming, and difficult to control. Certainly the ICP can elect to test a product as a specially designed study, but simple culturing of solutions or equipment to test the efficacy of a product is not a reliable or cost-effective means of evaluation.

In summary, the ICP can in most cases get all the needed information from the product label. He or she should understand the desired level of disinfection, as well as characteristics of different groups of disinfectants. Other considerations, then, will be cost, toxicity or irritation, and personnel preference. Sometimes discussing products with another ICP whose institution uses the product in question may supply additional information that will help in the selection process.

5.5 INFECTION CONTROL COMMITTEE

In the mid-1950s health care practitioners became concerned about the drastically increased incidence of staphylococcal infections and their resistance to penicillin. This prompted the American Hospital Association in 1958 to recommend: “that each hospital should establish Committees on Infections, to devote particular attention to infections which are acquired in hospitals so they may be reduced to the lowest level”

Although there have been some minor changes in recommended membership, functions, and responsibilities, the basic idea has remained throughout the development of infection control practice. The most current recommendations of the Joint Commission on Accreditation of Hospitals (JCAH) state: “Responsibility for monitoring the infection control program shall be vested in a multidisciplinary committee”.

The goal of the ICC should be the reduction of infections occurring within, or related to, the institution. LaForce put it more strongly, stating that his committee’s goals were prevention of infections in hospitalized patients and hospital personnel. The ICC is able to approach its goal with more or less success, depending on the strength of its chairperson, its membership, its authority, and its functions within the hospital.

CHAIRPERSON OF AN ICC

The chairperson of the ICC is "an individual whose credentials document knowledge of, and special interest or experience in infection control". Brachman states the chairperson should also have specific training in microbiology, epidemiology, or infectious disease. The JCAH further recommends that the chairperson be a physician; LaForce agrees, stating that decisions are communicated more effectively from physician to physician. It is critical that chairpersons have the respect of their peers in the hospital and community. In some hospitals the chairmanship of the ICC is assumed by the hospital epidemiologist who is knowledgeable and trained in hospital infection control; in others there may be some difficulty in finding an appropriate chairperson with all the desired qualities. Chairpersons who are interested in and willing to learn about infection control and have the respect of their peers can be supplemented by ICPs with experience and education in infection control practice.

In the past, hospitals have assigned the chairperson of the ICC to serve a 1 or 2 year term. This caused a problem in terms of development, continuity, and maintenance of an effective infection control program. Additionally, educational programs for ICC chairpersons are only now being developed. Most medical school programs in which infectious disease fellowships are awarded include few internships in infection control practice. Until these educational programs are more widely available, chairpersons of hospital ICCs may not be adequately prepared for the role. It is imperative, therefore, that the developed skills of the ICC chairperson be adequately utilized and that the chairmanship of the ICC not be rotated frequently.

MEMBERSHIP OF AN ICC

Standards set by the JCAH provide a guideline for selecting members of the ICC. "Its membership shall include representation from the medical staff, administration, nursing services, and where available, the microbiology section of the laboratory. Any individual employed in a surveillance or epidemiologic

capacity shall be a member of the Committee". Additionally, the JCAH recommends committee representation from medical, surgical, pediatric, pathology, and obstetrics-gynecology (OB/Gyn) services, and house staff, if present within the medical staff. A liaison between the ICC and the local or state health department is suggested. Representatives from other areas in the hospital, such as Housekeeping, Maintenance, Laundry, Dietary Services, Central Supply, Operating Room, Engineering, and Pharmacy, should be named to serve on the committee as consultants or ad hoc members to attend as needed.

A closer look at the required members may be helpful. The medical staff representative is essential to "provide direction and strengthen the clinical aspects of the program". The JCAH standards further direct that no policies or clinical decisions can be made except at meetings where appropriate physician members are present. It is clear, in current hospital practice, that any decisions involving the medical management and care of patients will require physicians input in order to be acceptable to other physicians. Furthermore, the expertise of the physician-epidemiologist and other involved physicians may be essential in the decision-making process in clinical areas.

A hospital administrator must be a member of the ICC for an effective infection control program. The hospital administration is responsible for the allocation of funds and resources within the institution and thus plays an important role in the functioning of the infection control activities. Without the support of administration it would be difficult to initiate new programs or to maintain the effectiveness of established programs. Brachman and Haley state that infection control programs have flourished where there is administrative support and are inhibited in their development when administrators are reluctant to provide support and resources. The hospital administration will be unable to appreciate these needs unless it is actively involved in the ICC. The administrative member should be high enough in the administrative structure to be able to give the committee realistic expectations of the implementation of their decisions.

The administrative member of the committee is also in a position to help in the implementation of policies, programs, and control measures. The administrator is a key person in the communication, implementation, and enforcement of hospital wide decisions.

Another essential number of the ICC is from nursing service. There is no other group in the hospital that has a more prolonged, intimate contact with patients than nurses. Their role in infection control is very important from the standpoint of infection risks to personnel as well as to patients. The nursing service representative should be high enough in the nursing service structure to be able to speak as a representative and have authority within the nursing department to implement change. This member should also have a genuine concern for infection control and be instrumental in carrying out recommendations of the ICC at the nursing level.

A representative from the microbiology laboratory is also an essential member of the ICC because of the impact of the infection control program on the laboratory. Routine infection control activities as well as epidemic investigations require close cooperation between the ICC and the microbiology laboratory personnel. A certain amount of laboratory personnel time and supplies will be used for infection control activities, and the laboratory representative should be qualified to address these issues.

The remaining member of the ICC is the ICP. The ICP is responsible for the daily activities of the infection control program and thus is an indispensable member of the ICC.

The ICP is mainly responsible for implementing the infection control program. The ICP was originally described and continues to be the liaison between the ICC and the personnel of all hospital departments. Since the JCAH requires departmental representation only from medical staff, administration, nursing, microbiology,a nd infection control epidemiology, in each hospital there is a considerable amount of freedom in determining the number of additional members and specific departments or areas to be represented on the committee. In some hospitals, additional members have been drawn from

Employee Health, Blood Bank and the Outpatient Department. Because of size, however, an ICC with members representing all the suggested departments and areas may have difficulty in finding times suitable to all and in making progress. Copies of the minutes of all meetings can keep them informed of activities of the ICC in which they are not directly related.

Himmelsbach recommended that the committee members represent those specialties necessary for an adequate evaluation of infections and that the members be people with respect and prestige in the institution. Infection control committees will vary from hospital to hospital, but it is important that the members be interested in infection control, knowledgeable in the subject or willing to spend some time to learn about it, and have an administrative position high enough in their respective departments to both speak for there area of expertise and implement decisions made in the committee.

Ad hoc representation from all patients areas can make the ICC large and unworkable. Smaller committees, made up of individuals actively involved in infection control activities, or persons genuinely interested in control of infections may be more effective. These individuals should be high enough in the hospital hierarchy to make decisions and have the capacity for implementation. Representatives from the medical staff should be committed to infection control, support the ICC decisions, and disseminate committee information to members of their medical subspecialties.

AUTHORITY

The ICC is a standing committee of the hospital's medical staff. Administratively, it must report its activities, findings, and decisions to the medical staff through the executive committee, to the director of nursing service, and to the chief executive officer of the hospital. Carefully written minutes of each meeting must be kept and made available to all members and also to department heads and chiefs of services as needed.

More specific lines of authority need to be drawn up within each hospital, and without the authority to initiate prompt and necessary corrective action, the ICC is an ineffectual group. Generally, the ICC fits into a staff rather than a line

position in the administrative hierarchy. The successful functioning of the committee depends on support from the administration and the hospital's board of directors. Specific areas of authority must be delineated in emergencies when critical decisions are needed immediately; for example, if a hospital unit is to be closed during an outbreak of infection. One solution is to give the authority in this case to the chairperson, the appropriate physician (director of the unit in question or chief of the clinical service), and administrator to make emergency decisions in the absence or unavailability of the entire committee. Determining these lines of authority and power in advance and having them approved by the medical staff and hospital administration are crucial early activities of the ICC.

FUNCTIONS

The ICC gives structure, direction and administrative power to the infection control program. During regular meetings the group serves as a review and recommendation board. Policies, protocols, and results of any surveillance programs are reviewed and recommendations are passed on to other committees, hospital administration, and the medical staff. These review and recommendation functions should be examined in greater depth to show the role of the ICC in the infection control program.

MEETINGS AND AGENDAS

The ICC is required by the JCAH to meet at least once every 2 months; in order to maintain some continuity, it should meet every month. The agenda and materials should be handed out at least 1 week prior to the meeting and should be appropriate for the level of operation of this committee within the hospital administration. This allows committee members to be well informed prior to the meeting and make appropriate decisions on agenda items.

Daily decisions of the ICP, alone or with the ICC chairperson, should not be made part of the ICC agenda unless they are important as information items.

Example. The ICP is consulted by nurses on a surgical floor regarding the appropriate placement of a patient with a wound infection. After talking with nurses and the patient's physician and determining the amount of purulence

in the wound, the ICP's recommendation is to place the patient in Wound and Skin Precautions, in a room on the crowded surgical floor with a patient whose wound is nearly healed. This kind of decision should not be brought to the ICC. Even in the event of a disagreement, the ICC Chairperson's involvement alone would be sufficient and appropriate. If, however, the question came up repeatedly, the ICP could propose a policy or procedure change to the committee. The wound and Skin Precautions policy could be modified to specify more clearly the criteria for the placement of patients in this kind of isolation. A change in hospital policy or procedure would be ICC business. Or, if the ICP determined an educational need, a proposal for a change in the infection control program to include an intensive educational program or a proposal to do a study of the transmission of organisms infecting wounds on the surgical floors would need review by the ICC.

REVIEW FUNCTIONS

The ICC is charged by the JCAH with reviewing all data collected by the ICP, as well as policies, procedures, and protocols related to the risk of infections in the hospital. Specifically, the ICC reviews the following:

1. *Surveillance data*. Any data collected on nosocomial infections in patients or employees, environmental monitoring, and the results of outbreak investigations must be reviewed by the committee.
2. *Policies and procedures*. All departments and areas must have infection control policies and procedures, which are reviewed by the ICC and approved or modified. In addition, certain policies are hospital wide, stemming from the overall hospital policy and procedure manual. For example, isolation policies and procedures are reviewed by the committee since all personnel directly or indirectly involved with patients must abide by these policies.
3. *Protocols*. Protocols for proposed studies as well as the infection control program itself are reviewed by the ICC. The infection control program structure, including methods of surveillance, time allocations, and basic components of the program, are reviewed and approved by the committee.

RECOMMENDATION FUNCTIONS

After review of the results of infection control activities, policies, and procedures, and protocols related to infection control, the ICC makes recommendations to appropriate groups or areas in the hospital. This should be the major function of the committee, and its decisions should be on a high administrative level. The ongoing decisions in infection control practice are made by the ICP, with help as needed from appropriate committee members.

FUTURE

In the past, the ICC has been the recognized basis for the institution's infection control program. Mallison has stated that "an effective infection control committee is the most important part of a program for control of nosocomial infection". The JCAH standards can be interpreted in a such a way that the committee actually develops and conducts the daily business of the infection control program. It is unreasonable to assume that the committee as a whole has the expertise or time to run the infection control program. The ICP, alone or in conjunction with the chairperson, should be responsible for this.

Many hospitals are beginning to examine the role and function of the ICC. These committees have for the most part been recommending rather than authoritative bodies. Hospitals must examine their purpose for the ICC-fulfilling regulatory agencies' requirements of a group committed to the prevention and control of nosocomial infections. More authority should be given to the ICC for implementation of its policies through the ICP, because a committee without this authority is an ineffectual group. The ICC should be a hospital committee whose authority is clearly supported and endorsed by the hospital board or executive committee. The ICC chairperson and the ICP should receive their direction and support from the hospital administration.

The ICC has an administrative and supervisory role in the infection control program, performing this function for other committees, departments, and areas of the institution as well. Through its review and approval functions, the committee sanctions and gives credibility to the daily activities and decisions

of the ICP. The ICP develops the expertise needed to implement the program and, in turn, provides the committee with appropriate data, proposals for policy and procedure changes, and the clinical input to help in its decision making process.

The JCAH has written its new accreditation manual in a style that allows it to be used as an assessment tool by the ICC and the ICP for evaluation of its program. In the future more attention may be focused on the ICC concerning the cost : benefit ratio of its infection control practices. As hospital revenues continue to be limited, the ICC will need to constantly modify its practices and assess its direction for reduction of nosocomial infections to their lowest possible level and demonstrate to administration the cost-effectiveness of their activities in achieving this goal.

Diagnosis-related groups (DRGs), as established in 1983 for the reimbursement of Medicare patient hospital costs, have presented the ICC and the ICP with an opportunity to interact directly with administration and demonstrate that nosocomial infections cost the institution in nonreimbursable expenditures. The ICC must show administration that a strong infection control program with adequate funding will reduce nosocomial infections and save money.

SUMMARY

This unit has explained Medical Asepsis, Nosocomial Bacteremia, Reservoir, Carrier & Mode of Transmission. The various Infection Control Measures, Sterilization and Aseptic Techniques have also been discussed. The functioning and process of Infection Control Committee has been narrated which provides the reader a sketch of the various aspects of infection control.

KEYWORDS

intravenous	nosocomial	bacteremia
hemodynamic	staphylococci	colonize
corynebacterium	phlebitis	venipuncture

tincture	pseudomonas	hyperalimentation
crystalline	parasitology	

REVIEW QUESTIONS

1. Explain Medical Asepsis, Nosocomial Bateremia
2. What are the Sterilization and Aseptic Techniques?

SUGGESTED READINGS

1. K. Park, Textbook of Preventive and Social Medicine
   (M/s. Banarsidas Bhanot Publishers, Jabalpur)

Model Question Paper

BBA DEGREE EXAMINATION

MSH 13 HUMAN ANATOMY, PHYSIOLOGY & MEDICAL TERMINOLOY

Time 3 hrs **Max Marks 75**

Part- A (3 X 5 = 15 marks)

Answer any three questions. All questions carry equal marks

Write short notes on three of the following.

1. Meckel's diverticulum
2. Synovial joints
3. Functions of Insulin
4. Down Syndrome
5. Primary Nosocomial Bacteremia

Part- B (4 X 15 = 60 marks)

Answer any four questions. All questions carry equal marks

6. Enumerate the parts of the Central Nervous System. Describe the functional areas of Cerebrum.
7. Describe the course, relation and applied anatomy of ureter.
8. Describe the faces of cardiac cycle. Describe in detail factors maintaining cardiac output.
9. Explain the various properties of skeletal muscle. Describe in detail the mechanism of contraction of skeletal muscle.
10. List out the suffixes related to conditions, symptoms or diagnoses.
11. Define Illness. Describe the main processes causing illness.
12. What is meant by infection control? Describe the infection control measures.

அன்பிற்கினியோர்களே!

தமிழ்நாடு திறந்தநிலைப் பல்கலைக்கழகம்
தங்களை அன்புடன் வரவேற்கிறது.
இந்தப் பாடத்திட்டம்
தங்களுக்குப் பெரிதும் துணையாக இருக்கும்.
தாங்கள் சுயமாகப் படித்து
அறிந்து கொள்ளும் வகையில்
பாடப் பொருளும் பாடத்திட்டமும் அமைக்கப்பட்டுள்ளன.
இது தங்களின் கற்றல் அனுபவத்தினை விரிவுபடுத்தும்.
இப்பாடங்களைத் தாங்கள் கவனமுடன் கற்றுத் தேற
வேண்டும்.
உங்கள் படிப்பில் ஒவ்வொரு நிலையிலும் நீங்கள்
கவனம் செலுத்த வேண்டும். ஒவ்வொரு பிரிவின்
இறுதியிலும் சுயமதிப்பீட்டு வினாக்கள்
இணைக்கப்பட்டுள்ளன.
இது தங்களின் கற்றல் நிலையைத்
தாங்களே அறிந்து கொள்ள உதவியாக இருக்கும்.
மகிழ்வுடன் படித்துப் பயன்பெறுங்கள்.

வாழ்த்துக்கள்!

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