

Anatomy & Physiology

For the students of
Pharmacy Technicians
(Category-B)

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Dedication

To

Prof. Dr. Naim Anwar Muzaffar “The Father of Pharmacy”

Whose Dedications Toward Pharmacy Education Are Priceless.

Acknowledgement

I am very grateful to **Ch. Muhammad Shamoan**, Secretary, Punjab Pharmacy Council, Lahore, who give me honor to compile **Anatomy & Physiology** Book for the students of Pharmacy Technician.

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Contents

ANATOMY	10
HUMAN ANATOMY	10
BRANCHES OF ANATOMY	10
MACROSCOPIC OR GROSS ANATOMY	10
MICROSCOPIC ANATOMY OR HISTOLOGY	10
HISTOLOGY	10
CYTOLOGY	10
EMBRYOLOGY	10
SURFACE ANATOMY	10
APPLIED ANATOMY	11
RADIOLOGICAL ANATOMY	11
TERMINOLOGY OF POSITION	11
TERMINOLOGY OF MOVEMENT	13
FLEXION AND EXTENSION	13
ABDUCTION AND ADDUCTION	13
ELEVATION AND DEPRESSION	13
DORSIFLEXION AND PLANTARFLEXION	13
EVERSION AND INVERSION	14
SURFACE ANATOMY	14
HUMAN SKELETON	14
OVER VIEW OF HUMAN SKULL	14
OVER VIEW OF THE UPPER LIMB	16
OVER VIEW OF LOWER LIMB	16
VERTEBRAL COLUMN	16
ANATOMY OF PELVIC GIRDLE	17
ANATOMY OF DIGESTIVE SYSTEM	18
ANATOMY OF RESPIRATION SYSTEM	18
ANATOMY OF URINARY SYSTEM	19
ANATOMY OF CARDIOVASCULAR SYSTEM	19
ANATOMY OF REPRODUCTIVE SYSTEM	20
MALE REPRODUCTIVE SYSTEM	20
FEMALE REPRODUCTIVE SYSTEM	20
INTRODUCTION TO PHYSIOLOGY	21
HUMAN PHYSIOLOGY	21
CELL	21
STRUCTURE OF CELL	21
COMPONENT OF A CELL	22
PLASMA MEMBRANE OR CELL MEMBRANE	22
FUNCTIONS OF PLASMA MEMBRANE	23
CYTOPLASM	23
ZONES OF CYTOPLASM	23
NUCLEUS	23
FUNCTIONS OF NUCLEUS	23
MITOCHONDRIA	23
RIOSOMES	23
ENDOPLASMIC RETICULUM (ER)	23
GOLGI APPARATUS	23
LYSOSOMES	23
MICROFILAMENTS AND MICROTUBULES	23
TISSUE	24
EPITHELIAL TISSUE	24
TYPES OF EPITHELIAL TISSUES	24
SIMPLE EPITHELIUM	24
STRATIFIED EPITHELIA	24
CONNECTIVE TISSUE	24
MAJOR FUNCTIONS OF CONNECTIVE TISSUE	24
STRUCTURE OF THE CONNECTIVE TISSUE	24
CELLS OF CONNECTIVE TISSUE	24
CONNECTIVE TISSUE FIBERS	25
GROUND SUBSTANCE OF THE CONNECTIVE TISSUE	25
MUSCULAR TISSUE	25
SKELETAL MUSCLE TISSUE	25
SMOOTH (VISCERAL) MUSCLE TISSUE	25
CARDIAC MUSCLE TISSUE	26

NERVOUS TISSUE	26
BONE OR OSSEOUS TISSUES	27
BONE CELLS	27
BONE MATRIX	27
TYPES OF BONES	27
LONG BONES	27
SHORT, IRREGULAR, FLAT AND SESAMOID BONES	27
FUNCTIONS OF BONES	27
JOINTS	27
TYPES OF JOINTS	27
FIBROUS OR FIXED JOINTS	28
CARTILAGINOUS OR SLIGHTLY MOVABLE JOINTS	28
SYNOVIAL OR FREELY MOVABLE JOINTS	28
BLOOD	29
PROPERTIES OF BLOOD	29
COMPOSITION OF BLOOD	29
CELLULAR CONTENT OF BLOOD	29
ERYTHROCYTES OR RED BLOOD CELLS (RBC)	29
COMPOSITION OF RED BLOOD CELLS	29
PROPERTIES OF RBC	30
FUNCTIONS OF RBC	30
FATE OR PRODUCTION RBCs	30
FACTORS NEEDED FOR ERYTHROPOIESIS	30
RBC COUNT	31
VARIATION IN RBC COUNT	31
HEMOGLOBIN (Hb)	31
NORMAL VALUE OF HEMOGLOBIN	31
FACTORS NECESSARY FOR Hb SYNTHESIS	31
FUNCTIONS OF HEMOGLOBIN	31
LEUKOCYTES OR WHITE BLOOD CELLS (WBC)	31
PROPERTIES OF WHITE BLOOD CELLS	31
COUNT OF WHITE BLOOD CELLS	31
CLASSIFICATION OF WHITE BLOOD CELLS	31
GRANULOCYTES	31
AGRANULOCYTES	32
FUNCTION OF WHITE BLOOD CELLS	32
THROMBOCYTES OR PLATELETS	32
SHAPES OF PLATELETS	32
SIZE OF PLATELETS	33
COUNT OF PLATELETS	33
LIFE SPAN OF PLATELETS	33
TYPES OF PLATELETS	33
FUNCTIONS OF PLATELETS	33
BLOOD GROUPS	34
IMPORTANT TERMINOLOGY RELATED TO BLOOD GROUP	34
BLOOD GROUP SYSTEMS	34
O-A-B BLOOD TYPES	34
RH FACTORS (RHESUS FACTORS)	35
ERYTHROCYTE SEDIMENTATION RATE (ESR)	35
DETERMINATION OF ESR	35
NORMAL VALUE OF ESR	35
FACTORS EFFECTS ESR	35
ANEMIA	37
CLASSIFICATION OF ANEMIA	37
MORPHOLOGICAL CLASSIFICATION	37
NORMOCYTIC NORMOCHROMIC ANEMIA	37
MACROCYTIC NORMOCHROMIC ANEMIA	37
MACROCYTIC HYPOCHROMIC ANEMIA	37
MICROCYTIC HYPOCHROMIC ANEMIA	37
ETIOLOGICAL CLASSIFICATION	37
HEMORRHAGIC ANEMIA	37
ACUTE HEMORRHAGE	37
CHRONIC HEMORRHAGE	37
HEMOLYTIC ANEMIA	38
INTRINSIC HEMOLYTIC ANEMIA	38
SICKLE CELL ANEMIA	38
EXTRINSIC HEMOLYTIC ANEMIA	38

NUTRITION DEFICIENCY ANEMIA	38
IRON DEFICIENCY ANEMIA	38
PROTEIN DEFICIENCY ANEMIA	38
PERNICIOUS ANEMIA (VITAMIN B12 DEFICIENCY ANEMIA)	38
MEGALOBlastic ANEMIA (FOLIC ACID DEFICIENCY ANEMIA)	39
APLastic ANEMIA	39
ANEMIA OF CHRONIC DISEASE	39
CIRCULATION	40
PULMONARY CIRCULATION	40
SYSTEMIC OR GENERAL CIRCULATION	40
FUNCTIONAL PARTS OF CIRCULATION	40
PROPERTIES OF CARDIAC MUSCLE	41
CARDIAC CYCLE	42
STAGES OF THE CARDIAC CYCLE	42
SUBDIVISIONS AND DURATION OF CARDIAC CYCLE	42
HEART SOUNDS	42
ELECTROCARDIOGRAPHY (ECG)	43
ELECTROCARDIOGRAPH	43
ELECTROCARDIOGRAPHIC PAPER AND GRID	43
ECG LEADS	43
WAVES OF NORMAL ECG	43
MAJOR COMPLEXES IN ECG	44
USES OF ECG	44
BLOOD PRESSURE	45
SYSTOLIC BLOOD PRESSURE	45
DIASTOLIC BLOOD PRESSURE	45
MEASUREMENT OF BLOOD PRESSURE	45
PALPATORY METHOD	45
AUSCULTATORY METHOD	45
PHYSIOLOGICAL VARIATIONS OF BLOOD PRESSURE	45
PULSE	46
HEMORRHAGES	46
TYPES AND CAUSES OF HEMORRHAGE	46
ACUTE HEMORRHAGE	47
CHRONIC HEMORRHAGE	47
LYMPH	47
LYMPHATIC SYSTEM	47
COMPOSITION OF LYMPH	47
FUNCTIONS OF LYMPH	47
RESPIRATORY SYSTEM	48
RESPIRATION	48
PHASES OF RESPIRATION	48
TYPES OF RESPIRATION	48
FUNCTIONAL ANATOMY OF RESPIRATORY TRACT	48
MECHANICS OF RESPIRATION	48
MECHANISM OF INSPIRATION	48
MECHANISM OF EXPIRATION	48
PULMONARY VENTILATION	49
LUNG VOLUMES	49
LUNG CAPACITIES	49
PHYSIOLOGICAL VARIATIONS OF VITAL CAPACITY	50
CARRIAGE OF O₂ AND CO₂ BY THE BLOOD	50
TRANSPORT OF OXYGEN	50
TRANSPORT OF CARBON DIOXIDE	51
REGULATION OF BREATHING/ RESPIRATION	51
NERVOUS OR NEURAL MECHANISM	51
CHEMICAL MECHANISM	52
TYPES OF CHEMORECEPTORS	52
CENTRAL CHEMORECEPTORS	52
MECHANISM OF ACTION OF CENTRAL CHEMORECEPTORS	52
PERIPHERAL CHEMORECEPTORS	52
MECHANISM OF ACTION OF PERIPHERAL CHEMORECEPTORS	52
SKIN	53
STRUCTURE OF SKIN	53
EPIDERMIS	53
DERMIS	53
FUNCTIONS OF SKIN	54

TEMPERATURE REGULATION BY SKIN	54
MECHANISM OF TEMPERATURE REGULATION	55
WHEN BODY TEMPERATURE INCREASES	55
WHEN BODY TEMPERATURE DECREASES	55
<u>DIGESTIVE SYSTEM</u>	56
ACTIVITIES OF DIGESTIVE SYSTEM	56
FUNCTIONS OF DIGESTIVE SYSTEM	56
ORGANS OF THE DIGESTIVE SYSTEM	56
ALIMENTARY TRACT	56
ACCESSORY DIGESTIVE ORGANS	56
<u>DIGESTIVE JUICES</u>	56
<u>SALIVA</u>	57
SALIVARY GLANDS	57
COMPOSITION OF SALIVA	57
FUNCTIONS OF SALIVA	57
<u>GASTRIC JUICE</u>	58
COMPOSITION OF GASTRIC JUICE	58
FUNCTIONS OF GASTRIC JUICE	58
<u>PANCREATIC JUICE</u>	59
COMPOSITION OF PANCREATIC JUICE	59
FUNCTIONS OF PANCREATIC JUICE	59
<u>BILE JUICE</u>	60
COMPOSITION OF BILE	60
FUNCTIONS OF BILE	60
<u>INTESTINAL JUICES</u>	60
<u>SMALL INTESTINE JUICE</u>	60
COMPOSITION OF SUCCUS ENTERICUS	60
FUNCTIONS OF SUCCUS ENTERICUS	61
<u>LARGE INTESTINE JUICE</u>	61
COMPOSITION OF LARGE INTESTINAL JUICE	61
FUNCTIONS OF LARGE INTESTINAL JUICE	62
<u>MOVEMENTS OF THE STOMACH AND INTESTINES</u>	62
MOVEMENTS OF STOMACH	62
HUNGER CONTRACTIONS	62
RECEPTIVE RELAXATION	63
PERISTALSIS WAVES	63
<u>MOVEMENTS OF THE INTESTINES</u>	63
<u>MOVEMENTS OF SMALL INTESTINE</u>	63
TYPES OF MOVEMENTS OF SMALL INTESTINE	63
MIXING MOVEMENTS	63
PROPULSIVE MOVEMENTS	63
MIGRATING MOTOR COMPLEX (PERISTALSIS IN FASTING)	63
MOVEMENTS OF VILLI	63
<u>MOVEMENTS OF LARGE INTESTINE</u>	63
TYPES OF MOVEMENTS OF LARGE INTESTINE	63
MIXING MOVEMENTS – SEGMENTATION CONTRACTIONS	63
PROPULSIVE MOVEMENTS – MASS PERISTALSIS	64
<u>FUNCTIONS OF LIVER AND GALL BLADDER</u>	64
LIVER	64
FUNCTIONS OF LIVER	64
GALL BLADDER	64
FUNCTIONS OF THE GALLBLADDER	64
<u>URINARY SYSTEM</u>	65
KIDNEYS	65
URETERS	65
URINARY BLADDER	65
URETHRA	65
URINE FORMATION	65
PROCESSES OF URINE FORMATION	65
COMPOSITION OF URINE	66
<u>GENERAL INTRODUCTION TO NERVOUS SYSTEM</u>	67
NEURON	67
CLASSIFICATION OF NEURONS	67
NEUROGLIA	67
RECEPTOR	68
NEUROTRANSMITTER	68
<u>NERVOUS SYSTEM</u>	68

CENTRAL NERVOUS SYSTEM	68
PERIPHERAL NERVOUS SYSTEM	69
SOMATIC NERVOUS SYSTEM	69
AUTONOMIC NERVOUS SYSTEM	69
SENSATION OF VISION	70
STRUCTURE OF EYE	70
FUNCTION OF EYE	71
SENSATION OF HEARING	71
STRUCTURE OF EAR	71
THE PARTS OF THE EAR	72
FUNCTIONS OF EAR	72
SENSATION OF TASTE	72
STRUCTURE OF TASTE BUD	72
SENSATION OF SMELL	73
SENSATION OF TOUCH	73
SKIN AND TOUCH	73
SKIN ABILITY TO SENSE TOUCH	74
HORMONES	75
ENDOCRINE SYSTEM	75
CHEMICAL MESSENGERS	75
ENDOCRINE GLANDS	75
THE MAIN ENDOCRINE GLANDS INCLUDE	75
HORMONES INTRODUCTION	75
CLASSIFICATION OF HORMONES	76
CLASSIFICATION OF HORMONES BASED ON THE SITE OF PRODUCTION/ ACCUMULATION	76
HORMONES OF PITUITARY GLANDS	76
HORMONES OF ANTERIOR PITUITARY GLANDS	76
HORMONES OF POSTERIOR PITUITARY GLANDS	76
HORMONES OF THYROID GLANDS	76
HORMONES OF PARATHYROID GLANDS	76
HORMONES OF ADRENAL GLAND	76
HORMONES OF OVARY GLAND	76
HORMONES OF TESTIS	76
HORMONE OF PANCREAS	76
CLASSIFICATION OF HORMONES BASED ON THE CHEMICAL NATURE	76
STEROID HORMONES	76
PROTEIN HORMONES	76
DERIVATIVE OF THE AMINO ACID CALLED TYROSINE	76
HORMONAL ACTIONS	77
GROWTH HORMONE (GH)	77
NORMAL FUNCTIONS OF GH	77
EFFECT ON PROTEIN METABOLISM	77
EFFECTS ON CARBOHYDRATE METABOLISM	77
EFFECTS ON FAT METABOLISM	77
EFFECTS ON INORGANIC METABOLISM	77
EFFECTS ON BONE, CARTILAGE, AND SOFT TISSUES	77
VASOPRESSIN/ ANTIDIURETIC HORMONE (ADH)	78
OXYTOCIN (OT)	78
ACTION IN FEMALES	78
ACTION IN MALES	78
INSULIN	78
EFFECTS OF INSULIN	78
EFFECTS OF INSULIN ON CARBOHYDRATE METABOLISM	78
EFFECTS OF INSULIN ON FAT METABOLISM	78
EFFECTS OF INSULIN ON PROTEIN METABOLISM	78
EFFECTS OF INSULIN ON GROWTH	79
TESTOSTERONE	79
EFFECTS OF TESTOSTERONE	79
EFFECT ON THE MALE REPRODUCTIVE SYSTEM	79
EFFECTS ON SECONDARY SEX CHARACTERISTICS	79
EFFECT ON PROTEIN METABOLISM	79
EFFECT ON BONE	79
EFFECT ON RBCs	79
EFFECT ON ELECTROLYTE AND WATER BALANCE	79
ESTROGEN	79
ACTIONS OF ESTROGENS	79

ANATOMY

Anatomy is the study of structure and organization of the body. The word "anatomy" is the combination of two Greek words, ana="apart", tomy="to cut". So, it means to study by cutting apart, that is, by dissection.

HUMAN ANATOMY

Human anatomy is the science concerned with the structure of the human body or structural organization of the human body.

The science of physiology is concerned with the function of the body. Anatomy and physiology are both subdivisions of the science of biology, the study of living organisms.

BRANCHES OF ANATOMY

Anatomy can be divided into various branches. Major branches are as follows

- **Macroscopic Or Gross Anatomy**
- **Microscopic Anatomy Or Histology**
- **Histology**
- **Cytology**
- **Embryology**
- **Surface Anatomy**
- **Applied Anatomy**
- **Radiological Anatomy**

MACROSCOPIC OR GROSS ANATOMY

It is branch of anatomy which deals with the study of structure of human body parts by naked eye without the aid of microscopes.

Gross anatomy can be studied using the following two approaches

1. **Regional Approach**
2. **Systemic Approach**

Regional Approach

In this approach, we focus on a particular region and study various structures and their arrangement in that particular region. For example, in regional anatomy of the head, we will study the bones, muscles, blood vessels, nerves, etc of the head region only.

Systemic Approach

In this approach, we study a particular system of the body as a whole. For example, in systemic study of the cardiovascular system, we will study the heart and the blood vessels found in all parts of the body.

MICROSCOPIC ANATOMY OR HISTOLOGY

In this branch, we study the structures with the help of microscopes.

HISTOLOGY

It deals with the study of microscopic details of tissues that make human body.

CYTOLOGY

It is the branch of anatomy that deals with the study of structure of cell and its components.

EMBRYOLOGY

It is the branch of anatomy which deals with the study of embryo (a human being or animal in an early stage of development, either in its mother's uterus or in an egg or a plant that is developing in a seed is called embryo).

SURFACE ANATOMY

In this branch, surface of the human body is studied in relation to the deeper parts. Hence, it enables us to locate the internal structures from the surface of the body. Surface anatomy is of paramount importance in physical examination and surgery.

APPLIED ANATOMY

It is the direct application of facts of human anatomy to medicine and surgery. Applied anatomy is usually concerned with human structural abnormalities, which are useful in medicine especially in surgical techniques but also in clinical diagnosis.

RADIOLOGICAL ANATOMY

This is the study of the structure of human body that includes the use of several imaging techniques,

TERMINOLOGY OF POSITION**Anterior and Posterior (Ventral and Dorsal)**

Anterior and posterior describe structures at the front (anterior) and back (posterior) of the body. For example, the toes are anterior to the heel.

Superior And Inferior

Superior and Inferior Describe a position above (superior) or below (inferior) another part of the body. For example, the pelvis is inferior to the abdomen.

Proximal And Distal

Proximal and distal describe a position that is closer (proximal) or greater distance (distal) from the trunk of the body. For example, the shoulder is proximal to the arm, and the foot is distal to the knee.

[Trunk is an anatomical term for the central part of the many animal bodies (including that of the human) from which extend the neck and limbs. The trunk includes the thorax and abdomen]

Superficial And Deep

Superficial and deep describe structures that are closer to (superficial) or further/ greater distance from (deep) the surface of the body. For example, the skin is superficial to the bones, and the brain is deep to the skull.

Medial And Lateral

Medial and lateral describe a position that is closer to (medial) or further/ greater distance from (lateral) the midline of the body. For example, the nose is medial to the eyes, and the thumb is lateral to the other fingers.

Medial line

The line which divides the body into two equal mean right and left parts is called medial line.

Inferomedial

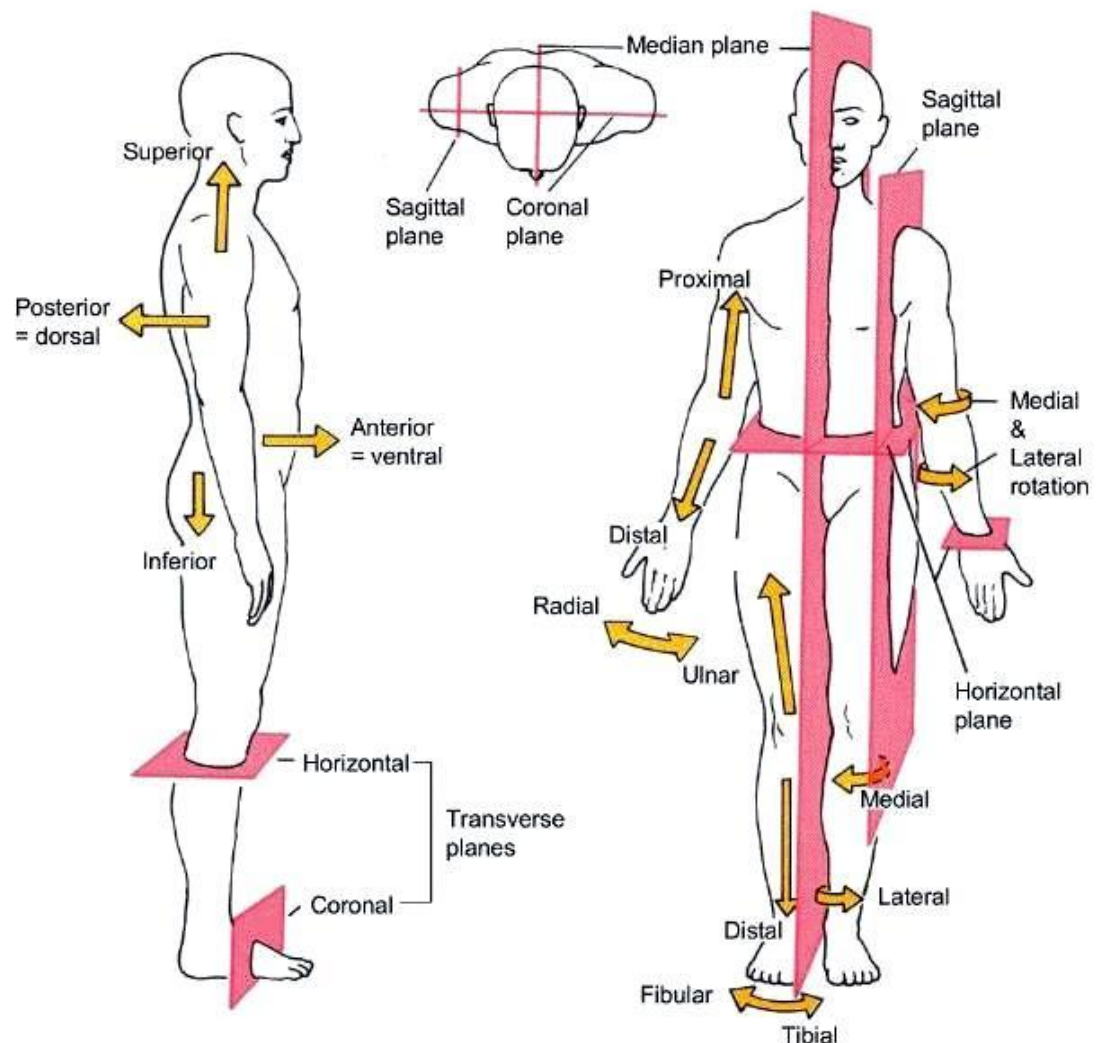
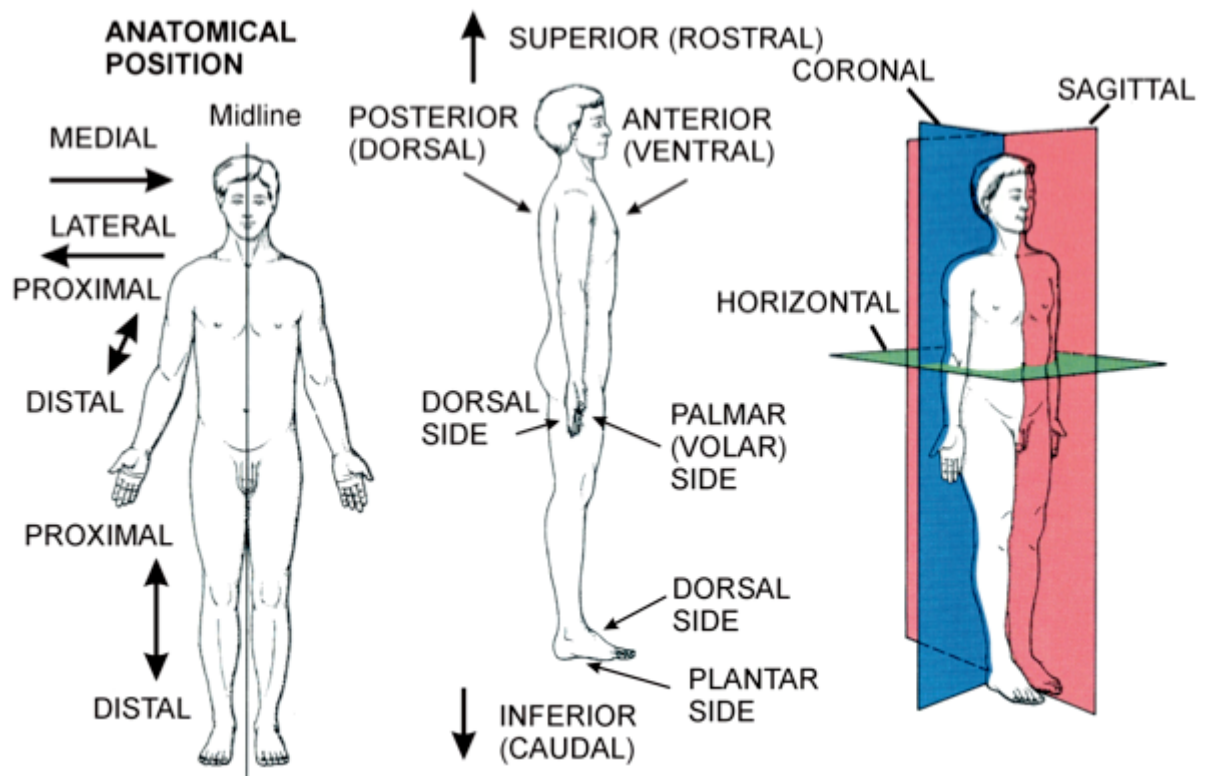
It is the part of body that present near to the medial line and towards the lower side.

Ipsilateral

Two parts of body that present at the same side of body e.g. Liver and gall bladder.

Contra Lateral

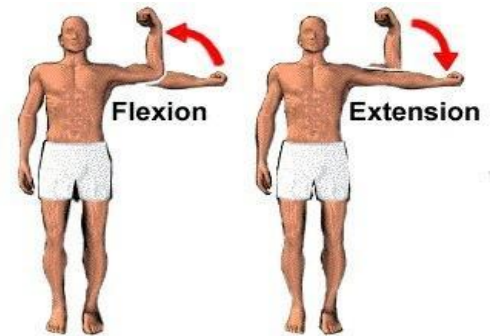
Two body organs which are present opposite to each other is called contra lateral.



TERMINOLOGY OF MOVEMENT

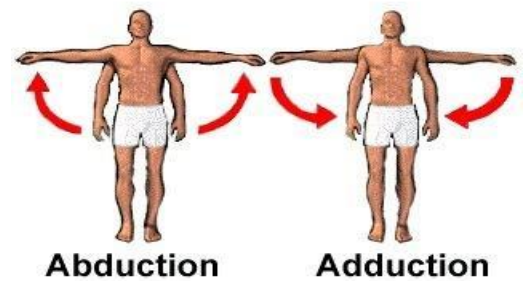
FLEXION AND EXTENSION

Flexion and extension refer to a movement that decreases (flexion) or increases (extension) the angle between body parts.



ABDUCTION AND ADDUCTION

Abduction and adduction refers to a movement of limb away (abduction) or towards (adduction) the medial line of the body.



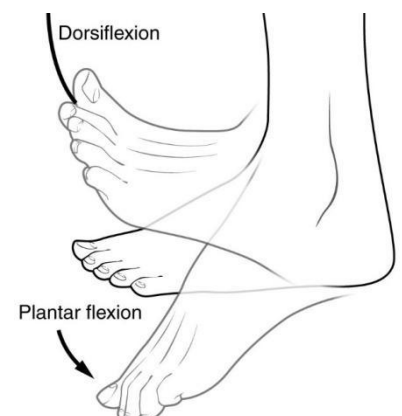
ELEVATION AND DEPRESSION

Elevation and depression refers to movement of bones toward upper side (elevation) or toward lower side (depression).



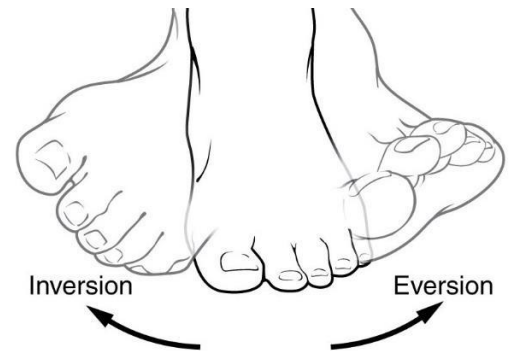
DORSIFLEXION AND PLANTARFLEXION

Dorsiflexion and Plantarflexion refers to decrease in distance (Dorsiflexion) or increase in distance (Plantarflexion) between foot and leg.



EVERSION AND INVERSION

Eversion and inversion refer to movements that tilt (move into a sloping position) the sole of the foot away (eversion) or towards (inversion) the medial line of the body.

**SURFACE ANATOMY**

Surface anatomy is to observe the surface of body. Its aim is visualization in the mind's "eye" of structure that lies beneath the skin and or hidden by it. Surface anatomy is the basis for the physical examination of the body to reach a physical diagnosis.

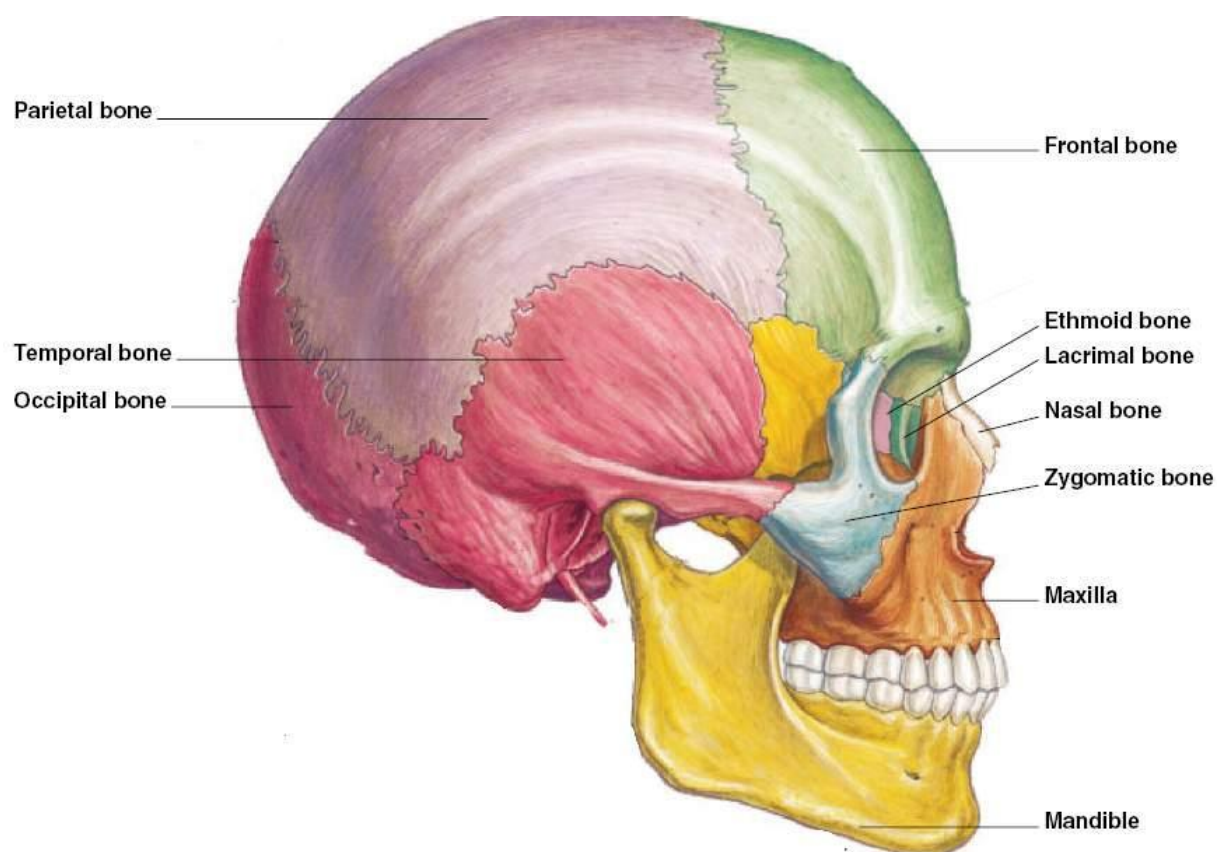
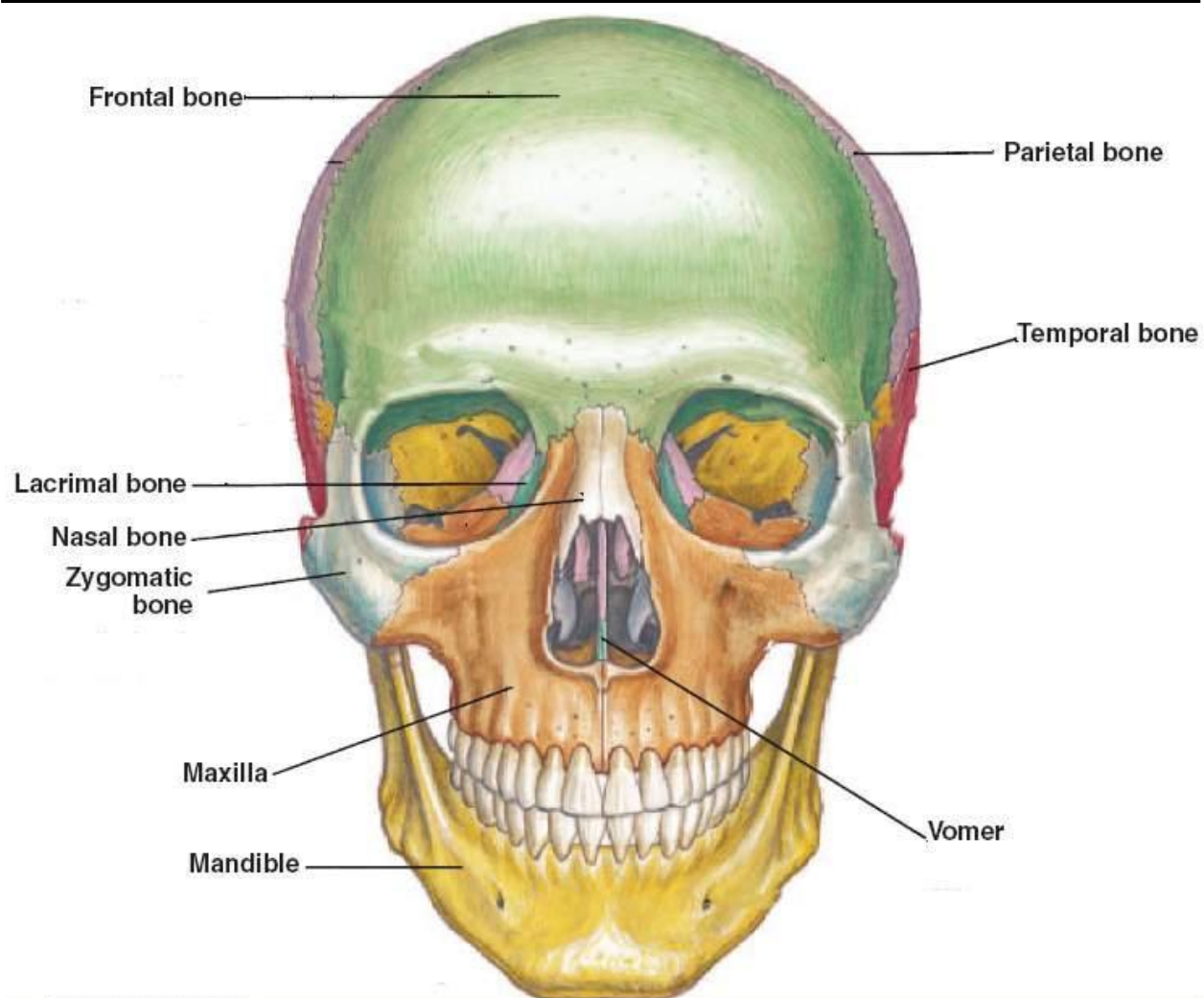
HUMAN SKELETON

The overall parts of human skeleton are following.

OVER VIEW OF HUMAN SKULL

It is a type of flat bone. It is very hard. It covers the brain. Skull is divided into following major parts.

- | | |
|------------------|--------------------|
| 1. Frontal Bone | 6. Zygomatic Bone |
| 2. Temporal Bone | 7. Maxilla Bone |
| 3. Lacrimal Bone | 8. Mandible Bone |
| 4. Viral Bone | 9. Parietal Bone |
| 5. Vomer Bone | 10. Occipital Bone |



OVER VIEW OF THE UPPER LIMB

It consists of three main parts.

1. Forearm
2. Arm
3. Hand

Fore Arm

- It starts from scapula and ended to elbow joint
- It consists of single long bone which is called humerus
- Humerus is long bone in upper limb

Arm

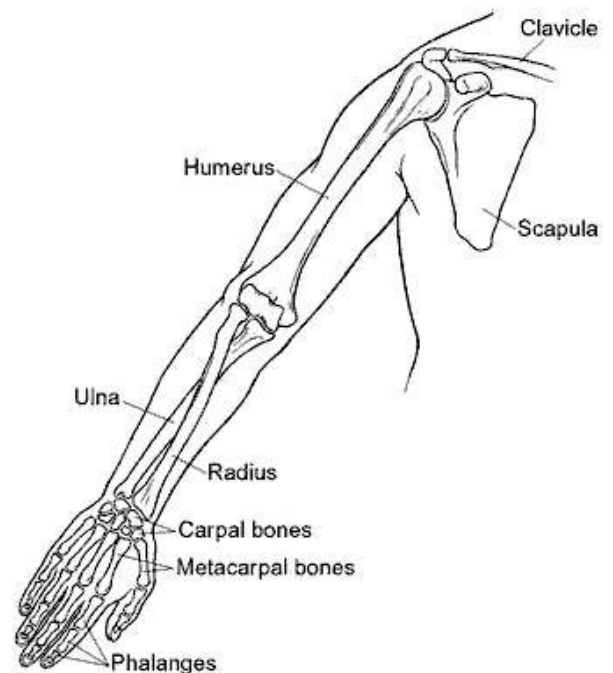
Arm consists of two bones.

- Radius
- Ulna

It is larger bone in this region. It is opposite to the radius is called ulna.

Hand

In start of hand there are some little bones which are called carpals. Then metacarpals are present, after those phalanges are presents.

**OVER VIEW OF LOWER LIMB**

The lower limb consists of thigh bone, leg, knee and foot.

Thigh

It is upper portion in upper limb in which there is a single leg bone which is called femur. Femur is start from pelvic girdle to knee. It is a large bone of lower limb.

Leg

Technically it starts from knee to ankle. It consists of two bones which are called tibia. Tibia is attached to the toe nearest to medial line. Fibula is away from medial line tibia is large bone and bear whole of the weight fibula is small it is attach to muscles.

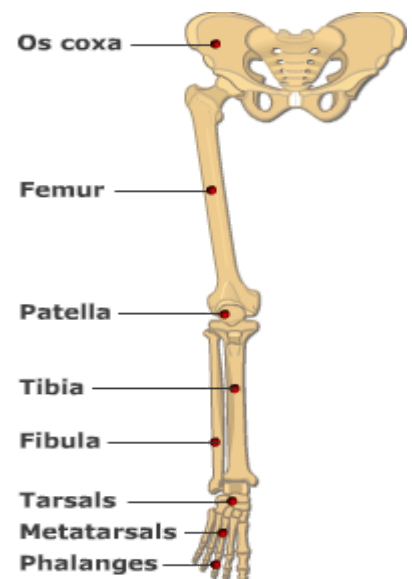
Patella

It is also called knee cap. It connects femur and tibia its bone is somewhat like triangular shape or sessamoid bone.

Foot

It consist of following bone

- Tarsal
- Metatarsal
- Phalanges

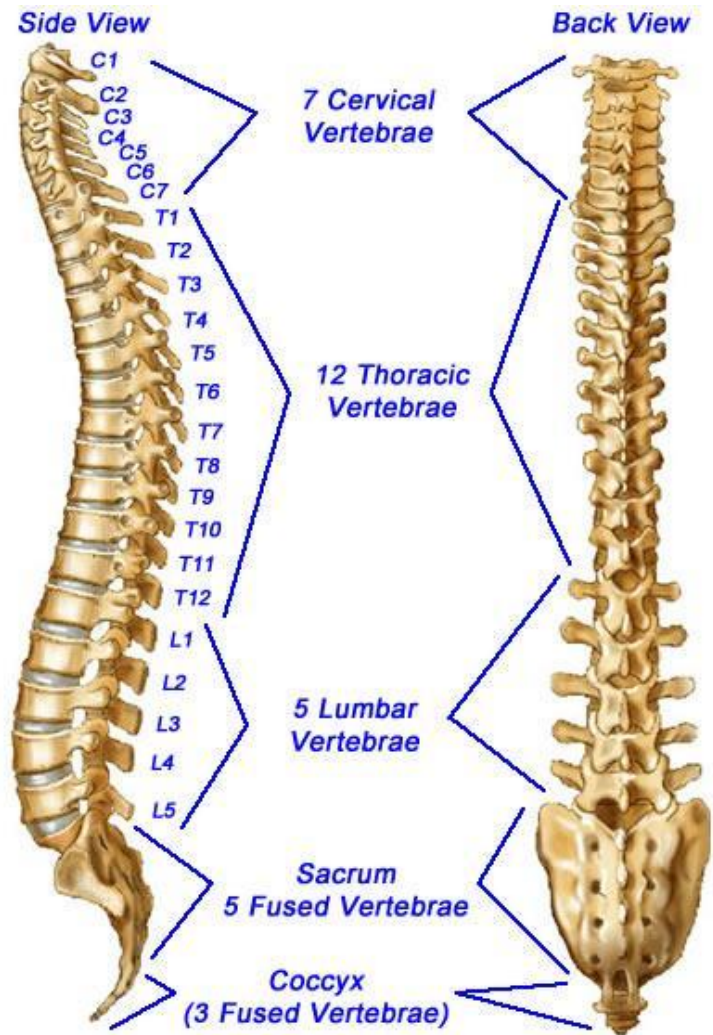
**VERTEBRAL COLUMN**

It is also called back bone. It is consist of 33 irregular bones. These bones are classified in to 5 different regions.

1. C1 _ C7 (Cervical Region)
2. T1 _ T12 (Thoracic Region)
3. L1 _ L5 (Lumbar Region)
4. S1 _ S5 (Sacrum Region)
5. Coccyx 3 Bone (Coccyx Region)

- First seven vertebrae are called cervical vertebrae it helps for flexibility in work.
- Next twelve vertebrae are considered as thoracic vertebra.
- It consist of 5 vertebrae considered as lumbar vertebra, in these humerus is the large bone in whole vertebral column.

- It also supports the body consists of 5 vertebrae considered as sacral region. Back muscles are mostly attached here.



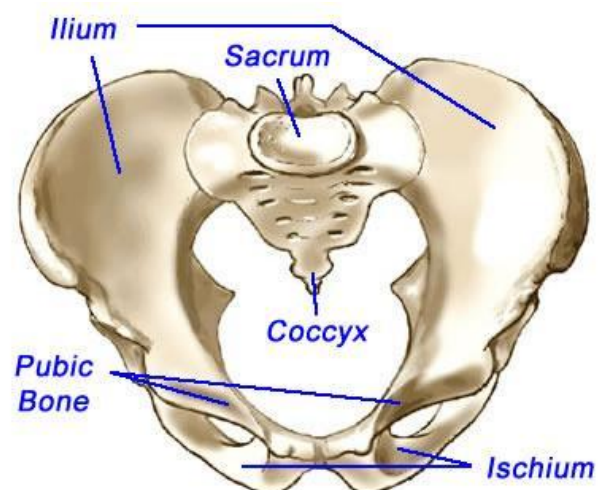
ANATOMY OF PELVIC GIRDLE

It is also called as hipbone. It consists of two coxal (hip) bones.

This coxal bone is also called os coxae. In childhood, this coxal bone is divided into three parts.

- First part is Ilium
- Second part is Ischium
- Third part is Pubic bone

In adults, these three bones are finely fused to form a single bone. On the back side, these two bones are connected to the sacrum. In front, it is connected with the help of muscles to the pubic fossa. In men, the iliac crest is very compact and the distance between them is narrow. In women, the iliac crest is wider and the distance between them is wider.

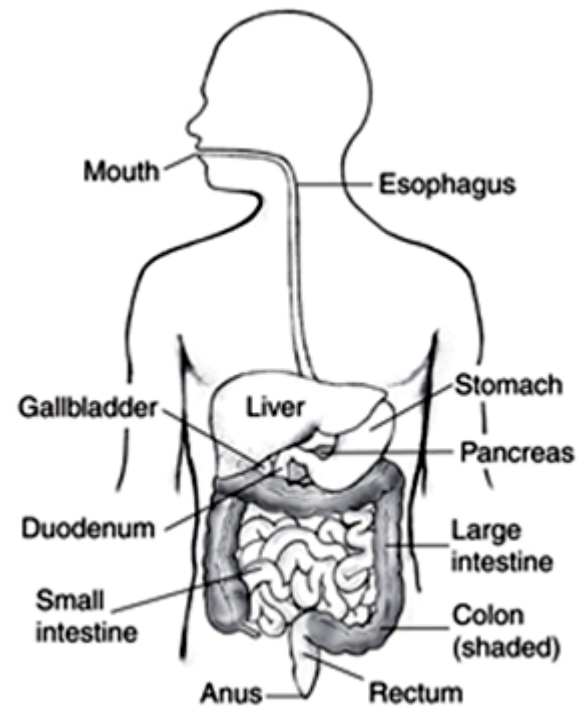


ANATOMY OF DIGESTIVE SYSTEM

The digestive system in human being is composed of a long muscular tube called gastrointestinal tract (GIT) or alimentary canal and accessory organs it extends from the mouth to the anus and consists of the following organs...

- Oral Cavity
- Pharynx
- Esophagus
- Stomach
- Small Intestine
- Large Intestine
- Rectum
- Liver
- Gall Bladder
- Pancreas

(Liver, Gall bladder and pancreas are supporting organs)

**ANATOMY OF RESPIRATION SYSTEM**

From a clinical point of view, the respiratory system is divided into the upper and lower respiratory tract. The respiratory system consists of the following...

1. Upper Respiratory Tract

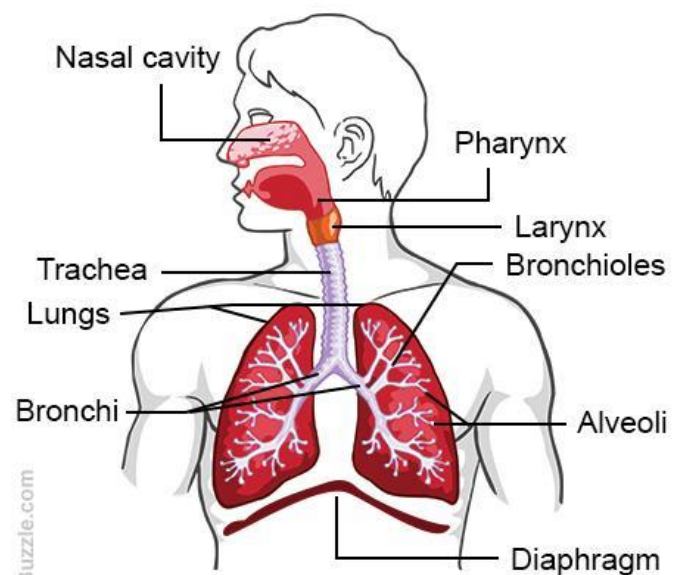
The upper respiratory tract is consisting of the nose, pharynx (throat) and associated structures.

2. Lower Respiratory Tract

The lower respiratory tract is consisting of the larynx, trachea, bronchi and lungs.

Respiratory system consists of the following organs.

- Nose
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lungs



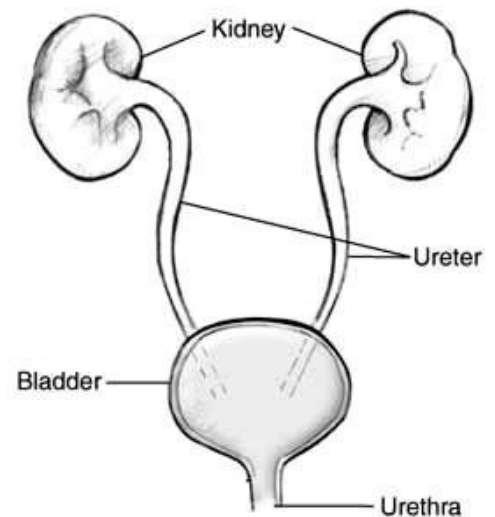
ANATOMY OF URINARY SYSTEM

It is a set of organs producing urine in human beings, comprised chiefly of the kidneys, ureters bladder, and urethra. The main organs of the urinary system are the kidneys, which form urine. The other parts of the system are ureters, urinary bladder, and the urethra neither form urine nor change its composition. They only transport urine from the kidneys to the outside of the body.

Urinary system consists of the following organs

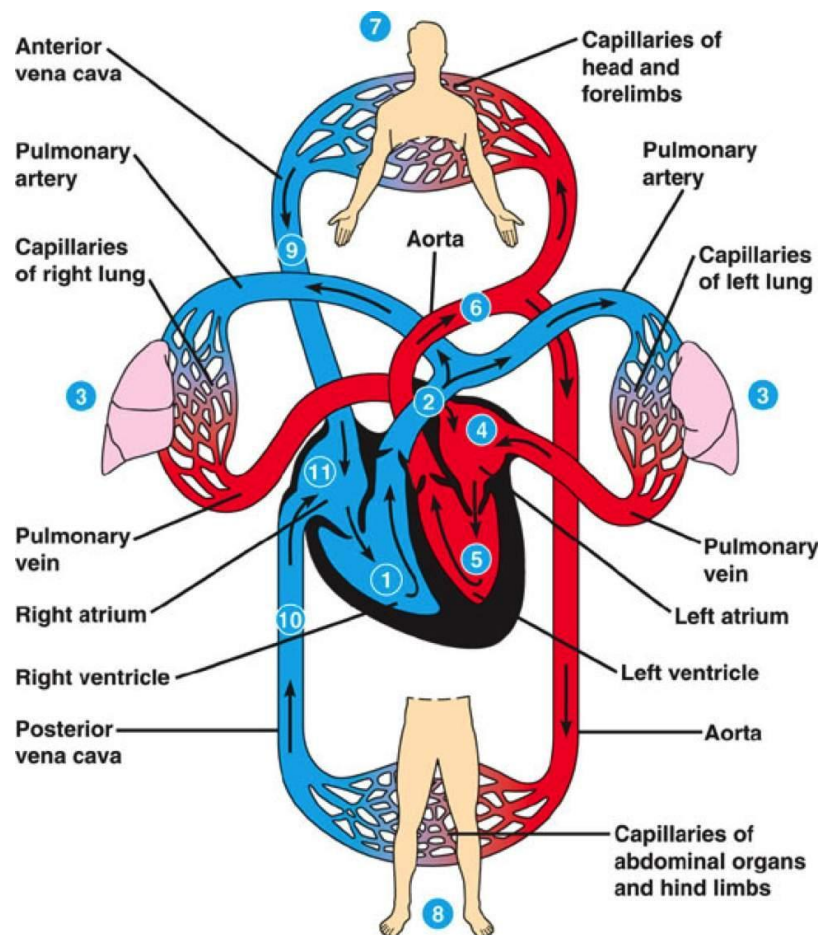
- **Kidney**
- **Ureters**
- **Bladder**
- **Urethra**

(Nephron is basic structural & functional unit of kidney)

**ANATOMY OF CARDIOVASCULAR SYSTEM**

Following are the major organs for the circulation of blood in the human body.

- **Heart**
- **Aorta**
- **Arteries**
- **Arterioles**
- **Capillaries**
- **Venules**
- **Veins**
- **Vena-Cava**



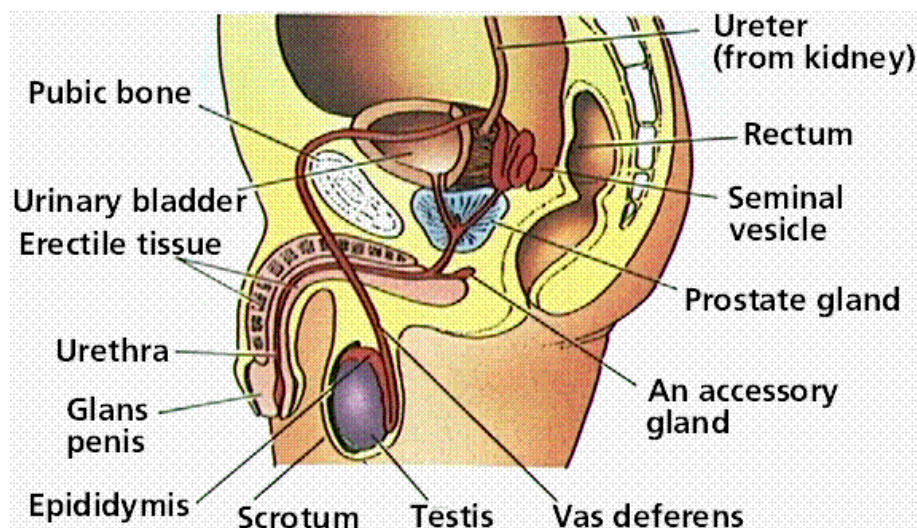
ANATOMY OF REPRODUCTIVE SYSTEM

The anatomy of human reproductive system can be discussed as following.

MALE REPRODUCTIVE SYSTEM

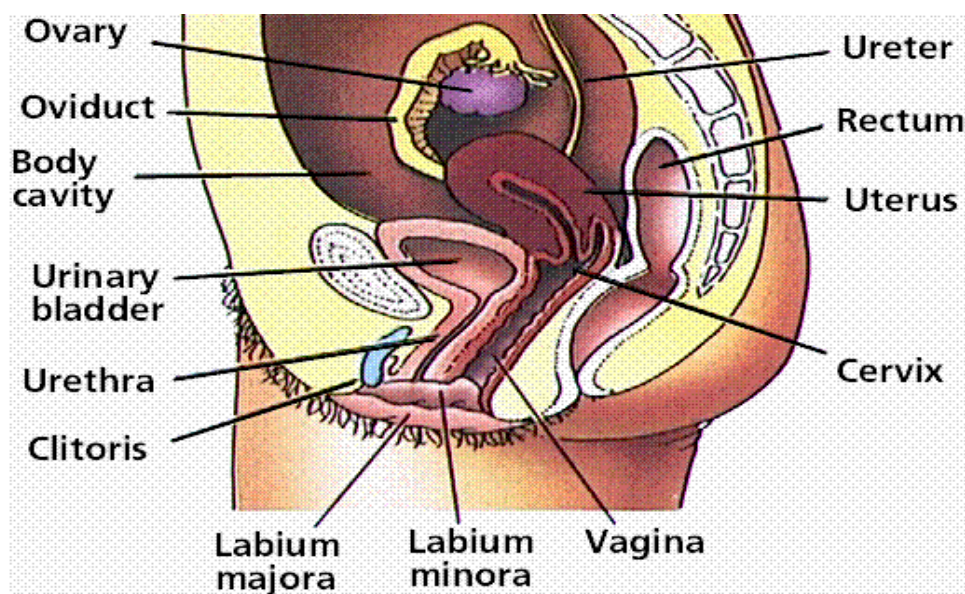
The male reproductive system consists of the following organ.

- Testes
- Urethra
- Penis
- Prostate Gland
- Seminal Vesicles
- Scrotum

**FEMALE REPRODUCTIVE SYSTEM**

The female reproductive system consists of the following organ.

- Ovaries
- Uterus
- Uterine Tube
- Fallopian Tubes
- Vagina
- Vulva
- Hyman
- Breasts
- Labia Minor
- Labia Major



INTRODUCTION TO PHYSIOLOGY

The goal of physiology is to explain the physical and chemical factors that are responsible for the origin, development, and progression of life. Each type of life, from the simple virus to the largest tree or the complicated human being, has its own functional characteristics.

Therefore, the vast field of physiology can be divided into

- Viral Physiology
- Bacterial Physiology
- Cellular Physiology
- Plant Physiology
- Human Physiology and many more subdivisions

HUMAN PHYSIOLOGY

You are about to begin the study of one of nature's most wondrous structures the human body. Physiology deals with body function that is how the body parts work to support life.

In human physiology, we attempt to explain the specific characteristics and mechanisms of the human body that make it a living being. Physiology term is a combination of two Greek words (physis "nature" and logos "science or study"). Simply stated it is the study of physiology that helps us to understand how the body works. Physiologists attempt to discover and understand through active experimentation the intricate control systems and regulatory mechanisms that permit the body to operate and survive in an often hostile environment.

CELL

Cells are the smallest functional units of the body. They are grouped together to form tissues. Different tissues are grouped together to form organs, e.g. heart, stomach, brain. Organs are grouped together to form systems, each of which performs a particular function, for example, the digestive system is responsible for taking in, digesting and absorbing food and involves a number of organs, including the stomach and intestines.

Types Of Cell

- Nerve Cell
- Muscle Cell
- Connective Cell
- Immune Cell
- Blood Cell

Composition Of Cell

- Water 65-80%
- Proteins
- Electrolytes
- Lipids
- Carbohydrates

STRUCTURE OF CELL

A typical cell, as seen by the light microscope consist of two major parts are the nucleus and the cytoplasm.

A cell consists of a *plasma membrane* inside which there are a number of *organelles* floating in a watery fluid called cytosol.

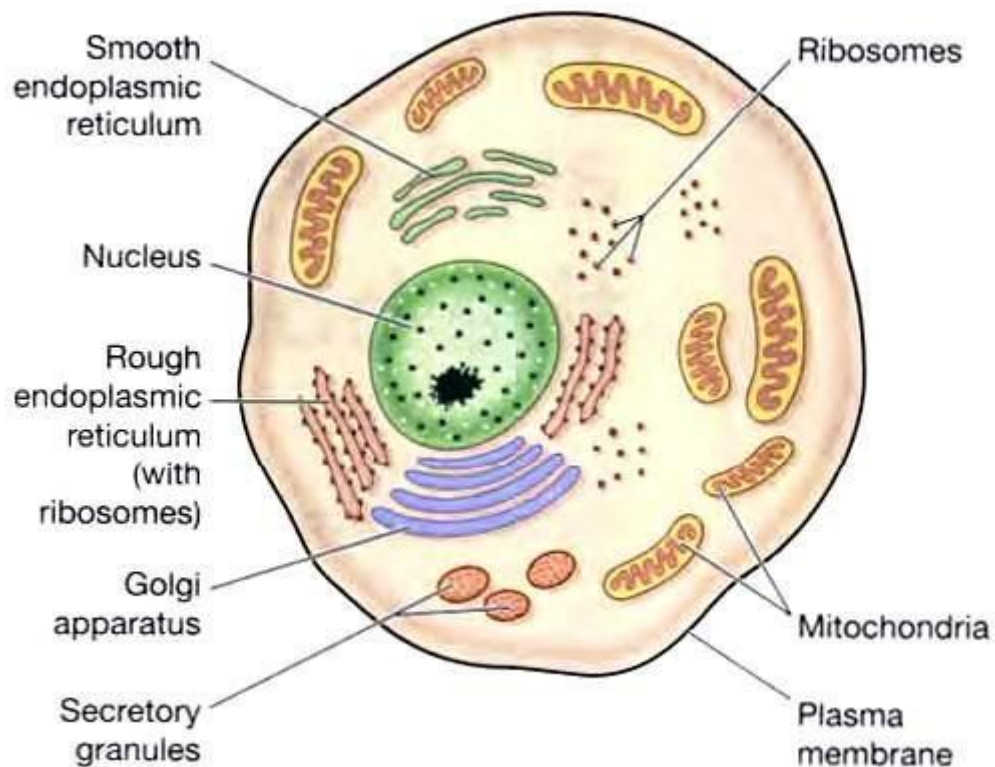
(Watery fluid of cytoplasm is called cytosol)

(Organelles are small structures with highly specialized functions, many of which are contained within a membrane. They include: the nucleus, mitochondria, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, microfilaments and microtubules)

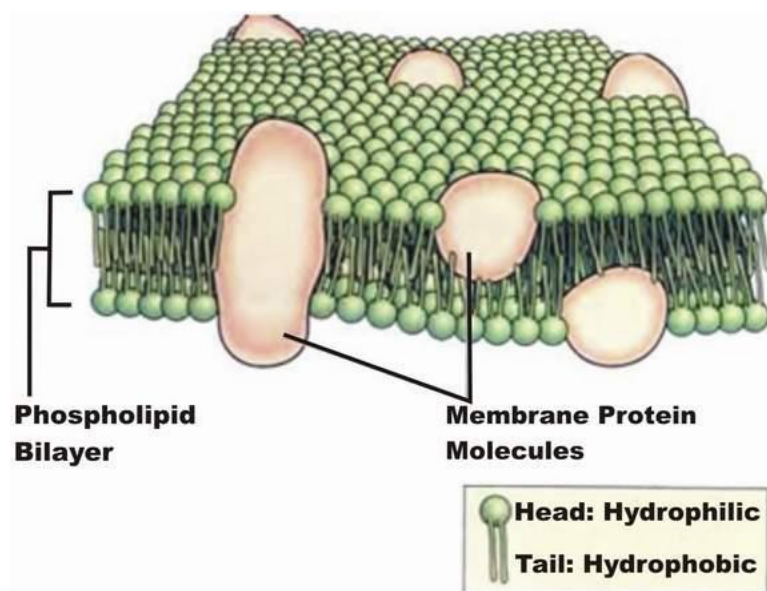
(The different substances that make up the cell are collectively called protoplasm. Protoplasm is composed mainly of five basic substances: water, electrolytes, proteins, lipids, and carbohydrates.)

COMPONENT OF A CELL

- Plasma Membrane Or Cell Membrane
- Cytoplasm
- Nucleus
- Mitochondria
- Ribosomes
- Endoplasmic Reticulum (ER)
- Golgi Apparatus
- Lysosomes
- Microfilaments And Microtubules

**PLASMA MEMBRANE OR CELL MEMBRANE**

It is outer covering of cell. It is a thin, elastic structure only 7.5 to 10 nanometers thick. The plasma membrane consists of two layers of phospholipids with some protein molecules embedded in them. It is composed almost entirely of proteins and lipids.



FUNCTIONS OF PLASMA MEMBRANE

- It protects the cell organelles
- It provides the passage of the water soluble substances
- These act as transported by attaching to the cell membrane proteins
- It permits the passage of ions and molecules outside the cell
- Some carbohydrates in plasma membrane are helpful for binding of hormones

CYTOPLASM

It is jelly-like substance that surrounds the nucleus of a cell.

ZONES OF CYTOPLASM

1. Ectoplasm --- near to the cell membrane
2. Endoplasm --- near to the nucleus

NUCLEUS

Every cell in the body has a nucleus, with the exception of mature erythrocytes (red blood cells). Skeletal muscle and some other cells contain several nuclei. The nucleus is the largest organelle and is contained within a membrane similar to the plasma membrane but it has tiny pores, through which some substances can pass between it and the cytoplasm.

The nucleus contains the body's genetic material, which directs the activities of the cell.

FUNCTIONS OF NUCLEUS

- It is a control center of cell
- It controls the protein synthesis by messenger RNA
- It helps in hereditary material transformation
- It controls the cell division
- It controls the activity of cytoplasm

MITOCHONDRIA

The mitochondria are called the “powerhouses” of the cell. Without them, cells would be unable to extract enough energy to perform its functions. Mitochondria are present in all areas of each cell's cytoplasm

RIBOSOMES

These are tiny granules composed of RNA and protein. They synthesize proteins from amino acids, using RNA as the template. Ribosomes are also found on the outer surface of rough endoplasmic reticulum.

ENDOPLASMIC RETICULUM (ER)

Endoplasmic reticulum is a series of interconnecting membranous canals in the cytoplasm.

There are two types of endoplasmic reticulum

1. Smooth surface ER: Smooth surface ER synthesizes lipids and steroid hormones, and is also associated with the detoxification of some drugs.
2. Rough surface ER: Ribosomes are attached to outer surface of rough surface ER. Proteins are synthesized by ribosome and then transferred to the endoplasmic lumen.

GOLGI APPARATUS

The Golgi apparatus is closely related to the endoplasmic reticulum. It is membranous organelle, which is responsible for packaging and lysosomes formation.

LYSOSOMES

The lysosomes provide an intracellular digestive system. They contain a variety of enzymes involved in breaking down fragments of organelles, large molecules (e.g. RNA, DNA, carbohydrates, proteins) and unwanted matter such as bacteria inside the cell into smaller particles that are either recycled or extruded (pushing out) from the cell as waste material.

MICROFILAMENTS AND MICROTUBULES

- **Microfilaments:** These are tiny strands of protein that provide structural support and maintain the characteristic shape of the cell.
- **Microtubules:** These are contractile protein structures in the cytoplasm involved in the movement of the cell

TISSUE

The tissues of the body consist of large numbers of cells and they are classified according to the size, shape and functions of these cells. There are four main types of tissue, each of which has subdivisions.

1. **Epithelial Tissue Or Epithelium**
2. **Connective Tissue**
3. **Muscular Tissue**
4. **Nervous Tissue**

EPITHELIAL TISSUE

This group of tissues is found covering the body and lining cavities and tubes. It is also found in glands. The structure of epithelium is closely related to its functions which include...

- Protection of underlying structures from, for example, dehydration, chemical and mechanical damage
- Secretion
- Absorption

The cells are very closely packed and the intercellular substance, called the matrix, is minimal.

TYPES OF EPITHELIAL TISSUES

There are two types of epithelial tissues

1. Simple Epithelial Tissues
2. Stratified Epithelial Tissues

SIMPLE EPITHELIUM

Simple epithelium consists of a single layer of identical cells and is divided into four types. It is usually found on absorptive or secretory surfaces.

STRATIFIED EPITHELIA

Stratified epithelia consist of several layers of cells of various shapes. The main function of stratified epithelium is to protect underlying structures.

Simple epithelium



Basement membrane

Stratified epithelium



CONNECTIVE TISSUE

Connective tissue is the most abundant tissue in the body. Connective tissue is characterized by the presence of relatively few cells but a large amount of inter cellular substance.

MAJOR FUNCTIONS OF CONNECTIVE TISSUE

- Binding and structural support
- Protection
- Transport
- Insulation

STRUCTURE OF THE CONNECTIVE TISSUE

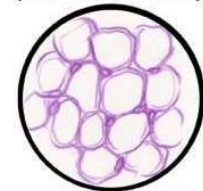
Basically all types of connective tissue following three components.

1. Cells
2. Fibers
3. Ground Substance

Dense
Connective Tissue



Adipose Tissue
(Connective Tissue)



Areolar Tissue
(Connective Tissue)



Compact Bone
(Connective Tissue)



Blood
(Connective Tissue)



The fibers and ground substance are collectively known as matrix.

CELLS OF CONNECTIVE TISSUE

Connective tissue, excluding blood is found in all organs supporting the specialized tissue. The different types of cell involved include...

- Fibroblasts
- Fat Cells

- Macrophages
- Leukocytes
- Mast Cells

CONNECTIVE TISSUE FIBERS

Connective tissue fibers are of three types

1. Collagenous Fibers
2. Reticular Fibers
3. Elastic Fibers

GROUND SUBSTANCE OF THE CONNECTIVE TISSUE

The ground substance is composed mainly macromolecular protein polysaccharide complexes called proteoglycans. In addition it contains glycoprotein, water and salts.

MUSCULAR TISSUE

There are more than 600 muscles in our body. Muscles perform many useful functions and help us in doing everything in day-to-day life. Their functions could be voluntary and involuntary functions.

The two principal functions of muscle are to produce movement and to maintain posture. These functions are achieved by adjusting the length and tension of muscle. In other words, muscle works by contracting. Therefore, when we look at the structure and function of muscle, we see that muscle is designed to contract.

Depending upon situation, there are three types of muscle tissue, which consists of specialized contractile cells...

1. Skeletal Muscle Tissue
2. Smooth (Visceral) Muscle Tissue
3. Cardiac Muscle Tissue

SKELETAL MUSCLE TISSUE

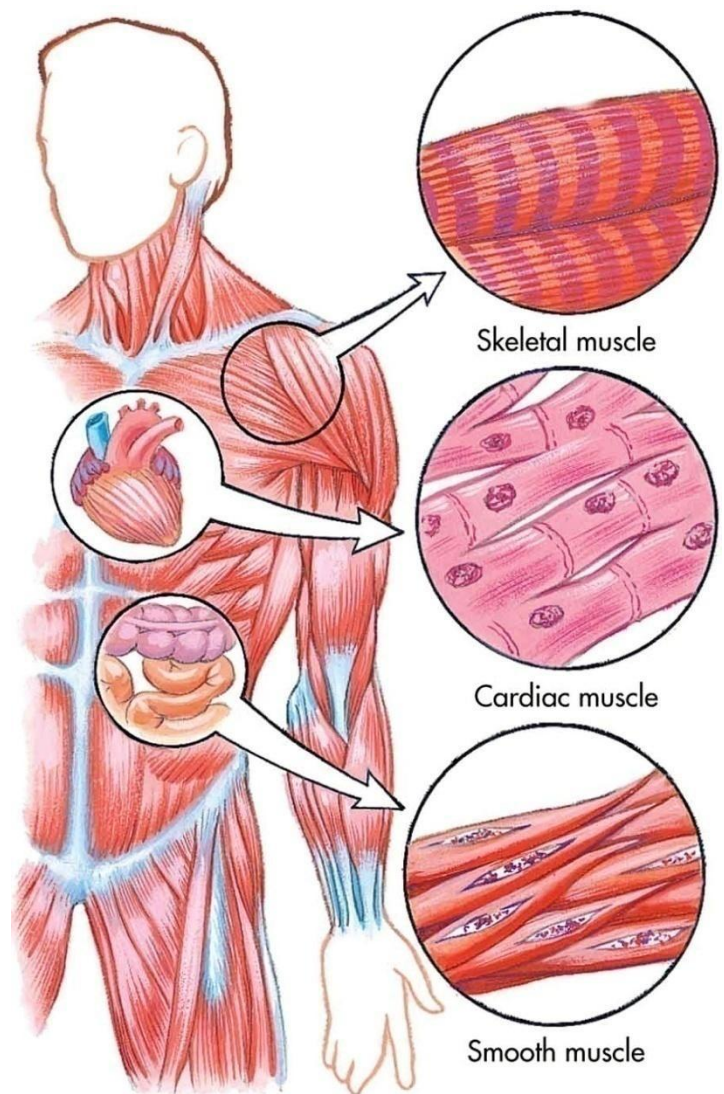
Skeletal muscle tissues are rough, cylindrical in shape and may be as long as 35 cm. Skeletal muscles are the most abundant type of muscle; they form 40%-50% of body mass. They attach to bone and so are important in producing movements in our joints and maintaining our posture. Under the microscope, skeletal muscle cells look like long fibers and have a striped (striated) appearance. Skeletal muscle cells also have many mitochondria and more than one nucleus. We generally think of skeletal muscle as being under voluntary control.

SMOOTH (VISCERAL) MUSCLE TISSUE

They are also called plain, un-striated, non-striated or involuntary muscles. Smooth muscle is the muscle, which lines our blood vessels and internal organs. Under the microscope, visceral muscle cells do not have the obvious striations of skeletal or cardiac muscle. Hence, it is called smooth muscle. Smooth muscle cells are often relatively short, and usually they each have only one nucleus. We generally think of visceral muscle as being involuntary.

CARDIAC MUSCLE TISSUE

Cardiac muscle is the muscle of the heart. Under the microscope, cardiac muscle cells also appear striated; however the striations are not as well organized as in skeletal muscle. Cardiac muscle cells are



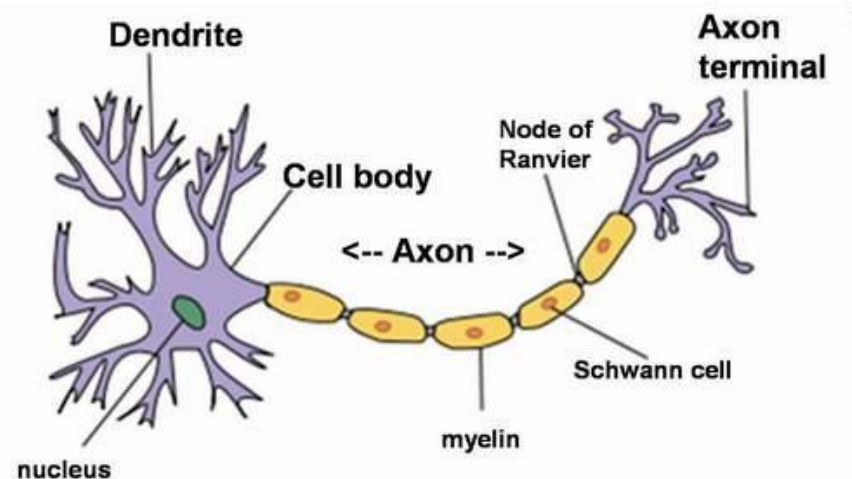
often branched, so that one cell forms connections with several of its neighbors. The activity of cardiac muscle is controlled to a large degree by the autonomic nervous system. We generally think of cardiac muscle as being involuntary.

NERVOUS TISSUE

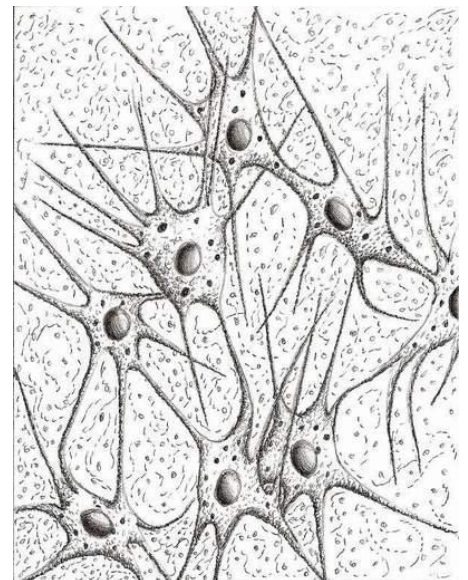
The nervous system consists of a vast number of cells called neurons, supported by a special type of connective tissue neuroglia. Each neuron consists of a cell body and its processes, one axon and many dendrites. Neurons are commonly referred to simply as nerve cells. Nerve cells vary considerably in size and shape but they are all too small to be seen by the naked eye.

Two types of tissue are found in the nervous system

1. **Excitable Cells:** These are called neurons and they initiate, receive, conduct and transmit information.
2. **Non-Excitable Cells:** These support the neurons.



□ Neuron Cell



□ Nervous Tissue

BONE OR OSSEOUS TISSUES

Bone is a strong and durable type of connective tissue. Like other types of connective tissue the bone (osseous tissue) also consists of cells and intercellular substance or matrix. The matrix of bones has the special property of being rigid because it is impregnated (saturated) with mineral salts mainly calcium phosphate. Hence the chief physical property of the bone tissue is its toughness and hardness.

BONE CELLS

Three different cell types are found in the osseous tissue

1. Osteoblasts
2. Osteoclasts
3. Osteocytes

BONE MATRIX

The bone matrix consists of inorganic and organic components. The inorganic (minerals) components of bone matrix are responsible for hardness of bone tissue and constitute about 65% of the dry weight of the bone. Calcium and phosphate are chief bone minerals but substantial quantities of sodium, magnesium, carbonate and citrate are also found. Calcium and Phosphorus also present in small quantity.

TYPES OF BONES

Bones are classified as

- Long Bone
- Short Bone
- Irregular Bone
- Flat Bone
- Sesamoid Bone

LONG BONES

These consist of a shaft and two extremities. As the name suggests the length is much greater than the width. Examples include the femur, tibia and fibula.

SHORT, IRREGULAR, FLAT AND SESAMOID BONES

These have no shafts or extremities and are diverse in shape and size.

Examples include

- Short Bones, carpals (wrist)
- Irregular Bones, vertebrae and some skull bones
- Flat Bones, sternum, ribs and most skull bones
- Sesamoid Bones, patella (knee cap).

FUNCTIONS OF BONES

Bones have a variety of functions. They...

- Provide the framework of the body
- Give attachment to muscles and tendons (ligaments)
- Permit movement of the body as a whole and of parts of the body
- protect the organs they contain
- Contain red bone marrow in which blood cells develop (haematopoiesis)
- Provide a reservoir of minerals, especially calcium phosphate

JOINTS

A joint is the site at which any two or more bones articulate or come together. Some joints have no movement (fibrous), some only slight movement (cartilaginous) and some are freely movable (synovial).

TYPES OF JOINTS

There are three types of joints

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

FIBROUS OR FIXED JOINTS

These immovable joints have fibrous tissue between the bones, e.g. joints between the bones of the skull (sutures) and those between the teeth and the maxilla and mandible.

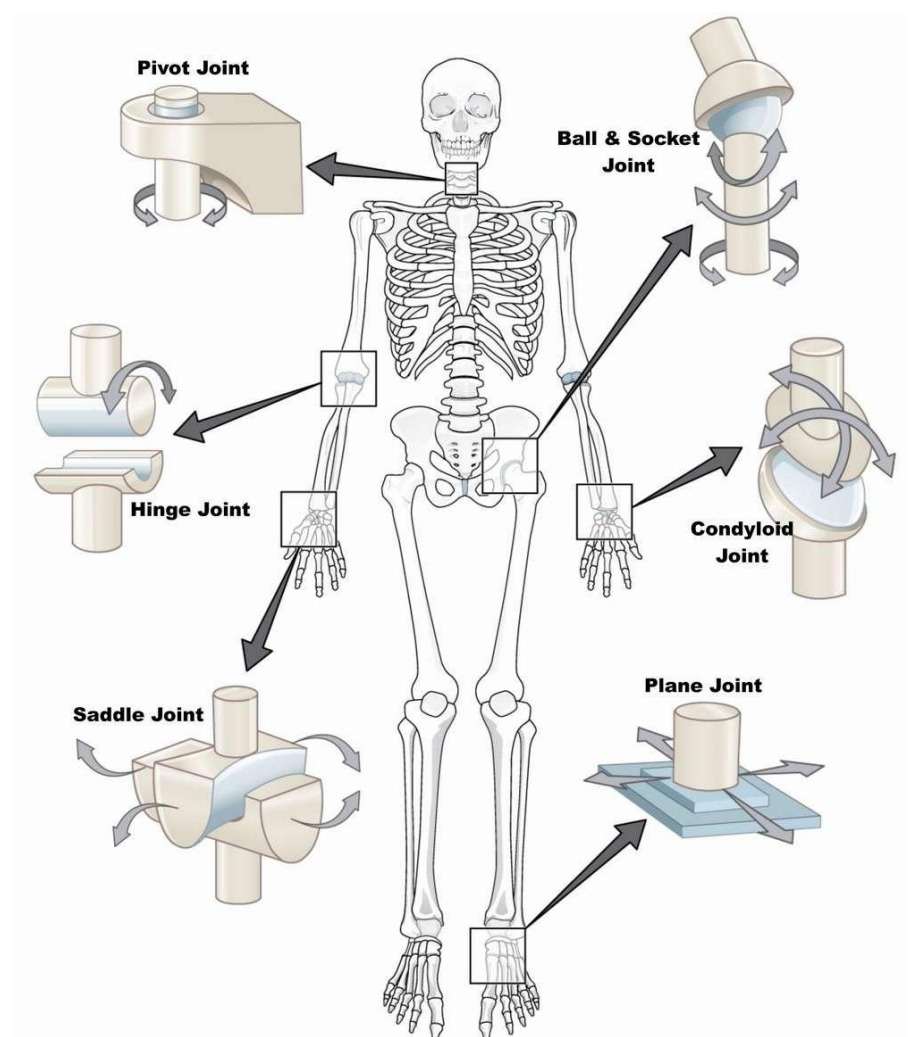
CARTILAGINOUS OR SLIGHTLY MOVABLE JOINTS

There is a pad of fibrocartilage between the ends of the bones that form the joint which allows for very slight movement where the pad of cartilage is compressed. Examples include the symphysis pubis and the joints between the vertebral bodies.

SYNOVIAL OR FREELY MOVABLE JOINTS

Synovial joints have characteristic features that enable a wide range of movements. They are classified according to the range of movement possible or to the shape of the bones involved.

- **Ball And Socket:** The head or ball of one bone articulates with a socket of another and the shape of the bones allows for a wide range of movement. Examples are the shoulder and hip.
- **Hinge Joints:** These allow the movements of flexion and extension only. Examples are the elbow, knee, and ankle.
- **Gliding Joints:** The articular surfaces glide over each other. Examples are joints between the carpal bones and those between the tarsal bones.
- **Pivot Joints:** Movement is round one axis (rotation). Examples is proximal and distal radioulnar joints and the joint between the atlas and the odontoid process of the axis.
- **Condylod and Saddle Joints:** Movements take place round two axes, permitting flexion, extension, abduction, adduction and circumduction. Example is the wrist.



Blood

Blood is a connective tissue in fluid form. It is considered as the fluid of life, because it carries oxygen from lungs to all parts of the body and carbon-dioxide from all parts of the body to the lungs. It is also known as fluid of growth, because it carries nutrition from digestive system and hormones from endocrine glands to all the tissues. Blood is also called the fluid of health, because it protects the body against diseases and gets rid of the waste products and unwanted substances by transporting them to the excretory organs like kidney.

PROPERTIES OF BLOOD

Color

Blood is red in color. Blood contain O_2 is bright red in color, while CO_2 containing blood is of purple reddish color.

Volume

The average volume of blood is approximately 5 liters. In new born baby, the volume is approximately 450 ml. In females, it is approximately 4.5 liters.

pH

Blood is slightly alkaline and its pH in normal condition is 7.4.

Viscosity

Blood is 5-times more viscous than water. It is due to red blood cells and plasma proteins.

COMPOSITION OF BLOOD

Blood is made up of two parts

1. Cellular part (formed elements) 45%
2. Non-cellular part (plasma) 55%

CELLULAR CONTENT OF BLOOD

There are three types of blood cells

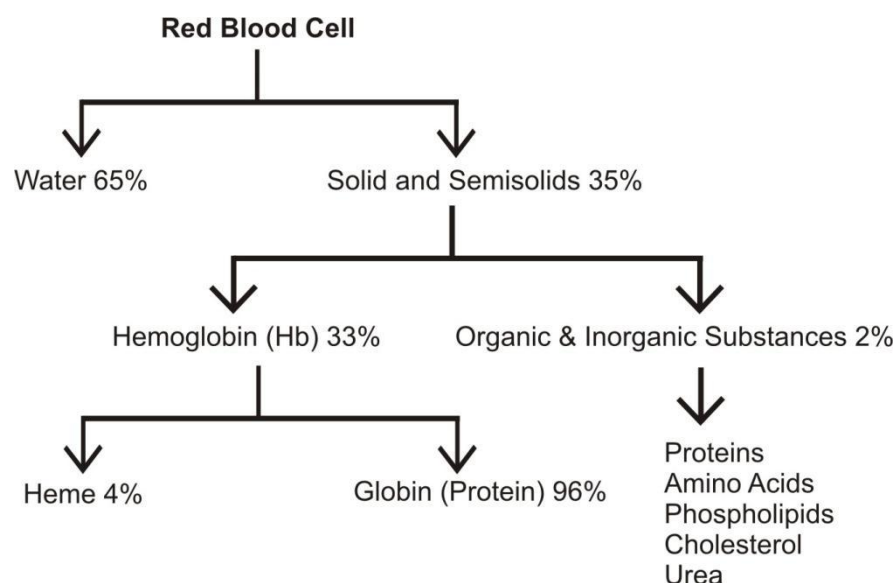
1. **Erythrocytes or Red Blood Cells (RBC)**
2. **Leukocytes or White Blood Cells (WBC)**
3. **Thrombocytes or Platelets**

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

ERYTHROCYTES OR RED BLOOD CELLS (RBC)

RBCs are the non-nucleated, oxygen carrying, hemoglobin containing cells present in blood.

COMPOSITION OF RED BLOOD CELLS



PROPERTIES OF RBC

- Blood is a connective tissue in fluid form
- Life span of RBCs is about 120 days
- Hemoglobin in RBCs transport the respiratory gases
- It transports nutrition from digestive system and hormones from endocrine glands to all the tissues.
- It transports waste products and unwanted substances to the excretory organs like kidney
- These are non-nucleated cells present in blood
- Camel is the only mammal which has nucleated RBCs
- Because of the absent of nucleus in human RBCs, the DNA is also absent in it
- Other organelles such as mitochondria and golgi-apparatus are also absent in RBCs
- RBCs do not have insulin receptor and so the glucose uptake by this cell is not controlled by insulin.
- During circulation, the RBCs remain suspended uniformly in the blood, this property of RBCs is called suspension stability

**FUNCTIONS OF RBC****Transport of O₂**

Hb in RBCs combines with O₂ to form oxyhemoglobin. About 97% of oxygen is transported in the blood in the form of oxyhemoglobin.

Transport of CO₂

Hb in RBCs combines with CO₂ and form carbhemoglobin. About 30% of CO₂ is transported in this form.

Buffering Action Or Acid Base Balance

Hb in RBCs regulates H⁺ ions concentration and play a role in maintenance of acid base balance.

Ionic Balance

RBCs maintain ionic balance

Viscosity Of Blood

RBCs help to maintain the viscosity of blood

Blood Group Determination

RBCs carry the blood group antigens like A-antigen, B-antigen and Rh-factor. This helps in determination of blood group.

FATE OR PRODUCTION RBCs

RBCs are produced in different areas of the body during different stages which are described below.

- **1st Trimester (first three months of pregnancy):** RBCs produced in the yolk sac.
- **2nd Trimester (three to six months of pregnancy):** RBCs are produced mostly in liver in spleen and lymph nodes.
- **3rd Trimester (six to nine months of pregnancy):** During the last trimester of pregnancy and up to 5-years age, RBCs are produced from bone marrow.
- **After The Age Of 20 Years:** Long bones do not produce RBC
- **After The Age Of 25 Years:** RBCs mostly produced in membranous bones, e.g. ribs, vertebrae, sternum, illium.

FACTORS NEEDED FOR ERYTHROPOIESIS

- Vitamin B12, Vitamin C and folic acid
- Proteins (amino acid)
- Fe (iron) and some hormones

RBC COUNT

- Male: 5.4 millions/ mm³

- Female: 4.7 millions/ mm^3
- Infant: 6.0 millions/ mm^3

VARIATION IN RBC COUNT

RBC Count Decrease during sleep, early morning, repeated x-ray and during pregnancy.

RBC Count Increase in evening, & when increases in external temperature, at high altitudes or deficiency of oxygen, after exercise, during the emotional conditions and after taking meals.

HEMOGLOBIN (Hb)

Hemoglobin is iron containing coloring matter of RBCs. It is red oxygen carrying pigment present in RBCs. Hemoglobin contains 4% Heme (non-protein, iron containing substance) and 96% Globin (protein).

NORMAL VALUE OF HEMOGLOBIN

- Male: 14-16 gm/100ml
- Female: 12-14 gm/100ml
- Fetus or newborn: approximately 23 gm/100ml
- Any condition that increase or decrease the RBCs count will affect the Hb concentration

FACTORS NECESSARY FOR Hb SYNTHESIS

- **Proteins:** proteins are necessary for the synthesis of Globin part of hemoglobin
- **Metals:** Fe is essential for the synthesis of non-protein part (Heme) of hemoglobin
- **Vitamins:** vitamins "B12" and vitamins "C" are necessary for hemoglobin synthesis

FUNCTIONS OF HEMOGLOBIN

- The function of Hb is to carry the respiratory gases, O_2 and CO_2
- It also acts as a buffer
- Acid-Base balance
- Different pigments of bile, stool, urine etc. are formed from Hb

LEUKOCYTES OR WHITE BLOOD CELLS (WBC)

WBCs are colorless and nucleated elements of blood. These are large in size and lesser in number as compared to RBCs.

They play very important role in defense mechanism of body and protect body from organism.

PROPERTIES OF WHITE BLOOD CELLS

- Large in size
- Irregular in shape
- Nucleated
- Many types
- Life span is shorter
- Mobile unit of body's protective system

COUNT OF WHITE BLOOD CELLS

- Average WBCs present in the body = $7000/\text{mm}^3$
- Range = 4000 to $11000/\text{mm}^3$

CLASSIFICATION OF WHITE BLOOD CELLS

WBCs are classified into two groups

1. **Granulocytes:** Neutrophils, Eosinophils, Basophils
2. **Agranulocytes:** Monocytes, Lymphocytes

GRANULOCYTES

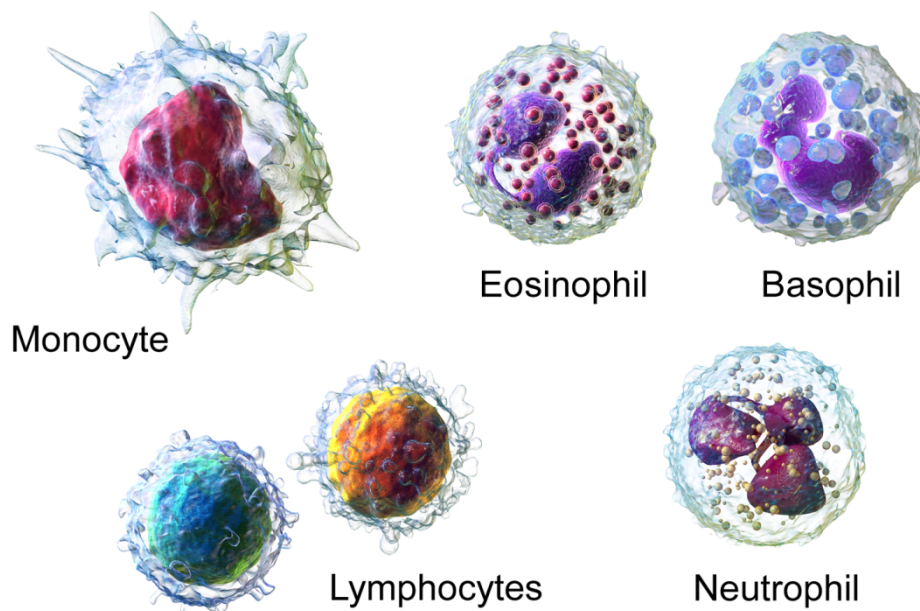
Some of WBCs have granules in the cytoplasm. These are developing from red bone marrow. We can see granules easily in the cytoplasm of WBCs.

1. **Neutrophils:** First line defense, they engulf and destroy foreign particles; they destroy microorganisms by their enzymes. They secrete platelets activating factor for blood clotting (PAF).
2. **Eosinophils:** They act against parasites; they are responsible for detoxification, disintegration and removal of foreign proteins.
3. **Basophils:** They play important role in healing process and allergy.

AGRANULOCYTES

There are no granules present in the cytoplasm of this type of WBCs. They develop from the lymphoid tissues.

1. **Monocytes:** They secrete platelets activating factor (PAF).
2. **Lymphocytes:** These cells develop the cellular immunity and hormonal immunity.



White Blood Cells

FUNCTION OF WHITE BLOOD CELLS

Generally, WBCs play an important role in defense mechanism. These cells protect the body from organisms or any foreign bodies either by destroying or inactivating them. However in defense mechanism, each type of WBCs acts in different way.

Phagocytosis

This is a process by which Neutrophils and Monocytes engulf and destroy the bacteria, viruses and foreign particles.

Antibody Formation

Lymphocytes play important role in defense mechanism of the body. They develop the immunity.

Fibroblast Formation

Lymphocytes may be converted into fibroblast at the site of inflammation, helping in the process of repairing.

Secretion of Heparin

Basophils secrete heparin which prevents intravascular clotting of blood.

THROMBOCYTES OR PLATELETS

Platelets are the formed elements of the blood. Platelets are small, colorless, non-nucleated cells.

SHAPES OF PLATELETS

Platelets are of several shapes e.g. spherical shape, rod shape, oval shape, disc shape, cigar shape or any other unusual shape.

SIZE OF PLATELETS

Size of platelets is 2-4microne

COUNT OF PLATELETS

150,000 to 300,000 / mm³

LIFE SPAN OF PLATELETS

Life span of platelets is 4 to 9 days.

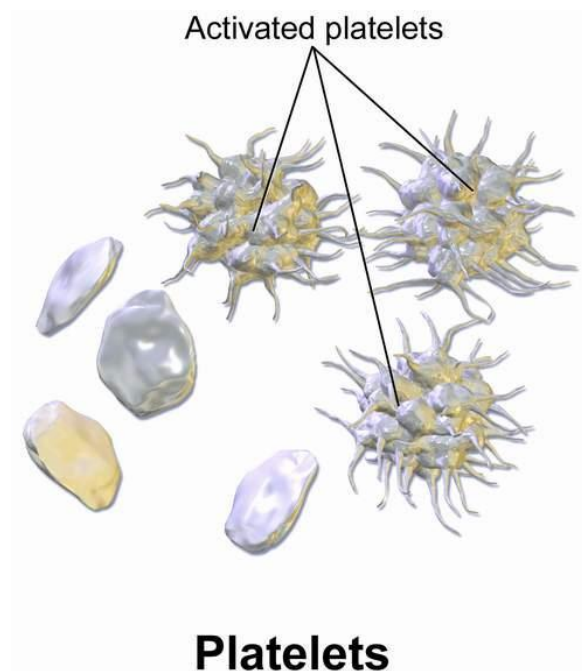
TYPES OF PLATELETS

Platelets can be classified into two types

1. Small or young or active platelets
2. Large or old platelets

FUNCTIONS OF PLATELETS

- Platelets play an important role in blood clotting
- Platelets prevents blood loss
- Platelets play role in repairing of ruptured blood vessel
- Platelets play role in defense mechanism



BLOOD GROUPS

Blood group (also called blood type) is a classification of blood based on the presence or absence of inherited antigenic substances on the surface of red blood cells (RBCs). These antigens may be proteins, carbohydrates, glycoprotein, or glycolipids, depending on the blood group system. Some of these antigens are also present on the surface of other types of cells of various tissues.

IMPORTANT TERMINOLOGY RELATED TO BLOOD GROUP

- **Antigen:** An antigen is any substance that causes your immune system to produce antibodies against it. An antigen may be a foreign substance from the environment such as chemicals, bacteria, viruses, or pollen. An antigen may also be formed within the body.
- **Antibody:** A blood protein produced in response to the counteracting a specific antigen. Antibodies combine with substances and neutralize them which the body recognizes as harmful, such as bacteria, viruses, and foreign substances in the blood.
- **Agglutinin:** An agglutinin is a substance, such as an antibody, that is capable of causing agglutination of a particular antigen, especially red blood cells or bacteria.
- **Agglutinogen:** An antigen (antigen-A, antigen-B) present in blood cells, which stimulates the formation of an agglutinin in blood serum is called agglutinogen.
- **Agglutination:** The clumping of red blood cells in the presence of an antibody, or simply we can say that in the presence of antibodies, the binding of multiple red blood cells and creating a large complex is called agglutination.

BLOOD GROUP SYSTEMS

More than 20 genetically determined blood group systems are known today. But O-A-B system and Rh system are the most important ones that are determined before blood transfusions.

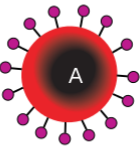
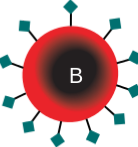
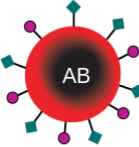
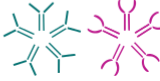
1. **O-A-B Blood Types**
2. **Rh Blood Types**

O-A-B BLOOD TYPES

The OAB blood groups were the first to be discovered (in 1900) and are the most important in assuring safe blood transfusions. In transfusing blood from one person to another, the bloods of donors and recipients are normally classified into four major O-A-B blood types.

Depending on the presence or absence of the two agglutinogens (antigen) "A" and "B" blood groups are defined by the OAB system.

1. **Blood group-A** has A antigens on the red blood cells with anti-B antibodies in the plasma
2. **Blood group-B** has B antigens with anti-A antibodies in the plasma
3. **Blood group-O** has no antigens but both anti-A and anti-B antibodies in the plasma
4. **Blood group-AB** has both A and B antigens but no antibodies

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

RH FACTORS (RHESUS FACTORS)

Along with the O-A-B blood type system, the Rh blood type system is also important when transfusing blood. Rh-factor is an antigen present in RBC. There are many Rh-antigens but only the "D" is more antigenic in human.

The persons having D-antigen are called Rh-Positive, and those without D-antigen are called Rh-negative.

This means that you can be one of eight blood groups

1. A RhD positive (A+)
2. A RhD negative (A-)
3. B RhD positive (B+)
4. B RhD negative (B-)
5. RhD positive (O+)
6. RhD negative (O-)
7. AB RhD positive (AB+)
8. AB RhD negative (AB-)

If Rh-positive blood is transfused to a Rh-negative person for the first time, then anti-D is formed in that person. On the other hand, there is no risk of complications if Rh-positive person receives Rh-negative blood.

ERYTHROCYTE SEDIMENTATION RATE (ESR)

ESR is the rate at which the RBCs settle down. Normally RBCs remain suspended uniformly in circulation (suspension stability of RBCs). If blood is mixed with an anticoagulant and allowed to stand in a vertical tube, the RBCs settle down due to gravity.

DETERMINATION OF ESR

There are two methods to determine ESR

1. **Westergren's Method**
2. **Wintrobe's Method**

NORMAL VALUE OF ESR**Westergren's Method**

- Male: 5-10 mm
- Female: 10-15 mm

Wintrobe's Method

- Male: 0-10 mm
- Female: 0-15 mm

FACTORS AFFECTING ESR

- Specific gravity of RBCs
- Size of RBC
- Viscosity of blood
- RBCs count
- O₂ concentration
- Cholesterol level
- Temperature
- Infection

Blood Coagulation

Coagulation or clotting of blood is the process of conversion of soluble plasma fibrinogen into insoluble fibrin substance to form a clot.

Stages Of Blood Clotting

Blood clotting occurs in three stages

1. Formation of Prothrombin active
2. Conversion of Prothrombin into Thrombin (enzyme, factor-II)
3. Conversion of Fibrinogen (factor-I) into Fibrin (fibrin is fibrous, non-globular protein)

Factors Preventing Coagulation

- Decrease in temperature
- Avoiding contact with water and wet surface
- Precipitation of fibrinogen
- Addition of heparin, peptone, sodium citrate

Factors Increasing Coagulation

- Increase in temperature
- Contact with water and wet surface
- Addition of thrombin
- Addition of calcium chloride

ANEMIA

Anemia means deficiency of hemoglobin in the blood, which can be caused by either too few red blood cells or too little hemoglobin in the cells. Some types of anemia and their physiologic causes are the following.

CLASSIFICATION OF ANEMIA

Anemia is classified by two methods

1. **Morphological Classification**
2. **Etiological Classification**

MORPHOLOGICAL CLASSIFICATION

Morphological classification depends upon the size and color of RBCs. By this method, the anemia is classified into four types...

1. **Normocytic Normochromic Anemia**
2. **Macrocytic Normochromic Anemia**
3. **Macrocytic Hypochromic Anemia**
4. **Microcytic Hypochromic Anemia**

NORMOCYTIC NORMOCHROMIC ANEMIA

In this type of anemia, the size and color of RBCs is normal but the number of RBC is less.

MACROCYTIC NORMOCHROMIC ANEMIA

In this type of anemia, the RBCs are larger in size with normal color. The RBC count is less

MACROCYTIC HYPOCHROMIC ANEMIA

In this type of anemia, the RBCs are larger in size and less colored.

MICROCYTIC HYPOCHROMIC ANEMIA

In this type of anemia, the RBCs are smaller with less colored.

ETIOLOGICAL CLASSIFICATION

On the basis of etiology (study of cause or origin), the anemia is divided into five types...

1. **Hemorrhagic Anemia** (Acute Hemorrhage, Chronic Hemorrhage)
2. **Hemolytic Anemia** (Intrinsic Hemolytic Anemia, Extrinsic Hemolytic Anemia)
3. **Nutrition Deficiency Anemia** (Iron Deficiency Anemia, Protein Deficiency Anemia, Pernicious Anemia, Megaloblastic Anemia)
4. **Aplastic Anemia**
5. **Anemia Of Chronic Disease**

HEMORRHAGIC ANEMIA

Hemorrhage refers to excessive loss of blood. Anemia due to hemorrhage is known as hemorrhagic anemia. It occurs both in acute and chronic hemorrhagic conditions.

ACUTE HEMORRHAGE

It refers to sudden loss of a large quantity of blood as in the case of accident. Decreased RBCs count causes hypoxia (lack of oxygen) stimulates the bone marrow to produce more number of RBCs. This condition is corrected within 4-6 weeks.

CHRONIC HEMORRHAGE

It refers to loss of blood by internal or external bleeding over a long period of time. It occurs in conditions like peptic ulcer, purpura, hemophilia and menorrhagia.

- **Purpura**, A rash of purple spots on the skin caused by internal bleeding from small blood vessels.
- **Hemophilia** is a medical condition in which the ability of the blood to clot is severely reduced, causing the sufferer to bleed severely from even a slight injury.
- **Menorrhagia**, abnormally heavy bleeding at menstruation in women.

HEMOLYTIC ANEMIA

Hemolysis means destruction of RBCs. Anemia due to excessive hemolysis which is not compensated by increased RBCs production is called hemolytic anemia or

Hemolytic anemia occurs when the bone marrow is unable to replace the red blood cells that are being destroyed.

There are two types of hemolytic anemia

1. **Intrinsic Hemolytic Anemia**
2. **Extrinsic Hemolytic Anemia**

INTRINSIC HEMOLYTIC ANEMIA

The destruction of the red blood cells is due to a defect within the red blood cells themselves. Intrinsic hemolytic anemia is often inherited, such as sickle cell anemia. These conditions produce red blood cells that do not live as long as normal red blood cells.

SICKLE CELL ANEMIA

Sickle cell anemia is a disease in which your body produces abnormally shaped red blood cells. The cells are shaped like a crescent or sickle. They don't last as long as normal, round red blood cells. This leads to anemia. The sickle cells also get stuck in blood vessels, blocking blood flow. This can cause pain and organ damage.

EXTRINSIC HEMOLYTIC ANEMIA

Red blood cells are produced healthy but are later destroyed by external factors such as antibodies, chemicals and drugs.

NUTRITION DEFICIENCY ANEMIA

Anemia that occurs due to deficiency of a nutritive substance necessary for erythropoiesis is called nutrition deficiency anemia.

The substances which are necessary for erythropoiesis are iron, protein, vitamin C, B12 and folic acid.

Nutrition deficiency anemias are as follow...

- **Iron Deficiency Anemia**
- **Protein Deficiency Anemia**
- **Pernicious Anemia (Vitamin B12 Deficiency Anemia)**
- **Megaloblastic Anemia (Folic Acid or Vitamin B9 Deficiency Anemia)**

IRON DEFICIENCY ANEMIA

Iron deficiency anemia is a common anemia caused by insufficient dietary intake and absorption of iron. Causes of iron deficiency anemia are...

- Loss of blood
- Decreased intake of iron
- Poor absorption of iron from intestine
- Increased demand for iron in conditions like growth and pregnancy

PROTEIN DEFICIENCY ANEMIA

Due to deficiency of proteins, the synthesis of hemoglobin is reduced. The RBCs are Macrocytic Hypochromic Anemia (RBCs are larger in size and less colored).

PERNICIOUS ANEMIA (VITAMIN B12 DEFICIENCY ANEMIA)

Pernicious anemia is a decrease in red blood cells that occurs when your intestines cannot properly absorb vitamin B12 because of a lack of intrinsic factor (IF) in gastric secretions.

Intrinsic factor is a special protein, helps your intestines absorb vitamin B12. This protein is released by cells in the stomach. When the stomach does not make enough intrinsic factor, the intestine cannot properly absorb vitamin B12.

Pernicious anemia is common in old age and it is more common in females than in male.

Common causes of pernicious anemia include

- Weakened stomach lining (atrophic gastritis)
- An autoimmune condition in which the body's immune system attacks intrinsic factor protein or the cells that make it.

MEGALOBlastic ANEMIA (FOLIC ACID DEFICIENCY ANEMIA)

Megaloblastic anemia is a condition in which the bone marrow produces unusually large, structurally abnormal, immature red blood cells. Megaloblastic anemia is due to the deficiency of another maturation factor called folic acid. Here the RBCs are not matured. The DNA synthesis is also defective so the nucleus remains immature.

APLastic ANEMIA

Aplastic anemia is due to the disorder of red bone marrow. The red bone marrow is reduced and replaced by fatty tissues. Bone marrow disorder occurs in the following conditions...

- Repeated exposure to x-ray or gamma ray radiation
- Presence of bacterial toxins, quinine, gold salts, benzene etc
- Tuberculosis
- Viral infections like hepatitis and HIV infections

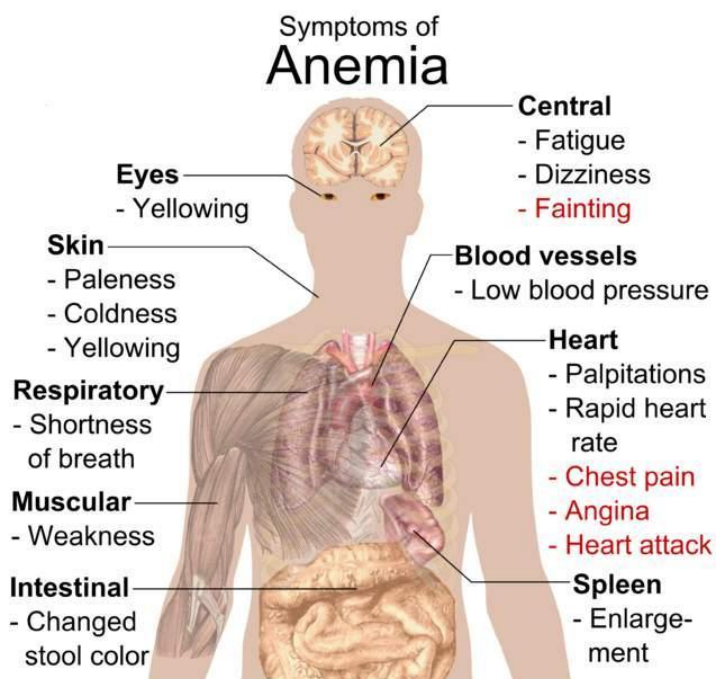
ANEMIA OF CHRONIC DISEASE

Anemia of chronic disease is anemia that is found in people with certain long-term (chronic) medical conditions.

Certain chronic infections, inflammatory diseases, and other illnesses can affect the body's ability to produce red blood cells.

Conditions that can lead to anemia of chronic disease include...

- Noninfectious inflammatory diseases
- Autoimmune disorders
- Cancer
- Chronic kidney disease
- Liver cirrhosis
- Long-term infections, such as HIV/AIDS, hepatitis B or hepatitis C



Anemia of chronic disease is often mild. You may not notice symptoms of anemia. If they occur, symptoms may include...

- Feeling weak or tired
- Headache
- Paleness
- Shortness of breath

CIRCULATION

This is the transport system which circulates blood and lymph throughout the body. There are two types of circulation.

PULMONARY CIRCULATION

This consists of the circulation of blood from the right ventricle of the heart to the lungs and back to the left atrium. In the lungs, carbon dioxide is excreted and oxygen is absorbed.

Right Ventricle of Heart □ **Pulmonary Arteries** □ **Pulmonary Arterioles** □ **Pulmonary Capillaries** □ **Pulmonary Venules** □ **Veins** □ **Left Atrium of Heart**

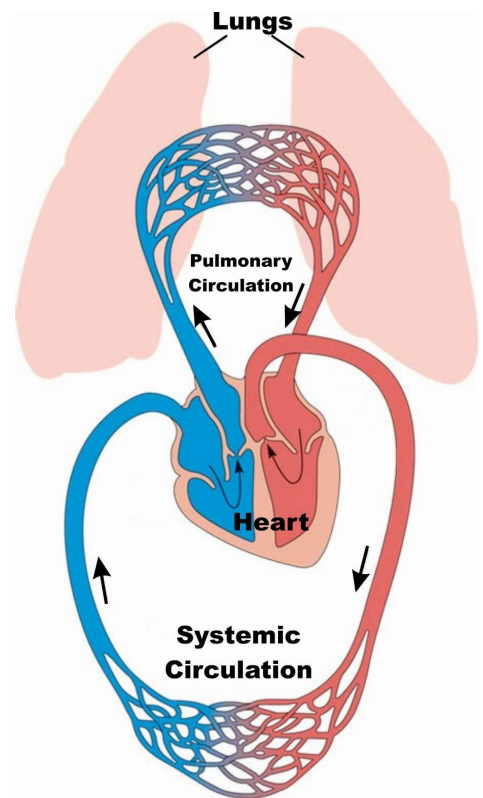
SYSTEMIC OR GENERAL CIRCULATION

In systemic or general circulation, the blood pumped out from the left ventricle is carried by the branches of the aorta around the body and is returned to the right atrium of the heart by the superior and inferior vena cava.

It is also known as the general circulation or peripheral circulation. This circulation supplies all the tissues of the body except the lungs. The sequence of events of systemic circulation is as follows.

Left Ventricle of Heart □ **Aorta** □ **Arteries** □ **Arterioles** □ **Capillaries** □ **Venules** □ **Veins** □ **Vena Cave** □ **Right Atrium of Heart**

The function of the circulation is to service the needs of the body tissues to transport nutrients to the body tissues, to transport waste products away, to conduct hormones from one part of the body to another, and, in general, to maintain an appropriate environment in all the tissue fluids of the body for optimal survival and function of the cells.



FUNCTIONAL PARTS OF CIRCULATION

Heart

The heart is a roughly cone-shaped hollow muscular organ. It is about 10 cm long and is about the size of the owner's fist (a person's hand when the fingers are bent in towards the palm and held there tightly). It weighs about 225g in women and is heavier in men.

Arteries

These are a series of blood vessels which carry oxygenated blood away from the heart (except pulmonary and umbilical arteries). The function of the arteries is to transport blood under high pressure to the tissues. For this reason, the arteries have strong vascular walls, and blood flows at a high velocity in the arteries.

Arterioles

These are the smaller branches of arteries which deliver blood to capillaries. Arterioles play a key role in regulating blood flow from arteries into capillaries.

Capillaries

These are diffuse net works of blood vessels which connect the arterioles and venules. Capillaries are found in almost every cell in the body. The distribution of capillaries in the body varies with the activity of the tissues. For example in those tissues whose activities are higher such as muscles, liver, kidneys, lungs and the nervous system, there are rich capillary supplies.

Venules

These are blood vessels that connect capillaries with veins. The *venules* collect blood from the capillaries, and they gradually combine into larger veins.

Veins

These are a series of blood vessels which carry blood towards the heart (except pulmonary and umbilical veins).

PROPERTIES OF CARDIAC MUSCLE

Properties of cardiac muscle can be divided into 2 groups

Beating Heart	Quiescent Heart (in a state or period of inactivity)
• Automaticity • Rhythmicity • Contractibility • Excitability • Conductivity • Distensibility • Functional Syncytium • Long Refractory Period • Extrasystole & Compensatory Pause	• All Or None Law • The Staircase Phenomenon • Length-Tension Relationship • Summation Of Subminimal Stimuli

Nature

Cardiac muscle is involuntary in function and striated in appearance.

Automaticity

Capability of contract even in the absence of neural control

Rhythmicity

Heart beats are extremely regular

Contractibility

Cardiac muscle contracts in response to a stimulus in the presence of ATP (Adenosine triphosphate) and calcium ion.

Excitability

Ability of the cardiac muscle to respond to different stimuli

Conductivity

This is the transfer of cardiac impulses from the sinoatrial node (S.A. node) to all the cardiac muscle. Impulses produced in the SA node is conducted by the specialized conducting pathway

Distensibility

Occurs due to compliance of the cardiac muscle

Functional Syncytium

When a number of cells function as a single unit the whole functional unit is called a functional syncytium. The heart is composed of two different syncytia, the atrial syncytium and ventricular syncytium.

Extrasystole & Compensatory Pause

When the ventricle is stimulated in the relaxation period (relative refractory period), the cardiac muscle may contract. It may occurs because a papillary muscle may fire an impulse before normal impulse reaches the ventricles

All Or None Law

The cardiac muscle fibers do not contract if the stimulus is sub-threshold. They will contract with constant strength if the stimulus is at or above the threshold.

Staircase Phenomenon

If a quiescent ventricle is stimulated repeatedly such that the interval between consecutive stimuli is less than 10 s, the first 3-4 contractions are progressively more forceful

Length-Tension Relationship (Frank-Starling Law)

Within the physiological limits, the force of contraction of cardiac muscle is directly proportional to the initial length of the muscle fibers

Summation Of Subminimal Stimuli

When subminimal stimuli are applied repeatedly, the stimuli summate & produce a response

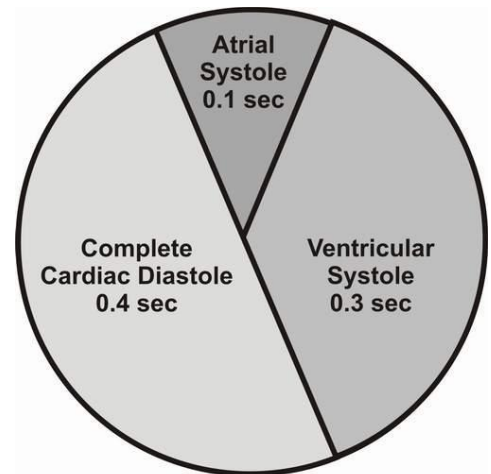
CARDIAC CYCLE

The function of the heart is to maintain a constant circulation of blood throughout the body. The heart acts as a pump and its action consists of a series of events known as the cardiac cycle.

During each heartbeat, or cardiac cycle, the heart contracts and then relaxes. The period of contraction is called systole and that of relaxation, diastole.

STAGES OF THE CARDIAC CYCLE

The normal number of cardiac cycles per minute ranges from 60 to 80. When the heart beats at the normal rate of 72/minute, the duration of each cardiac cycle is about 0.8 seconds. The duration of systole is 0.27 second and that diastole is 0.53 second.



Total Period of 1 Cycle = 0.8 Seconds

SUBDIVISIONS AND DURATION OF CARDIAC CYCLE

The events of cardiac cycle are classified into two divisions, systole and diastole...

Systole

- | | |
|--------------------------|-----------------|
| 1. Isometric Contraction | 0.05 Sec |
| 2. Ejection Period | 0.22 Sec |
| Total Time | 0.27 Sec |

Diastole

- | | |
|-------------------------|-----------------|
| 1. Protodiastole | 0.04 Sec |
| 2. Isometric Relaxation | 0.08 Sec |
| 3. Rapid Inflow | 0.11 Sec |
| 4. Slow Inflow | 0.19 Sec |
| 5. Atrial Systole | 0.11 Sec |
| Total Time | 0.53 Sec |

Total duration of cardiac cycle is $0.27 + 0.53 = 0.8$ seconds

HEART SOUNDS

Heart sounds are heard with the help of a stethoscope. Two sounds, separated by a short pause, can be clearly distinguished. They are described in words as 'LUB DUP'. In some cases one may hear a 3rd or 4th heart sound. These sounds are made by the closure of the heart valves and the acceleration and deceleration or vibration of valves due to blood flow in the cardiac chambers.

1st Heart Sound

The first sound, 'LUB', is fairly loud and is due to the closure of the atrioventricular valves. This corresponds with ventricular systole.

2nd Heart Sound

The second sound, 'DUP', is softer and is due to the closure of the aortic and pulmonary valves. This corresponds with atrial systole.

Murmurs

These are abnormal heart sounds produced when there is an excessive degree of turbulence of blood flow in the heart chambers.

ELECTROCARDIOGRAPHY (ECG)

Electrocardiography is the technique by which the electrical activities of the heart are studied. The spread of excitation through myocardium produces local electrical potential. This causes flow of small currents through the body which acts as volume conductor. These small currents can be picked up from the surface of the body by using suitable electrodes and recorded in the form of electrocardiogram.

ELECTROCARDIOGRAPH

Electrocardiograph is the instrument (ECG machine) by which the electrical activities of the heart are recorded.

ELECTROCARDIOGRAPHIC PAPER AND GRID

The paper that is used for recording ECG is called ECG paper. Electrocardiographic grid refers to the markings (lines) on ECG paper. ECG paper has horizontal and vertical lines at regular intervals of 1 mm. Every 5th line (5 mm) is thickened.

Duration

Time duration of different ECG waves is plotted horizontally on X-axis.

On X-axis

1 mm = 0.04 second

5 mm = 0.20 second

On Y-axis

1 mm = 0.1 mV

5 mm = 0.5 mV

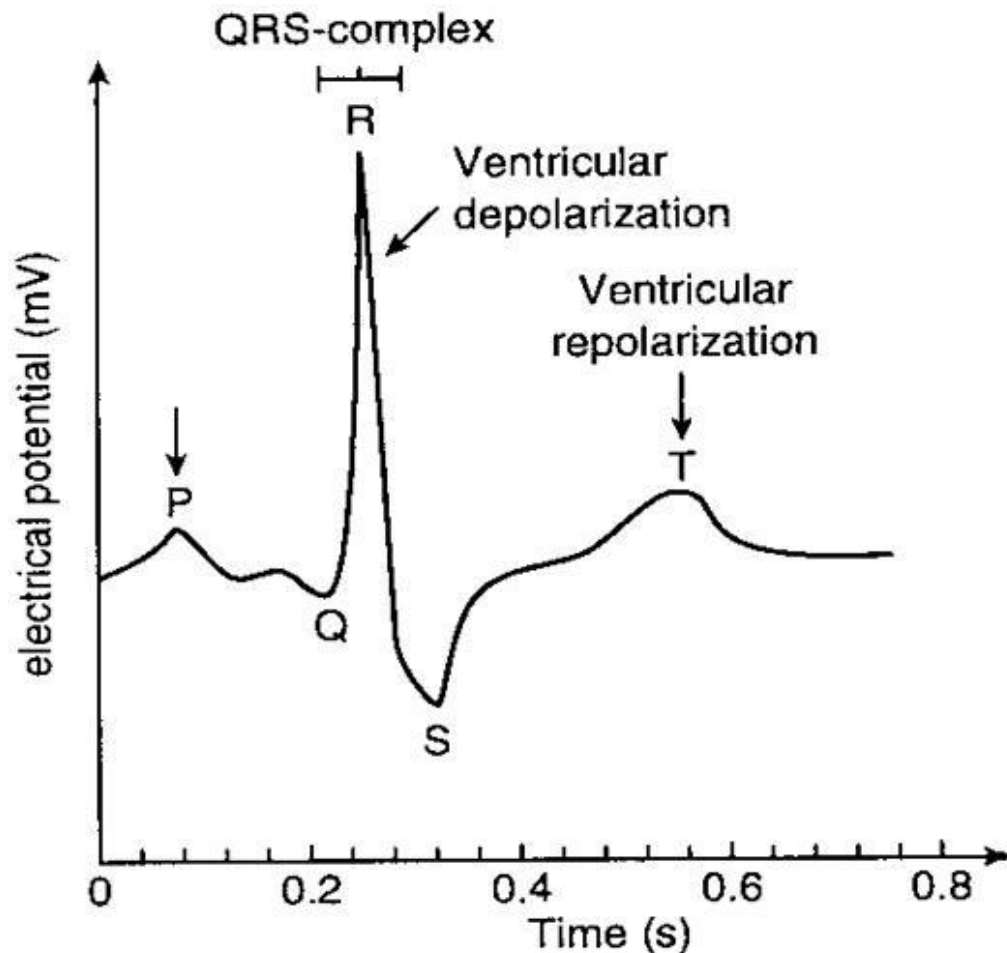
Amplitude of ECG waves is plotted vertically on Y-axis.

ECG LEADS

ECG is recorded by placing series of electrodes on the surface of the body. These electrodes are called ECG leads and are connected to the ECG machine. Electrodes are fixed on the limbs. Usually, right arm, left arm and left leg are chosen. Heart is said to be in the center of an imaginary equilateral triangle drawn by connecting the roots of these three limbs. This triangle is called Einthoven triangle.

WAVES OF NORMAL ECG

Normal ECG consists of waves, complexes, intervals and segments. Waves of ECG recorded by limb lead II are considered as the typical waves. Normal electrocardiogram has the following waves, namely P, Q, R, S and T.



MAJOR COMPLEXES IN ECG

1. 'P' wave, the atrial complex
2. 'QRS' complex, the initial ventricular complex
3. 'T' wave, the final ventricular complex
4. 'QRST', the ventricular complex

'P' Wave

'P' wave is a positive wave and the first wave in ECG. It is also called atrial complex when atria contacts.

'QRS' Complex

'QRS' complex is also called the initial ventricular complex. 'Q' wave is a small negative wave. It is continued as the tall 'R' wave, which is a positive wave. 'R' wave is followed by a small negative wave, the 'S' wave when ventricles contact.

'T' Wave

'T' wave is the final ventricular complex and is a positive wave when ventricles start repolarization.

'U' Wave

'U' wave is not always seen. It is also an insignificant wave in ECG. It is supposed to be due to repolarization of papillary muscle.

Uses of ECG

Electrocardiogram is useful in determining and diagnosing the following...

- Heart rate
- Heart rhythm
- Abnormal electrical conduction
- Poor blood flow to heart muscle (ischemia)
- Heart attack
- Coronary artery disease
- Hypertrophy of heart chambers.

BLOOD PRESSURE

Blood pressure is the force or pressure which the blood exerts on the walls of the blood vessels.

- Blood Pressure = Cardiac Output X Peripheral Resistance
- Cardiac Output = Stroke Volume X Heart Rate

SYSTOLIC BLOOD PRESSURE

This is the maximum pressure exerted by blood on the walls of blood vessels which develops at the peak of ventricular systole. Systolic Blood Pressure = 120mm Hg

DIASTOLIC BLOOD PRESSURE

This is the minimum pressure exerted by blood on the wall of blood vessels during ventricular diastole. Diastolic Blood Pressure = 80mm Hg

MEASUREMENT OF BLOOD PRESSURE

Blood pressure is measured clinically with a sphygmomanometer which is either of mercury or aneroid type. Advise the patient for rest at least 15 to 20 minutes. The patient should be in a sitting or lying position. There are two methods for taking blood pressure.

PALPATORY METHOD

Most common method for measuring blood pressure is palpatory but only systolic pressure can be measured with this method. The palpatory method is useful when a stethoscope cannot be used due to noise interference or other situations.

AUSCULTATORY METHOD

The auscultatory method uses a stethoscope and a sphygmomanometer. Sounds are heard with the help of stethoscope. Both systolic & diastolic blood pressure can be measured with this method. The auscultatory method is the predominant method of clinical measurement.

PHYSIOLOGICAL VARIATIONS OF BLOOD PRESSURE

Diurnal variation

Blood pressure is lowest early in the morning and highest in the afternoon.

Age

Blood pressure rises with age. The systolic blood pressure at different ages:

- Infancy 80-90mm Hg
- Childhood 90-110mm Hg
- Adult 110-120mm Hg
- Elderly 140-150mm Hg

(mm Hg □ "millimeters of mercury". Hg is symbol of Mercury_

Sex

Before the occurrence of menopause in females both the systolic and diastolic blood pressures are slightly lower than males. After menopause blood pressure may be slightly higher than males of the same age.

Body Build

Overweight persons tend to have higher blood pressure.

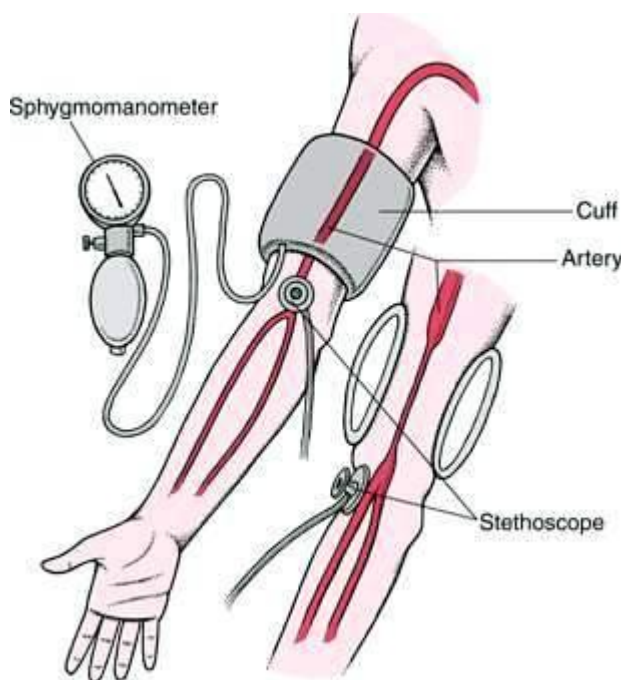
Sleep

In resting conditions as in sleep blood pressure is decreased.

Exercise

Light exercise such as walking increases the systolic blood pressure, but decreases the diastolic blood pressure. In severe exercise the systolic blood pressure may rise up to 180mm Hg

Posture



Standing position causes an increase in both systolic and diastolic blood pressure.

Excitement Or Emotion

This may cause an increase in systolic blood pressure.

After Digestion Of Food

There is a slight rise in systolic blood pressure but the diastolic blood pressure falls due to vasodilatation in certain vessels of the body.

PULSE

The pulse is a wave of distension and elongation felt in an artery wall due to the contraction of the left ventricle forcing about 60 to 80 milliliters of blood through the already full aorta and into the arterial system.

(Distension: The act of expanding by pressure)

(Elongation: The action or process of lengthening something)

The pulse is most often measured by feeling the arteries of the wrist. There is also a pulse, although far weaker in veins.

Pulse Rate

The number of times a heart beats per minute in a person's body.

Heart Rate

The number of contractions of the cardiac ventricles per unit of time is called heart rate.

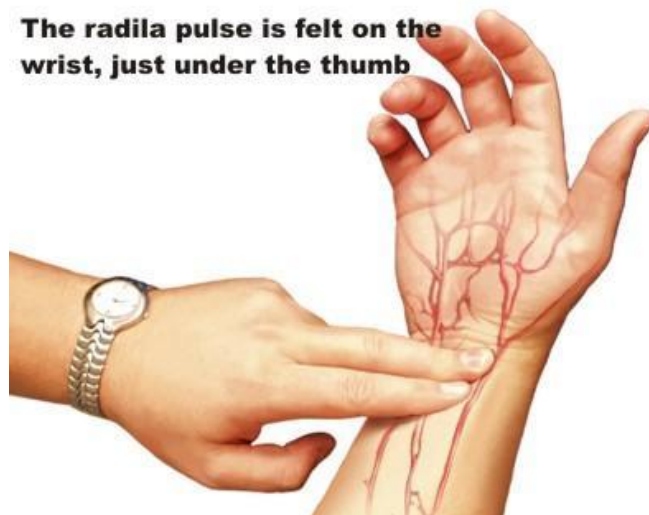
Radial Pulse

Arteries carry oxygenated blood away from the heart to the tissues of the body; veins carry blood depleted of oxygen from the same tissues back to the heart. The arteries are the vessels with the "pulse" a rhythmic pushing of the blood in the heart followed by a refilling of the heart chamber. To determine heart rate one feels the beats at a pulse point like the inside of the wrist for 10 seconds and multiplies this numbers by 6. This is the per-minute total.

Wrist Pulse

To measure the pulse at the wrist places the index and middle finger over the underside of the opposite wrist below the base of the thumb. Press firmly with flat fingers until you feel the pulse in the radial artery.

The radila pulse is felt on the wrist, just under the thumb



Arterial Pulse

Arterial pulse is the transient expansion of arteries due to internal pressure changes with in the arteries. This pulse move much faster than the blood itself.

Venous Pulse

This is the transient expansion of veins due to pressure changes. The venous pulse can be recorded directly by introducing of cannula into a vein and recoding the pressure changes via a mercury manometer.

HEMORRHAGES

Hemorrhage is defined as the excess loss of blood due to rupture of blood vessels.

TYPES AND CAUSES OF HEMORRHAGE

1. Accidental Hemorrhage
2. Capillary Hemorrhage
3. Internal Hemorrhage
4. Postpartum Hemorrhage
5. Hemorrhage Due To Premature Detachment Of Placenta

Accidental Hemorrhage

Accidental hemorrhage occurs in road accidents and industrial accidents, which are very common in the developed and developing countries.

Accidental hemorrhage is of two types...

1. Primary hemorrhage, which occurs immediately after the accident
2. Secondary hemorrhage, which takes place sometime (about few hours) after the accident.

Capillary Hemorrhage

Capillary hemorrhage is the bleeding due to the rupture of blood vessels, particularly capillaries. It is very common in brain (cerebral hemorrhage) and heart during cardiovascular diseases. The rupture of the capillary is followed by spilling (leak) of blood into the surrounding areas.

Internal Hemorrhage

Internal hemorrhage is the bleeding in viscera. It is caused by rupture of blood vessels in the viscera. The blood accumulates in viscera.

(Viscera = The internal organs in the main cavities of the body, especially those in the abdomen, e.g. the intestines)

Postpartum Hemorrhage

Excess bleeding that occurs immediately after labor (delivery of the baby) is called postpartum hemorrhage. In some cases, it is very severe and leads to major complications.

Hemorrhage Due To Premature Detachment Of Placenta

In some cases, the placenta is detached from the uterus of mother before the due date of delivery causing severe hemorrhage.

ACUTE HEMORRHAGE

It refers to sudden loss of a large quantity of blood as in the case of accident. This condition is corrected within 4-6 weeks.

CHRONIC HEMORRHAGE

It refers to loss of blood by internal or external bleeding over a long period of time. It occurs in conditions like peptic ulcer, purpura, hemophilia and menorrhagia.

- **Purpura**, A rash of purple spots on the skin caused by internal bleeding from small blood vessels.
- **Hemophilia** is a medical condition in which the ability of the blood to clot is severely reduced, causing the sufferer to bleed severely from even a slight injury.
- **Menorrhagia**, abnormally heavy bleeding at menstruation in women.

LYMPH

Lymph defined as a colorless fluid containing white blood cells, which bathes the tissues and drains through the lymphatic system into the bloodstream.

LYMPHATIC SYSTEM

Lymphatic system is a closed system of lymph channels or lymph vessels, through which lymph flows. It is a one-way system and allows the lymph flow from tissue spaces toward the blood.

COMPOSITION OF LYMPH

Usually, lymph is a clear and colorless fluid. It is formed by 96% water and 4% solids. Some blood cells are also present in lymph.

FUNCTIONS OF LYMPH

1. Important function of lymph is to return the proteins from tissue spaces into blood.
2. It is responsible for redistribution of fluid in the body.
3. Bacteria, toxins and other foreign bodies are removed from tissues via lymph.
4. Lymph flow is responsible for the maintenance of structural and functional integrity of tissue.
5. Lymph flow serves as an important route for intestinal fat absorption.
6. It plays an important role in immunity by transport of lymphocytes.

RESPIRATORY SYSTEM

RESPIRATION

Respiration is the process by which oxygen is taken in and carbon dioxide is given out. The first breath takes place only after birth. Fetal lungs are non-functional. So, during intrauterine life the exchange of gases between fetal blood and mother's blood occurs through placenta. After the first breath, the respiratory process continues throughout the life. Permanent stoppage of respiration occurs only at death.

PHASES OF RESPIRATION

Respiration occurs in two phases

1. **Inspiration** during which air enters the lungs from atmosphere
2. **Expiration** during which air leaves the lungs.

TYPES OF RESPIRATION

Respiration is classified into two types...

1. **External respiration:** Involves exchange of respiratory gases, i.e. oxygen and carbon dioxide between lungs and blood.
2. **Internal respiration:** Involves exchange of gases between blood and tissues.

FUNCTIONAL ANATOMY OF RESPIRATORY TRACT

Respiratory tract is the anatomical structure through which air moves in and out. It includes nose, pharynx, larynx, trachea, bronchi and lungs. From a clinical point of view, the respiratory system is divided into the upper and lower respiratory tract.

1. Upper Respiratory Tract

The upper respiratory tract is consisting of the nose, pharynx (throat) and associated structures.

2. Lower Respiratory Tract

The lower respiratory tract is consisting of the larynx, trachea, bronchi and lungs.

MECHANICS OF RESPIRATION

Respiration occurs in two phases namely inspiration and expiration. During inspiration, lungs expand so that air enters the lungs easily. During expiration, lungs decrease in size and attain the pre-inspiratory position so that air leaves the lungs easily.

MECHANISM OF INSPIRATION

Contraction Of Diaphragm

□

Vertical Diameter Of Chest Cavity Increase

□

Expansion Of Lungs

□

Pressure Inside Lungs Decrease

□

Air Move From Atmosphere To Lungs

□

Inspiration

MECHANISM OF EXPIRATION

Relaxation Of Inspiratory Muscle

□

Decreased Vertical Diameter Of The Chest Cavity

□

Size Of Lungs Decreases

□

Increased Pressure Inside The Lungs

□

Air Moves From Lung Alveoli Towards Atmosphere

□

Expiration

PULMONARY VENTILATION

(Pulmo = lungs, ventilation = breathing)

This is the inspiration (inflow) and expiration (outflow) of air between the atmosphere and lungs. In other words, pulmonary ventilation may be defined as the inflow and outflow of air between the atmosphere and the alveoli of the lungs.

In the process of pulmonary ventilation an important factor called the pressure gradient exist & air moves into the lungs when the pressure inside the lungs is less than that of the atmospheric pressure. Air moves from the lungs to the atmosphere when the pressure in the lungs is greater than the atmospheric pressure.

LUNG VOLUMES

Static lung volumes are the volumes of air breathed by an individual. Each of these volumes represents the volume of air present in the lung under a specified static condition (specific position of thorax). Static lung volumes are of four types...

1. **Tidal Volume (TV)**
2. **Inspiratory Reserve Volume (IRV)**
3. **Expiratory Reserve Volume (ERV)**
4. **Residual Volume (RV)**

Tidal Volume (TV)

Volume of air inspired or expired in each normal breath is called tidal volume.

Normal Value = 500 ml

Inspiratory Reserve Volume (IRV)

Inspiratory reserve volume is an additional volume of air that can be inspired forcefully after the end of normal inspiration.

Normal Value = 3300 ml

Expiratory Reserve Volume (ERV)

Expiratory reserve volume is the additional volume of air that can be expired out forcefully, after normal expiration.

Normal Value = 1000 ml

Residual Volume (RV)

Residual volume (RV) is the volume of air remaining in lungs even after forced expiration.

Normal Value = 1200 ml

LUNG CAPACITIES

Static lung capacities are the combination of two or more lung volumes. Static lung capacities are of four types...

1. **Inspiratory Capacity (IC)**
2. **Vital Capacity (VC)**
3. **Functional Residual Capacity (FRC)**
4. **Total Lung Capacity (TLC)**

Inspiratory Capacity (IC)

Inspiratory capacity (IC) is the maximum volume of air that is inspired after normal expiration (end expiratory position). It includes tidal volume and inspiratory reserve volume.

$$IC = TV + IRV$$

$$= 500 + 3300 = 3800 \text{ ml}$$

Vital Capacity (VC)

Vital capacity is the maximum volume of air that can be expelled out forcefully after a deep (maximal) inspiration. Vital capacity includes inspiratory reserve volume, tidal volume and expiratory reserve volume.

$$VC = IRV + TV + ERV$$

$$= 3300 + 500 + 1000 = 4800 \text{ ml}$$

Functional Residual Capacity (FRC)

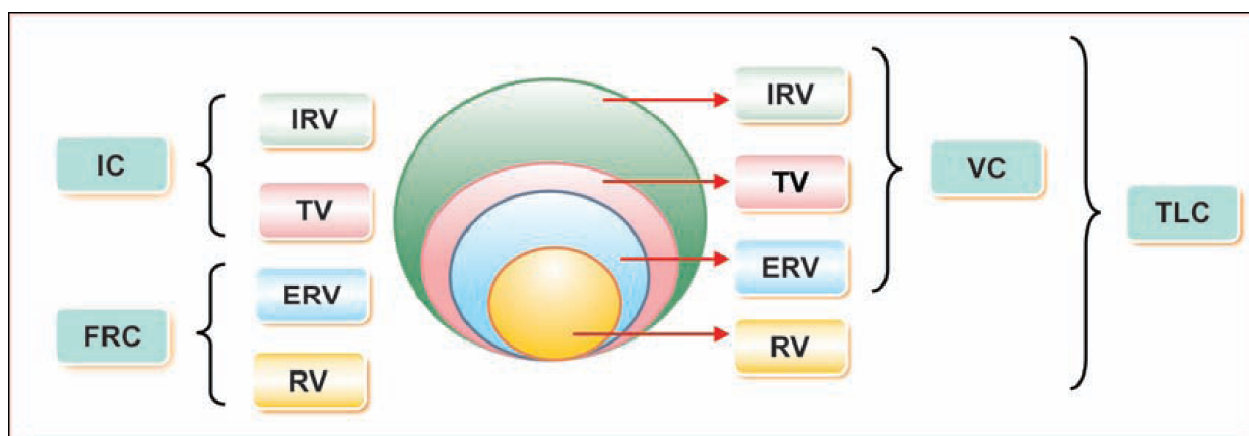
Functional residual capacity (FRC) is the volume of air remaining in lungs after normal expiration (after normal tidal expiration). Functional residual capacity includes expiratory reserve volume and residual volume.

$$\begin{aligned}\text{FRC} &= \text{ERV} + \text{RV} \\ &= 1000 + 1200 = 2200 \text{ ml}\end{aligned}$$

Total Lung Capacity (TLC)

Total lung capacity (TLC) is the volume of air present in lungs after a deep (maximal) inspiration. It includes all the volumes.

$$\begin{aligned}\text{TLC} &= \text{IRV} + \text{TV} + \text{ERV} + \text{RV} \\ &= 3300 + 500 + 1000 + 1200 = 6000 \text{ ml}\end{aligned}$$



Lung Volumes & Capacities: **TV** = Tidal volume, **IRV** = Inspiratory reserve volume, **ERV** = Expiratory reserve volume, **RV** = Residual volume, **IC** = Inspiratory capacity, **FRC** = Functional residual capacity, **VC** = Vital capacity, **TLC** = Total lung capacity.

PHYSIOLOGICAL VARIATIONS OF VITAL CAPACITY

- Age: In childhood and old age vital capacity is less than normal adults.
- Sex: In female it is 20% less than male.
- Height: Greater the height more will be vital capacity.
- Exercise: (athletes and swimmers) vital capacity is increased in persons.
- Position: vital capacity is greater at standing and less in lying or sleeping position.
- Pregnancy: It is decreased in pregnancy.

CARRIAGE OF O₂ AND CO₂ BY THE BLOOD

Blood serves to transport the respiratory gases. Oxygen, which is essential for the cells, is transported from alveoli of lungs to the cells. Carbon dioxide, which is the waste product in cells, is transported from cells to lungs.

TRANSPORT OF OXYGEN

Oxygen is transported from alveoli to the tissue by blood in two forms.

1. As Simple Physical Solution (3%)
2. In Combination With Hemoglobin (97%)

As Simple Physical Solution

Oxygen dissolves in water of plasma and is transported in this physical form. Amount of oxygen transported in this way is very negligible. It is only 0.3 ml/100 ml of plasma. It forms only about 3% of total oxygen in blood. It is because of poor solubility of oxygen in water content of plasma.

In Combination With Hemoglobin

Oxygen combines with hemoglobin in blood and is transported as **oxyhemoglobin**. Transport of oxygen in this form is important because, maximum amount (97%) of oxygen is transported by this method.

TRANSPORT OF CARBON DIOXIDE

Carbon dioxide is transported by the blood from cells to the alveoli. Carbon dioxide is transported in the blood in four ways...

1. As Dissolved Form (7%)
2. As Carbonic Acid (Negligible)
3. As Bicarbonate (63%)
4. As Carbamino Compounds (30%).

As Dissolved Form

Carbon dioxide diffuses into blood and dissolves in the fluid of plasma forming a simple solution. It is about 7% of total carbon dioxide in the blood.

As Carbonic Acid

Part of dissolved carbon dioxide in plasma combines with the water to form carbonic acid. Transport of carbon dioxide in this form is negligible.

As Bicarbonate

About 63% of carbon dioxide is transported as bicarbonate. From plasma, carbon dioxide enters the RBCs. In the RBCs, carbon dioxide combines with water to form carbonic acid. The reaction inside RBCs is very rapid because of the presence of carbonic anhydrase. This enzyme accelerates the reaction. Carbonic anhydrase is present only inside the RBCs and not in plasma. That is why carbonic acid formation is at least 200 to 300 times more in RBCs than in plasma.

As Carbamino Compounds

About 30% of carbon dioxide is transported as carbamino compounds. Carbon dioxide is transported in blood in combination with hemoglobin and plasma proteins. Carbon dioxide combines with hemoglobin to form carbamino hemoglobin or carbhemoglobin. And it combines with plasma proteins to form carbamino proteins. Carbamino hemoglobin and carbamino proteins are together called carbamino compounds.

Carbon dioxide combines with proteins or hemoglobin with a loose bond so that, carbon dioxide is easily released into alveoli, where the partial pressure of carbon dioxide is low. Thus, the combination of carbon dioxide with proteins and hemoglobin is a reversible one.

REGULATION OF BREATHING/ RESPIRATION

Respiration is regulated by two different mechanisms, these are the

1. Nervous Or Neural Mechanism
2. Chemical Mechanism

NERVOUS OR NEURAL MECHANISM

The nervous system normally adjusts the rate of alveolar ventilation almost exactly to the demands of the body.

Respiratory Centers

The respiratory center is composed of several groups of neurons located bilaterally in the medulla oblongata and pons of the brain stem. It is divided into three major collections of neurons...

1. A dorsal respiratory group, located in the dorsal portion of the medulla, which mainly causes inspiration
2. A ventral respiratory group, located in the ventrolateral part of the medulla, which mainly causes expiration
3. The pneumotaxic center, located dorsally in the superior portion of the pons, which mainly controls rate and depth of breathing

The dorsal respiratory group of neurons plays the most fundamental role in the control of respiration.

(The pons is a portion of the hindbrain that connects the cerebral cortex with the medulla oblongata. It also serves as a communications and coordination center between the two hemispheres of the brain.)

Dorsal Respiratory Group of Neurons

The dorsal respiratory group of neurons is involved in the generation of respiratory rhythm, and is primarily responsible for the generation of inspiration.

Ventral Respiratory Group of Neurons

The ventral respiratory group of neurons contains both inspiratory and expiratory neurons. The VRG is secondarily responsible for initiation of inspiratory activity, after the dorsal respiratory group. The nucleus para-ambiguus is active during inspiration, while the nucleus retrofacialis and the nucleus retroambiguus are active during exhalation. The ventral respiratory group of neurons is responsible for motor control of inspiratory and expiratory muscles during exercise.

Pneumotaxic Center

The pneumotaxic center regulates the amount of air a person can take into the body in each breath. The dorsal respiratory group has rhythmic bursts of activity that are constant in duration and interval. When we need to breathe faster, the pneumotaxic center tells the dorsal respiratory group to speed up. When we need longer breaths the bursts of activity are elongated. All the information that our body uses to help us breath happens in the pneumotaxic center.

CHEMICAL MECHANISM

Chemical mechanism of regulation of respiration is operated through the chemoreceptors. Chemoreceptors are the sensory nerve endings, which give response to changes in chemical constituents of blood.

Changes in Chemical Constituents of Blood which Stimulate Chemoreceptors are as follow...

- Hypoxia (decreased pO_2)
- Hypercapnea (increased pCO_2)
- Increased hydrogen ion concentration

(pO_2 = Partial Pressure of Oxygen)

(pCO_2 = Partial Pressure of Carbon Dioxide)

TYPES OF CHEMORECEPTORS

Chemoreceptors are classified into two groups

1. Central Chemoreceptors
2. Peripheral Chemoreceptors.

CENTRAL CHEMORECEPTORS

Central chemoreceptors are the chemoreceptors present in the brain.

MECHANISM OF ACTION OF CENTRAL CHEMORECEPTORS

Central chemoreceptors are connected with respiratory centers. These chemoreceptors act slowly but effectively. Central chemoreceptors are responsible for 70% to 80% of increased ventilation through chemical regulatory mechanism. Main stimulant for central chemoreceptors is the increased hydrogen ion concentration. However, if hydrogen ion concentration increases in the blood, it cannot stimulate the central chemoreceptors because, the hydrogen ions from blood cannot cross the blood brain barrier.

On the other hand, if carbon dioxide increases in the blood, it can easily cross the blood-brain barrier. Carbon dioxide combines with water to form carbonic acid. It immediately dissociates into hydrogen ion and bicarbonate ion. Hydrogen ions stimulate the central chemoreceptors. From chemoreceptors, the excitatory impulses are sent to dorsal respiratory group of neurons, resulting in increased ventilation (increased rate and force of breathing).

PERIPHERAL CHEMORECEPTORS

Peripheral chemoreceptors are the chemoreceptors present in carotid and aortic region.

MECHANISM OF ACTION OF PERIPHERAL CHEMORECEPTORS

Hypoxia is the most potent stimulant for peripheral chemoreceptors. It is because of the presence of oxygen sensitive potassium channels in the glomus cells of peripheral chemoreceptors.

Hypoxia causes closure of oxygen sensitive potassium channels and prevents potassium efflux. This leads to depolarization of glomus cells (receptor potential) and generation of action potentials in nerve ending.

These impulses pass through aortic and hering nerves and excite the dorsal group of neurons. Dorsal group of neurons in turn, send excitatory impulses to respiratory muscles, resulting in increased ventilation. This provides enough oxygen and rectifies the lack of oxygen.

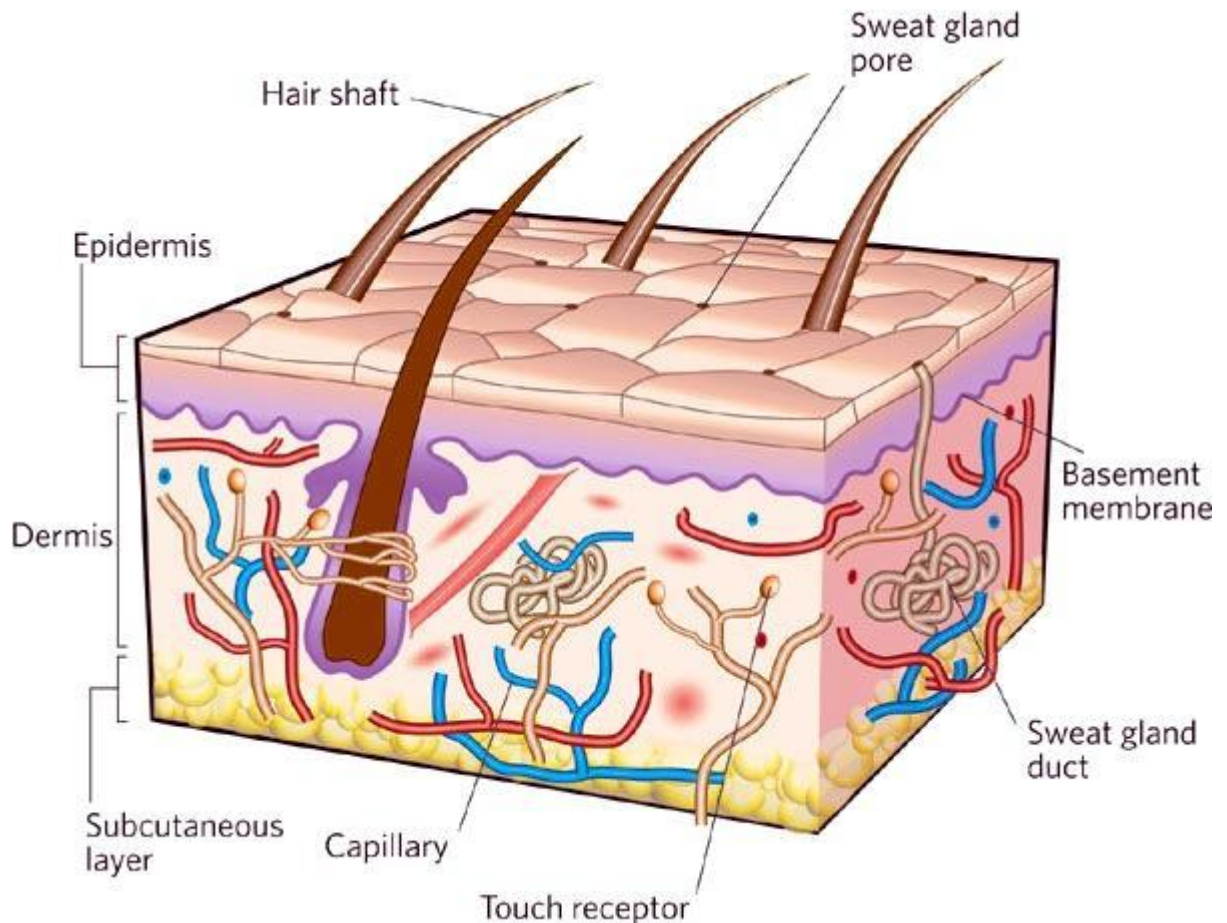
SKIN

Skin is the largest organ of the body. It is not uniformly thick. At some places it is thick and at some places it is thin. The average thickness of the skin is about 1 to 2 mm. In the sole of the foot, palm of the hand and in the interscapular region, it is considerably thick, measuring about 5 mm. In other areas of the body, the skin is thin. It is thinnest over eyelids and penis, measuring about 0.5 mm only.

STRUCTURE OF SKIN

Skin is made up of two layers

1. Epidermis Or Outer Epidermis
2. Dermis Or Inner Dermis



EPIDERMIS

Epidermis is the outer layer of skin. It is formed by stratified epithelium. Important feature of epidermis is that, it does not have blood vessels. Nutrition is provided to the epidermis by the capillaries of dermis.

Layers of Epidermis

Epidermis is formed by five layers

1. Stratum Corneum
2. Stratum Lucidum
3. Stratum Granulosum
4. Stratum Spinosum
5. Stratum Germinativum.

DERMIS

Dermis is the inner layer of the skin. It is a connective tissue layer, made up of dense and stout collagen fibers, fibroblasts and histiocytes. Collagen fibers exhibit elastic property and are capable of storing or holding water. Collagen fibers contain the enzyme collagenase, which is responsible for wound healing.

Layers of Dermis

Dermis is made up of two layers

1. Superficial Papillary Layer
2. Deeper Reticular Layer

FUNCTIONS OF SKIN

Primary function of skin is protection of organs. However, it has many other important functions also.

- Protective Function
- Regulation Of Body Temperature
- Regulation Of Water And Electrolyte Balance
- Absorptive Function
- Excretory Function
- Secretory Function
- Sensory Function
- Storage Function
- Synthetic Function
- Social Affect Of Skin

Protective Function

Skin forms the covering of all the organs of the body and protects these organs from bacteria and toxic substances, mechanical blow, ultraviolet rays etc.

Regulation of Body Temperature

Skin plays an important role in the regulation of body temperature. Excess heat is lost from the body through skin by evaporation. Sweat glands of the skin play an active part in heat loss, by secreting sweat. While the lipid content of sebum prevents loss of heat from the body in cold environment.

Regulation of Water and Electrolyte Balance

Skin regulates water balance and electrolyte balance by excreting water and salts through sweat.

Absorptive Function

Skin absorbs fat-soluble substances and some ointments.

Excretory Function

Skin excretes small quantities of waste materials like urea, salts and fatty substance.

Secretory Function

Skin secretes sweat through sweat glands and sebum through sebaceous glands. By secreting sweat, skin regulates body temperature and water balance. Sebum keeps the skin smooth and moist.

Sensory Function

Skin is considered as the largest sense organ in the body. It has many nerve endings. Nerve ending in the skin allows us to feel heat, cold, touch, pleasure, pressure, and pain.

Storage Function

Skin stores fat, water, chloride and sugar. It can also store blood by the dilatation of the cutaneous blood vessels.

Synthetic Function

Vitamin D3 is synthesized in skin by the action of ultraviolet rays from sunlight on cholesterol.

Social Affect of Skin

By its colors, texture and odor, it transmit social and sexual signals to others.

TEMPERATURE REGULATION BY SKIN

The body keeps its temperature constant at about 37°C by physiological adjustments controlled by the hypothalamus (Thermostat Center) where there are neurons sensitive to changes in skin and blood temperatures.

Hypothalamus has two centers which regulate the body temperature...

1. Heat Loss Center
2. Heat Gain Center

Heat Loss Center

Heat loss center is situated in preoptic nucleus of anterior hypothalamus. Neurons in preoptic nucleus are heat-sensitive nerve cells, which are called thermoreceptors. Stimulation of preoptic nucleus results in cutaneous vasodilatation and sweating.

Heat Gain Center

Heat gain is otherwise known as heat production center. It is situated in posterior hypothalamic nucleus. Stimulation of posterior hypothalamic nucleus causes shivering.

MECHANISM OF TEMPERATURE REGULATION**WHEN BODY TEMPERATURE INCREASES**

When body temperature increases, blood temperature also increases. When blood with increased temperature passes through hypothalamus, it stimulates the thermoreceptors that bring the temperature back to normal by two mechanisms:

1. **Promotion of Heat Loss:** By increasing the secretion of sweat.
2. **Prevention of Heat Production:** By inhibiting mechanisms involved in heat production, such as shivering and metabolic reactions.

WHEN BODY TEMPERATURE DECREASES

When the body temperature decreases, it is brought back to normal by two mechanisms...

1. **Prevention Of Heat Loss:** By decrease in blood flow to skin and so the heat loss is prevented.
2. **Promotion Of Heat Production:** By increased metabolic reactions and shivering

DIGESTIVE SYSTEM

The digestive system is the collective name used to describe the alimentary canal, some accessory organs and a variety of digestive processes which take place at different levels in the canal to prepare food eaten in the diet for absorption.

ACTIVITIES OF DIGESTIVE SYSTEM

Activities in the digestive system can be grouped under five main headings...

1. **Ingestion:** This is the process of taking food into the alimentary tract.
2. **Propulsion:** This moves the contents along the alimentary tract.
3. **Digestion:** This consists of mechanical breakdown of food by (chewing), chemical digestion of food by enzymes of the digestive system.
4. **Absorption:** This is the process by which digested food substances pass through the walls of some organs of the alimentary canal into the blood and lymph capillaries for circulation round the body.
5. **Elimination:** Food substances which have been eaten but cannot be digested and absorbed are excreted by the bowel as feces.

FUNCTIONS OF DIGESTIVE SYSTEM

- Ingestion or consumption of food substances
- Breaking them into small particles
- Transport of small particles to different areas of the digestive tract
- Secretion of necessary enzymes and other substances for digestion
- Digestion of the food particles
- Absorption of the digestive products (nutrients)
- Removal of unwanted substances from the body

ORGANS OF THE DIGESTIVE SYSTEM

ALIMENTARY TRACT

This is a long tube through which food passes. It starts from mouth and terminates at the anus, and the various parts are given separate names, although structurally they are remarkably similar. The parts are...

- | | |
|-------------|-------------------|
| • Mouth | • Small Intestine |
| • Pharynx | • Large Intestine |
| • Esophagus | • Rectum |
| • Stomach | • Anal Canal |

ACCESSORY DIGESTIVE ORGANS

Accessory digestive organs are those which help primary digestive organs in the process of digestion. They consist of...

- Teeth
- Tongue
- Salivary Glands
- Pancreas
- Liver
- Gallbladder

DIGESTIVE JUICES

The digestive juices are the secretions of the digestive tract that break down food. They include saliva, gastric juice, pancreatic juice, bile, and intestinal juice. The digestive juices are secreted by different organs, vary widely in chemical composition, and play different roles in the digestive process. Each is constantly produced by the body in small amounts, but the presence of food as it passes through the digestive tract causes increased production and secretion.

- **Saliva**
- **Gastric Juice**
- **Pancreatic Juice**
- **Bile Juice**
- **Intestinal Juices**

SALIVA

Saliva is a clear watery substance secreted by the salivary glands into the mouth.

SALIVARY GLANDS

There are three pairs of salivary glands

1. Parotid Glands
2. Submandibular Glands
3. Sublingual Glands

Parotid Glands

Parotid glands are the largest of all salivary glands, situated at the side of the face just below and in front of the ear.

Submandibular Glands

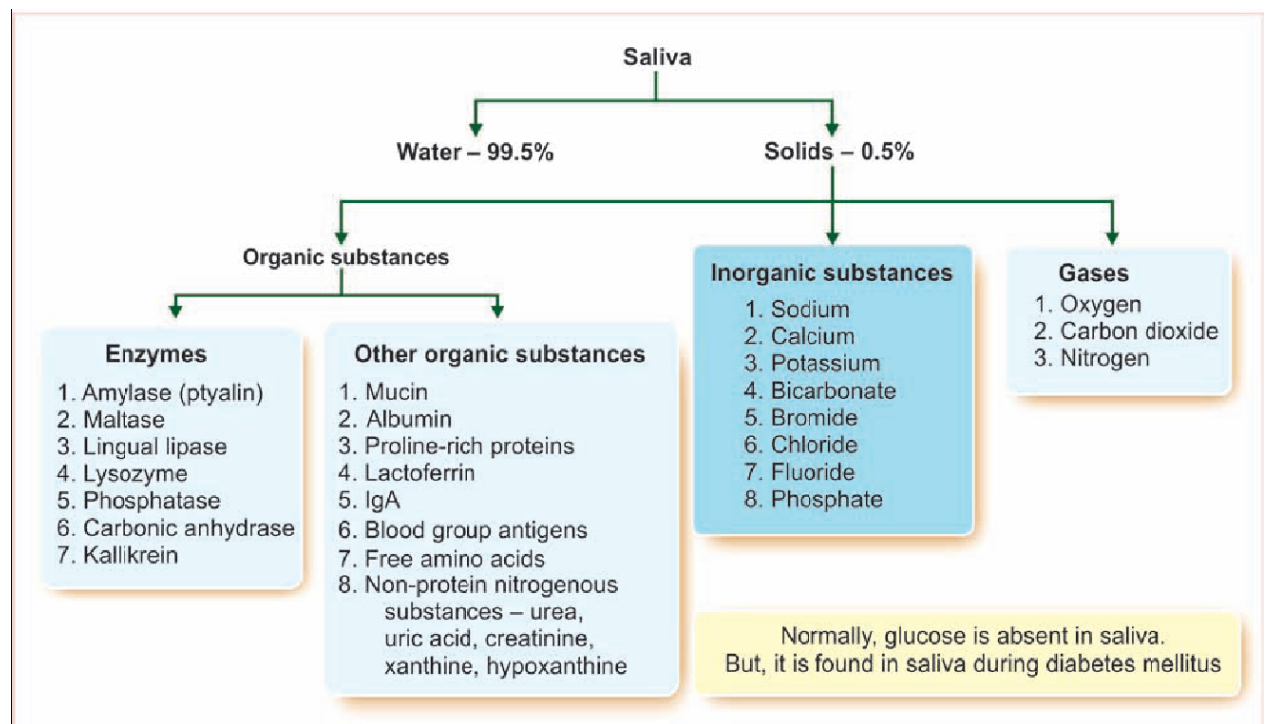
These are present on each side of the face under the angle of the jaw.

Sublingual Glands

Sublingual glands are the smallest salivary glands situated in the mucosa at the floor of the mouth.

COMPOSITION OF SALIVA

Saliva is the combined secretions from the salivary glands and the small mucus-secreting glands of the lining of the oral cavity. About 1.5 liters of saliva is produced daily and it consists of 99.5% water and 0.5% solids.



Composition of Saliva

FUNCTIONS OF SALIVA

Preparation Of Food For Swallowing

When food is taken into the mouth, it is moistened and dissolved by saliva. The mucus membrane of mouth is also moistened by saliva. It facilitates chewing.

Digestive Function

Saliva has three digestive enzymes that help in the process of digestion.

Appreciation Of Taste

Taste is a chemical sensation. By its solvent action, saliva dissolves the solid food substances, so that the dissolved substances can stimulate the taste buds. The stimulated taste buds recognize the taste.

Cleansing And Protective Functions

An adequate flow of saliva is necessary to cleanse the mouth and keep its tissues soft, moist and pliable.

Role In Speech

By moistening and lubricating soft parts of mouth and lips, saliva helps in speech. If the mouth becomes dry, articulation and pronunciation becomes difficult.

Excretory Function

Many substances, both organic and inorganic, are excreted in saliva.

Regulation Of Water Balance

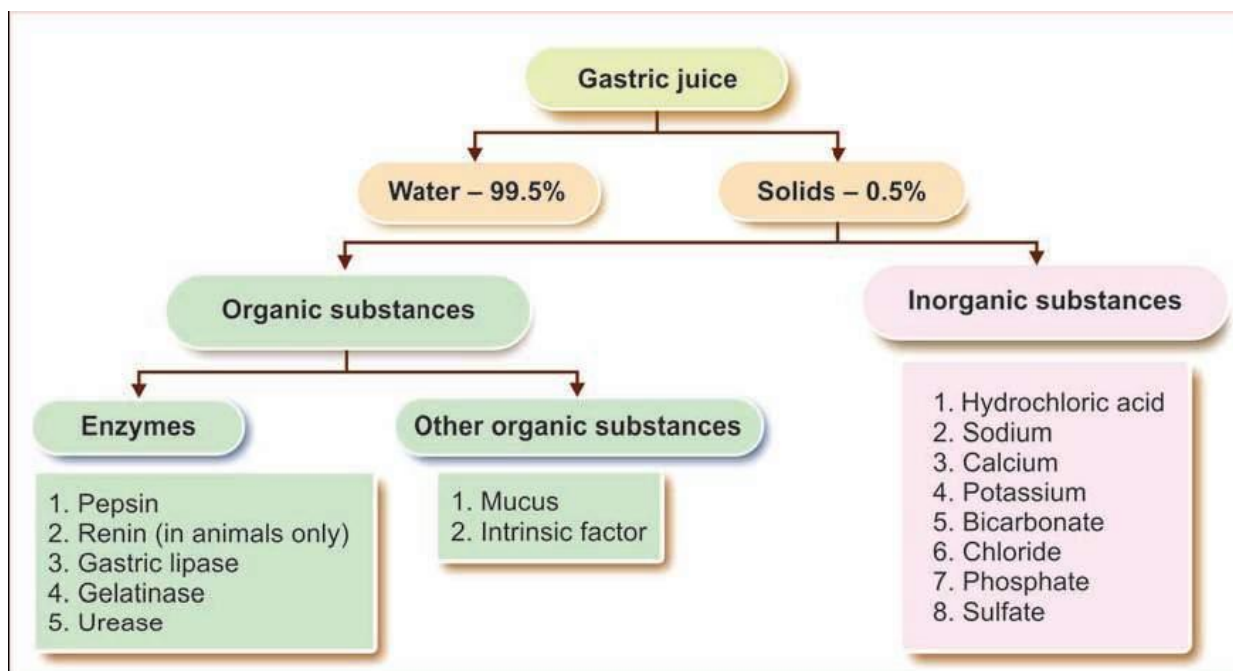
When the body water content decreases, salivary secretion also decreases. This causes dryness of the mouth and induces thirst. When water is taken, it quenches the thirst and restores the body water content.

GASTRIC JUICE

Gastric juice is a mixture of secretions from different gastric glands. About 2 liters of gastric juice are secreted daily.

COMPOSITION OF GASTRIC JUICE

Gastric juice contains 99.5% of water and 0.5% organic and inorganic substances.



Composition Of Gastric Juice

- ❖ **Water**, further liquefies the food swallowed.
- ❖ **Mucus**: it prevents mechanical injury to the stomach wall by lubricating the contents. It prevents chemical injury by acting as a barrier between the stomach wall and the corrosive (acidic) gastric juice.
- ❖ **Hydrochloric acid**: acidifies the food and stops the action of salivary amylase, kills ingested microbes, provides the acid environment needed for effective digestion by pepsins.
- ❖ **Intrinsic factor**: It is a protein which is necessary for the absorption of vitamin B12.
- ❖ **Pepsinogens**, They begin the digestion of proteins, breaking them into smaller molecules.

FUNCTIONS OF GASTRIC JUICE

Digestive Function

Gastric juice acts mainly on proteins. Proteolytic enzymes of the gastric juice are pepsin and rennin

Hemopoietic Function

Intrinsic factor of Castle, secreted by parietal cells of gastric glands plays an important role in erythropoiesis. It is necessary for the absorption of vitamin B12.

Protective Function

Mucus is a mucoprotein, secreted in stomach; it prevents mechanical injury to the stomach wall by lubricating the contents. It prevents chemical injury by acting as a barrier between the stomach wall and the corrosive (acidic) gastric juice.

Functions Of Hydrochloric Acid

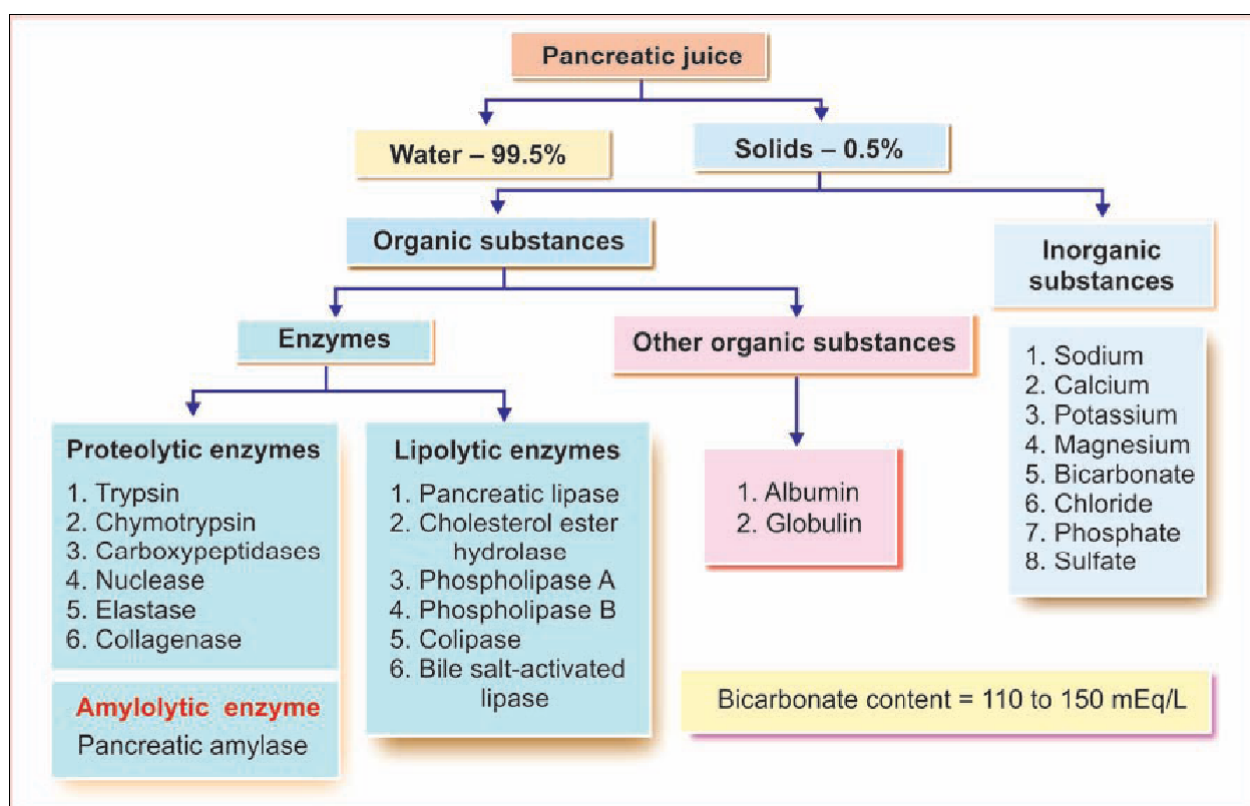
Hydrochloric acid is present in the gastric juice. It activates pepsinogen into pepsin, kills some of the bacteria entering the stomach along with food substances and provides acid medium, which is necessary for the action of hormones.

PANCREATIC JUICE

Pancreas is a dual organ having two functions, namely **endocrine function** and **exocrine function**. Endocrine function is concerned with the production of hormones. The exocrine function is concerned with the secretion of digestive juice called pancreatic juice.

COMPOSITION OF PANCREATIC JUICE

Pancreatic juice contains 99.5% of water and 0.5% of solids. The solids are the organic and inorganic substances.



Composition Of Pancreatic Juice

FUNCTIONS OF PANCREATIC JUICE

Pancreatic juice has digestive functions and neutralizing action.

Digestive Functions Of Pancreatic Juice

Pancreatic juice plays an important role in the digestion of proteins and lipids. It also has mild digestive action on carbohydrates.

Neutralizing Action Of Pancreatic Juice

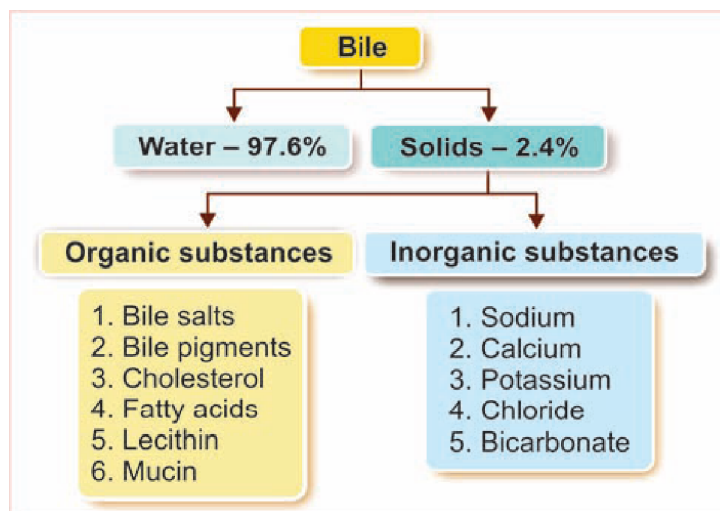
When acid chyme enters intestine from stomach, pancreatic juice with large quantity of bicarbonate is released into intestine. Presence of large quantity of bicarbonate ions makes the pancreatic juice highly alkaline. This alkaline pancreatic juice neutralizes acidity of chyme in the intestine. Neutralizing action is an important function of pancreatic juice because it protects the intestine from the destructive action of acid in the chyme.

BILE JUICE

Bile is a thick alkaline fluid that is secreted by the liver and stored in the gall bladder, from which it is ejected intermittently into the duodenum via the common bile duct.

COMPOSITION OF BILE

Bile contains 97.6% of water and 2.4% of solids. Solids include organic and inorganic substances.



Composition Of Bile

FUNCTIONS OF BILE

Digestive and Absorptive Function

Bile salts are required for digestion and absorption of fats in the intestine.

Excretory Functions

Bile pigments are the major excretory products of the bile. Other substances excreted in bile are...

- Heavy Metals Like Copper And Iron
- Some Bacteria Like Typhoid Bacteria
- Some Toxins
- Cholesterol
- Lecithin
- Alkaline Phosphatase

Laxative Action

Bile salts act as laxatives by stimulating peristaltic movements of the intestine.

Antiseptic Action

Bile inhibits the growth of certain bacteria in the lumen of intestine by its natural detergent action.

Maintenance of pH in Gastrointestinal Tract

As bile is highly alkaline, it neutralizes the acid chyme which enters the intestine from stomach. Thus, an optimum pH is maintained for the action of digestive enzymes.

Prevention of Gallstone Formation

Bile plays important role in prevention of gall stone formation.

Lubrication Function

The mucin in bile acts as a lubricant for the chyme in intestine.

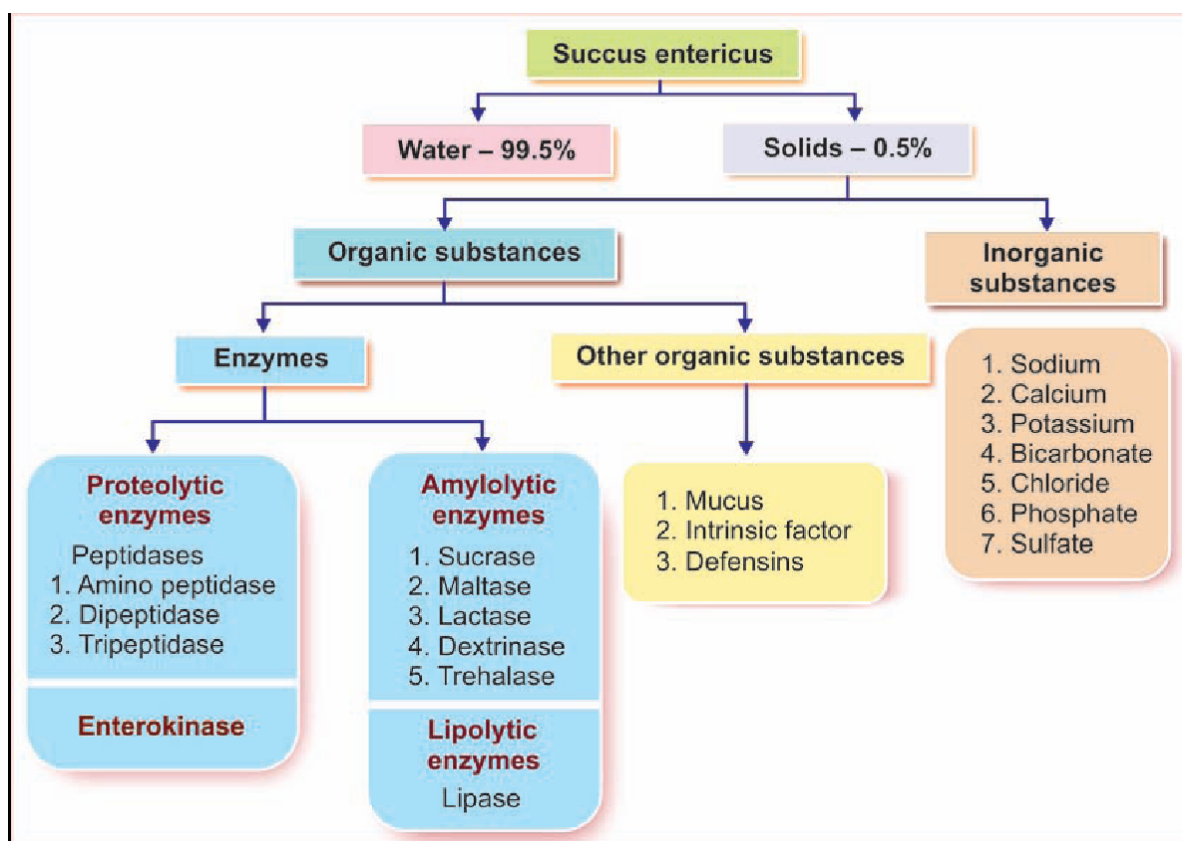
INTESTINAL JUICES

SMALL INTESTINE JUICE

Secretion from small intestine is called succus entericus.

COMPOSITION OF SUCCUS ENTERICUS

Succus entericus contains water (99.5%) and solids (0.5%). Solids include organic and inorganic substances.

**Composition Of Succus Entericus****FUNCTIONS OF SUCCUS ENTERICUS****Digestive Function**

Enzymes of succus entericus act on the partially digested food and convert them into final digestive products.

Protective Function

Mucus present in the succus entericus protects the intestinal wall from the acid chyme, which enters the intestine from stomach; thereby it prevents the intestinal ulcer.

Activator Function

Enterokinase present in intestinal juice activates trypsinogen into trypsin. Trypsin, in turn activates other enzymes

Hemopoietic Function

Intrinsic factor of Castle present in the intestine plays an important role in erythropoiesis. It is necessary for the absorption of vitamin B12.

Hydrolytic Process

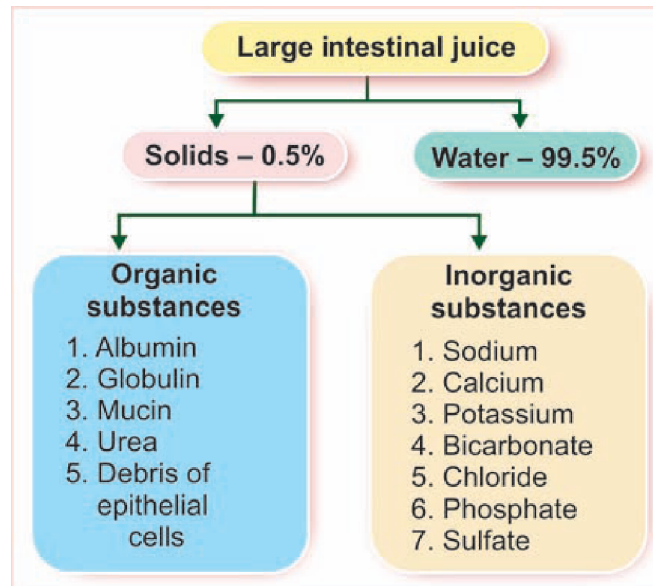
Intestinal juice helps in all the enzymatic reactions of digestion.

LARGE INTESTINE JUICE

Large intestinal juice is a watery fluid with pH of 8.0.

COMPOSITION OF LARGE INTESTINAL JUICE

Large intestinal juice contains 99.5% of water and 0.5% of solids. Digestive enzymes are absent and concentration of bicarbonate is high in large intestinal juice.



Composition Of Large Intestinal Juice

FUNCTIONS OF LARGE INTESTINAL JUICE

Neutralization of Acids

Strong acids formed by bacterial action in large intestine are neutralized by the alkaline nature of large intestinal juice. The alkalinity of this juice is mainly due to the presence of large quantity of bicarbonate.

Lubrication Activity

Mucin present in the secretion of large intestine lubricates the mucosa of large intestine and the bowel contents, so that, the movement of bowel is facilitated. Mucin also protects the mucus membrane of large intestine by preventing the damage caused by mechanical injury or chemical substances.

MOVEMENTS OF THE STOMACH AND INTESTINES

MOVEMENTS OF STOMACH

Activities of smooth muscles of stomach increase during gastric digestion (when stomach is filled with food) and when the stomach is empty.

Types of movements in stomach

1. Hunger Contractions
2. Receptive Relaxation
3. Peristalsis Waves

HUNGER CONTRACTIONS

Hunger contractions are the movements of empty stomach. These contractions are related to the sensations of hunger. Hunger contractions are the peristaltic waves superimposed over the contractions of gastric smooth muscle as a whole.

Hunger contractions are of three types...

1. **Type I Hunger Contractions:** Type I hunger contractions are the first contractions to appear in the empty stomach, when the tone of the gastric muscles is low.
2. **Type II Hunger Contractions:** Type II hunger contractions appear when the tone of stomach is stronger. Tone increases in stomach if food intake is postponed, even after the appearance of the type I contractions.
3. **Type III Hunger Contractions:** Type III hunger contractions are like incomplete tetanus. These contractions appear when the hunger becomes severe and the tone increases to a great extent.

RECEPTIVE RELAXATION

Receptive relaxation is the relaxation of the upper portion of the stomach when bolus enters the stomach from esophagus. Receptive relaxation is the relaxation of the upper portion of the stomach when bolus enters the stomach from esophagus. This process is called accommodation of stomach.

PERISTALSIS WAVES

When food enters the stomach, the peristaltic contraction or peristaltic wave appears with a frequency of 3 per minute. It starts from the lower part of the body of stomach, passes through the pylorus till the pyloric sphincter.

Some of the waves disappear before reaching the sphincter. Each peristaltic wave takes about one minute to travel from the point of origin to the point of ending. This type of peristaltic contraction is called digestive peristalsis because it is responsible for the grinding of food particles and mixing them with gastric juice for digestive activities.

MOVEMENTS OF THE INTESTINES**MOVEMENTS OF SMALL INTESTINE**

Movements of small intestine are essential for mixing the chyme with digestive juices, propulsion of food and absorption.

TYPES OF MOVEMENTS OF SMALL INTESTINE

Movements of small intestine are of four types...

1. Mixing Movements
2. Propulsive Movements
3. Migrating Motor Complex (Peristalsis In Fasting)
4. Movements Of Villi

MIXING MOVEMENTS

Mixing movements of small intestine are responsible for proper mixing of chyme with digestive juices such as pancreatic juice, bile and intestinal juice.

PROPULSIVE MOVEMENTS

Propulsive movements are the movements of small intestine which push the chyme in the aboral direction through intestine.

MIGRATING MOTOR COMPLEX (PERISTALSIS IN FASTING)

Migrating motor complex is a type of peristaltic contraction, which occurs in stomach and small intestine during the periods of fasting for several hours. It is different from the regular peristalsis because, a large portion of stomach or intestine is involved in the contraction. The contraction extends to about 20 to 30 cm of stomach or intestine.

MOVEMENTS OF VILLI

Intestinal villi also show movements simultaneously along with intestinal movements. Movements of villi are shortening, which occur alternatively and help in emptying lymph from the central lacteal into the lymphatic system.

MOVEMENTS OF LARGE INTESTINE

Usually, the large intestine shows sluggish movements. Still, these movements are important for mixing, propulsive and absorptive functions.

TYPES OF MOVEMENTS OF LARGE INTESTINE

Movements of large intestine are of two types...

1. Mixing Movements: Segmentation Contractions
2. Propulsive Movements: Mass Peristalsis

MIXING MOVEMENTS – SEGMENTATION CONTRACTIONS

Large circular constrictions, which appear in the colon, are called mixing segmentation contractions. These contractions occur at regular distance in colon. Length of the portion of colon involved in each contraction is nearly about 2.5 cm.

PROPULSIVE MOVEMENTS – MASS PERISTALSIS

Mass peristalsis or mass movement propels the feces from colon towards anus. Usually, this movement occurs only a few times every day. Duration of mass movement is about 10 minutes in the morning before or after breakfast. This is because of the neurogenic factors like gastrocolic reflex and parasympathetic stimulation.

FUNCTIONS OF LIVER AND GALL BLADDER**LIVER**

Liver is the largest gland in the body it weighs about 1.5kg (3-4 lb) lies immediately under the diaphragm and occupies most of the right hypochondrium and part of the epigastrium.

FUNCTIONS OF LIVER

- Liver cells detoxify the various substances.
- Liver cells secrete about a pint of bile in a day.
- Liver cells produce plasma proteins and serves as a site of hematopoiesis (process of blood cell production and maturation) during fetal development.
- Liver cells store several substances e.g. iron and vitamins A, B12 and D.
- Liver cells carry on numerous important steps in the metabolism of all three kind of food i.e. proteins carbohydrates and lipids.

GALL BLADDER

Gallbladder is pear shaped sac from 7-10 cm (3-4 inches) long and 3cm is broad at its widest part. It can hold 30-50ml of bile it lies on the undersurface of the liver and is attached there by areolar connective tissue.

FUNCTIONS OF THE GALLBLADDER

The main function of the gallbladder is to store bile, or gall. The gallbladder is part of the biliary system and serves as a reservoir for bile, which is produced by the liver. The liver produces the bile and then it flows through the bile ducts into the gallbladder, when digestion occurs in the stomach and intestines, the gallbladder contracts, ejecting the concentrated bile into the duodenum. Bile is highly alkaline; it neutralizes the acid chyme which enters the intestine from stomach. Thus, an optimum pH is maintained for the action of digestive enzymes.

URINARY SYSTEM

The urinary system is one of the excretory systems of the body. It is a set of organs producing urine in human beings. It consists of the following structures...

- **2-Kidneys**
- **2-Ureters**
- **1-Urinary Bladder**
- **1-Urethra**

The urinary system plays a vital part in maintaining homeostasis of water and electrolyte concentrations within the body.

KIDNEYS

Kidneys are bean-shaped organs. These are a pair of excretory organs situated on the posterior abdominal wall on each side of the vertebral column behind the peritoneum. Nephron is the basic structural and functional unit of the kidney which is capable of forming urine. The kidneys produce urine that contains metabolic waste products, including the nitrogenous compounds urea and uric acid, excess ions and some drugs.

The main functions of the kidneys are...

- Formation and secretion of urine
- Production and secretion of erythropoietin, the hormone responsible for controlling the rate of formation of red blood cells
- Production and secretion of renin, an important enzyme in the control of blood pressure

URETERS

The ureters are the tubes that convey urine from the kidneys to the urinary bladder.

URINARY BLADDER

The urinary bladder is a reservoir for urine. Its size and position vary, depending on the amount of urine it contains.

URETHRA

The urethra is a canal extending from the neck of the bladder to the exterior, at the external urethral orifice. Its length differs in the male and in the female.

URINE FORMATION

Urine formation is a blood cleansing function. Normally, about 1,300 mL of blood (26% of cardiac output) enters the kidneys. Kidneys excrete the unwanted substances along with water from the blood as urine. Normal urinary output is 1 L/day to 1.5 L/day.

PROCESSES OF URINE FORMATION

Urine formation takes place in three processes

1. **Glomerular Filtration**
2. **Tubular Reabsorption**
3. **Tubular Secretion**

Glomerular Filtration

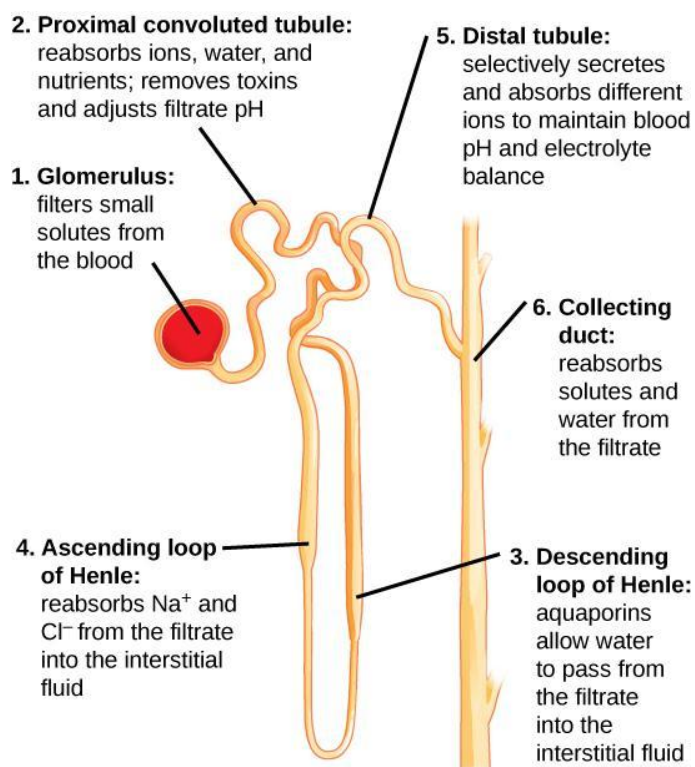
Glomerular filtration is the process by which the blood is filtered while passing through the glomerular capillaries by filtration membrane. It is the first process of urine formation. Plasma is filtered in glomeruli and the substances reach the renal tubules along with water as filtrate.

Tubular Reabsorption

Tubular reabsorption is the process by which water and other substances are transported from renal tubules back to the blood. When the glomerular filtrate flows through the tubular portion of nephron, both quantitative and qualitative changes occur. Large quantity of water (more than 99%), electrolytes and other substances are reabsorbed by the tubular epithelial cells. The 99% of filtrate is reabsorbed in different segments of renal tubules.

Tubular Secretion

Tubular secretion is the process by which the substances are transported from blood into renal tubules. It is also called tubular excretion. Some substances are transported from blood into the renal tubule. With all these changes, the filtrate becomes urine.



Structure And Function Of Nephron

COMPOSITION OF URINE

Urine is composed mostly of water containing organic wastes as well as some salts. The composition of urine can vary according to diet, time of day, and diseases. Normal constituents of urine or Composition of urine are as follow

Organic Substances

- Urea
- Uric Acid
- Creatine
- Creatinine
- Ammonia
- Oxalic Acid
- Amino Acid
- Vitamins
- Enzymes
- Hormones

Inorganic Substances

- Sodium
- Chloride
- Phosphate
- Sulphate
- Potassium
- Calcium
- Magnesium
- Iodine

Abnormal Constituents of Urine

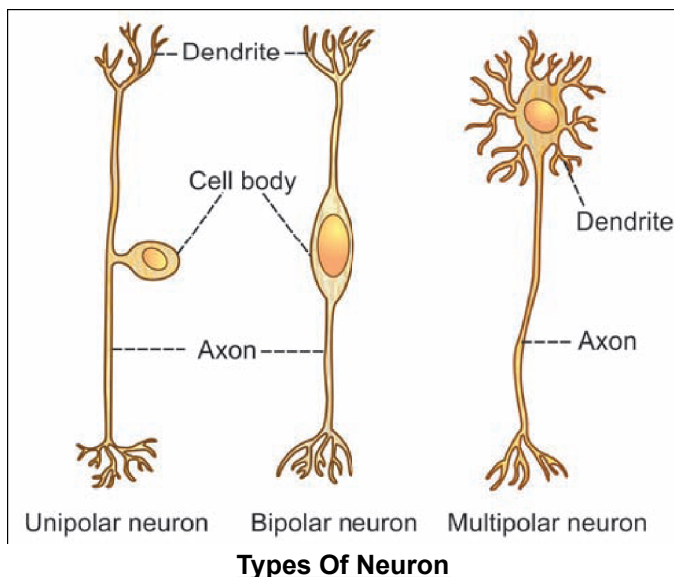
- Proteins
- Sugar
- RBCs, WBCs
- Ketone Bodies
- Indicant
- Pigments
- Casts
- Pus
- Renal Calculi
- Microbes

GENERAL INTRODUCTION TO NERVOUS SYSTEM

NEURON

Neuron or nerve cell is defined as the structural and functional unit of nervous system. Neuron is similar to any other cell in the body, having nucleus and all the organelles in cytoplasm. However, it is different from other cells by two ways

1. Neuron has branches or processes called axon and dendrites
2. Neuron does not have centrosome. So, it cannot undergo division



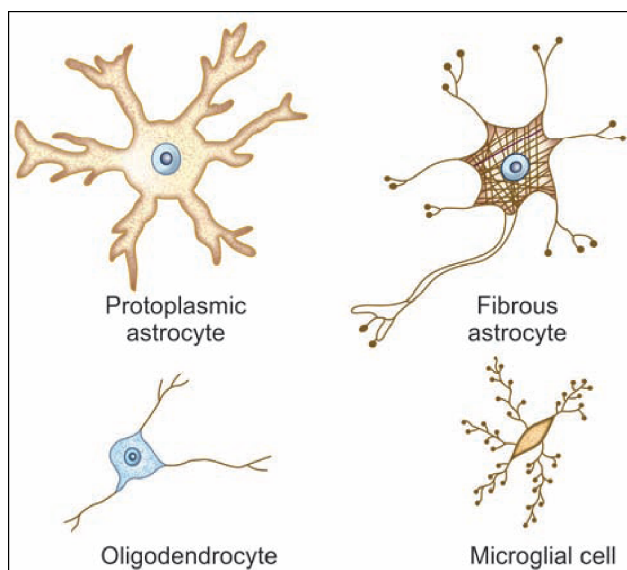
CLASSIFICATION OF NEURONS

On the basis of function, nerve cells are classified into two types

1. **Motor Or Efferent Neurons:** Efferent neurons carry nerve impulse from CNS to the effector organs
2. **Sensory Or Afferent Neurons:** Afferent neurons of ANS bring nerve impulse back to CNS from periphery

NEUROGLIA

Neuroglia or glia (glia = glue) is the supporting cell of the nervous system. Neuroglia cells are non-excitabile and do not transmit nerve impulse (action potential). So, these cells are also called non-neural cells or glial cells.



Neuroglia Cells In CNS

RECEPTOR

Pharmacology defines a receptor as any biological molecule to which a drug binds and produces a measurable response. Thus, enzymes and structural protein can be considered to be pharmacological receptors.

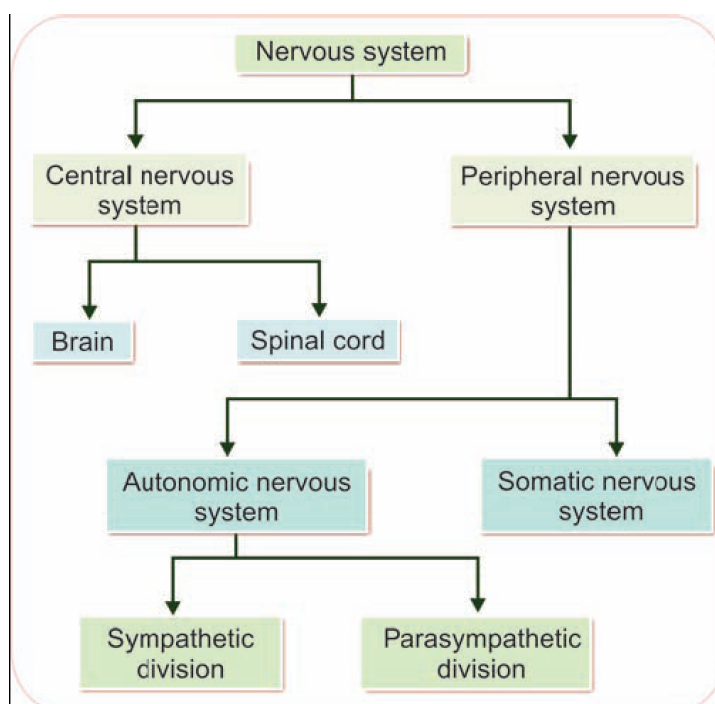
NEUROTRANSMITTER

Neurotransmitter is a chemical substance that acts as a mediator for the transmission of nerve impulse from one neuron to another neuron through a synapse.

NERVOUS SYSTEM

Nervous system controls all the activities of the body. It is quicker than other control system in the body. Primarily, nervous system is divided into two parts...

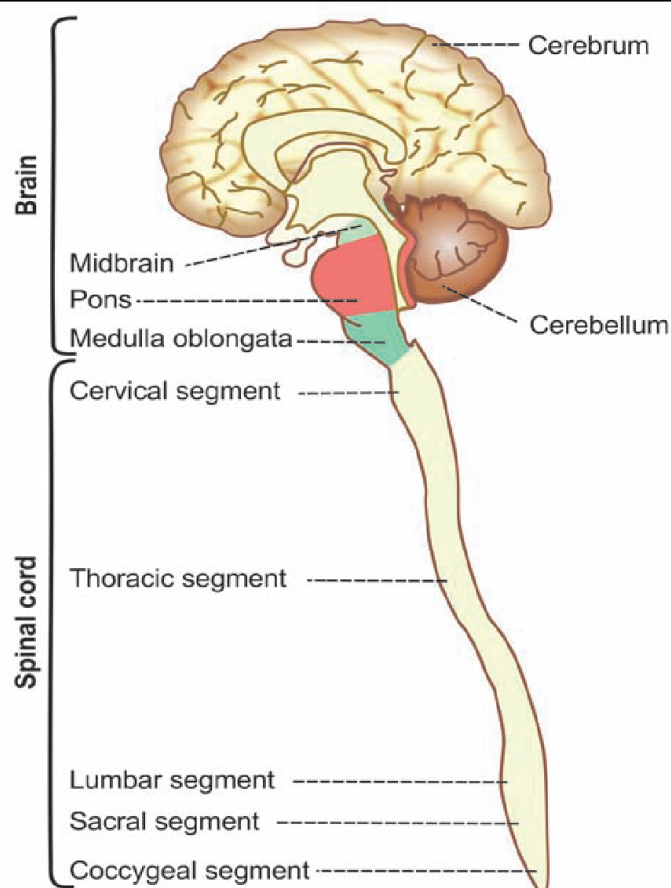
1. **Central Nervous System**
2. **Peripheral Nervous System**



Organization Of Nervous System

CENTRAL NERVOUS SYSTEM

Central nervous system (CNS) includes brain and spinal cord. It is formed by neurons and supporting cells called neuroglia.



Parts Of Central Nervous System

PERIPHERAL NERVOUS SYSTEM

Peripheral nervous system (PNS) is formed by neurons and their processes present in all regions of the body. It consists of cranial nerves, arising from brain and spinal nerves, arising from the spinal cord.

Peripheral Nervous System Divided Into Two Subdivisions

- Somatic Nervous System
- Autonomic Nervous System

SOMATIC NERVOUS SYSTEM

Somatic nervous system is concerned with somatic functions. It includes the nerves supplying the skeletal muscles. Somatic nervous system is responsible for muscular activities and movements of the body.

AUTONOMIC NERVOUS SYSTEM

Autonomic nervous system is concerned with regulation of visceral or vegetative functions. So, it is otherwise called vegetative or involuntary nervous system.

Introductory knowledge of structure and functions of the special senses

Special Senses

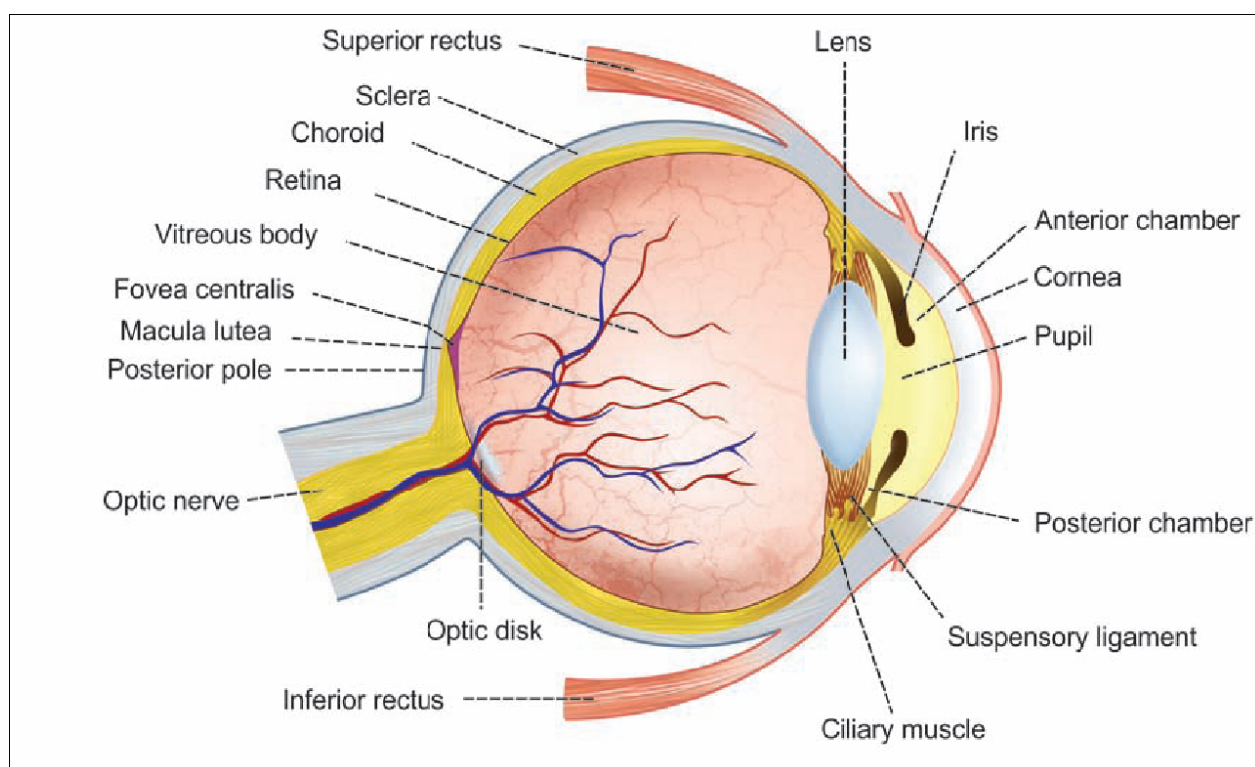
This is a special type of faculty by which the conditions or properties of things are perceived. There are five special types of senses, these are

1. **Sensation of Vision**
2. **Sensation of Hearing**
3. **Sensation of Taste**
4. **Sensation of Smell**
5. **Sensation of Touch**

SENSATION OF VISION

Eye

Eye is the organ of vision among all the sensory organs of our body. The eyes act as optical instrument, sensory receptor organ, and also our windows on the world.



STRUCTURE OF EYE

Human eyeball is approximately globe shaped, with a diameter of about 24 mm. Major parts of eye are as follow...

Eyeball

Eyeball is made up of two segments, an anterior part and a posterior part. Anterior part is small and forms one sixth of the eyeball. Posterior part is larger and forms five sixth of the eyeball.

Orbital Cavity

Eyeball is situated in a bony cavity known as orbital cavity or eye socket.

Eyelids

Eyelids protect the eyeball from foreign particles coming in contact with its surface and cutoff the light during sleep. Eyelids are opened and closed voluntarily, as well as by reflex action.

Conjunctiva

Conjunctiva is a thin mucus membrane, which covers the exposed part of eye.

Lacrimal Gland And Tear

The lacrimal glands are exocrine glands. The glands secrete tears composed of water, mineral salts, and antibodies etc.

Lens

Lens of the eyeball is crystalline in nature. It is situated behind the pupil. It is a biconvex, transparent and elastic structure. It is avascular and receives its nutrition mainly from the aqueous humor. Lens refracts light rays and helps to focus the image of the objects on retina.

Sclera

Sclera is the tough white fibrous outer layer of eyeball.

Cornea

Cornea is the transparent convex anterior portion of the outer layer of eyeball, which covers the iris and pupil.

Iris

Iris is a thin colored curtain-like structure of eyeball, located in front of the lens.

Pupil

Pupil is the circular opening in the centre of the iris, through which light passes into the lens of the eye.

FUNCTION OF EYE

The major function of the eye is to work with the brain to provide us with vision.

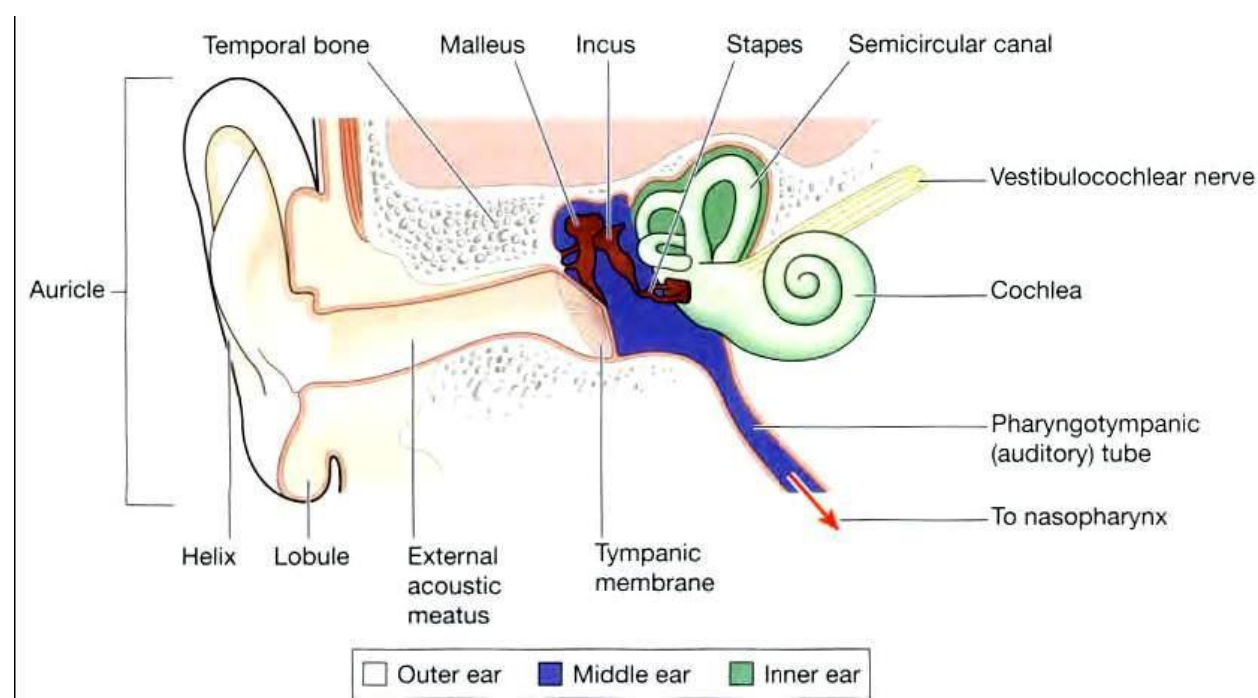
SENSATION OF HEARING

The ear is the organ of hearing and balance. Sound waves travel through the outer ear, are modulated by the middle ear, and are transmitted to a nerve in the inner ear. This nerve transmits information to the brain, where it is registered as sound. Ears provide balance, when moving or stationary, is also a central function of the ear.

STRUCTURE OF EAR

The ear is divided into three distinct parts

1. **Outer Ear**
2. **Middle Ear**
3. **Inner Ear**



THE PARTS OF THE EAR

Outer Ear

The outer ear consists of the auricle (pinna) and the external acoustic meatus.

Middle Ear

This is an irregular-shaped air-filled cavity within the petrous portion of the temporal bone. The cavity, its contents and the air sacs which open out of it are lined with either simple squamous or cuboidal epithelium.

Inner Ear

The inner (internal) ear contains the organs of hearing and balance.

FUNCTIONS OF EAR

Hearing

Major function of ears is hearing. Sound waves travel through the outer ear, are modulated by the middle ear, and are transmitted to a nerve in the inner ear. This nerve transmits information to the brain, where it is recognized as sound.

Balance

Ears provide balance, when moving or stationary, is also a central function of the ear. The ear facilitates two types of balance: static balance, which allows a person to feel the effects of gravity, and dynamic balance, which allows a person to sense acceleration.

SENSATION OF TASTE

Taste is a chemical sense; its sensory modality is mediated by chemoreceptors of tongue mouth and pharynx. Sense organs for taste or gustatory sensation are the taste buds. Taste buds are ovoid bodies with a diameter of 50 μ to 70 μ .

STRUCTURE OF TASTE BUD

Taste bud is a bundle of taste receptor cells, with supporting cells embedded in the epithelial covering of the papillae. Each taste bud contains about 40 cells, which are the modified epithelial cells.

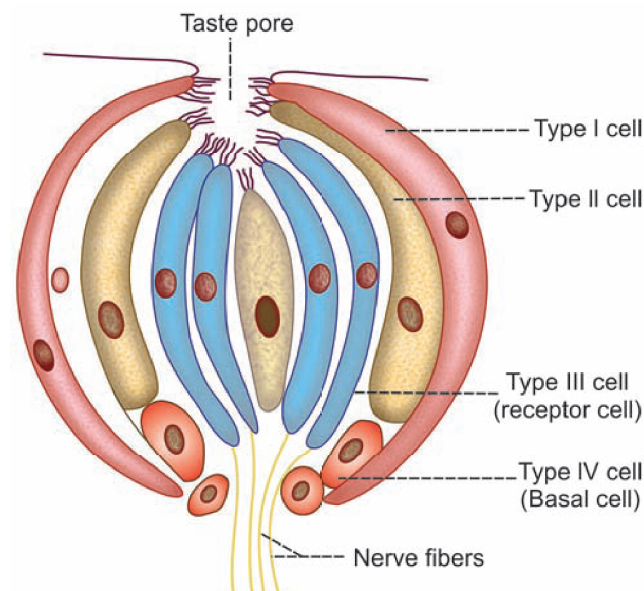
Cells of taste bud are divided into four groups...

1. Type I Cells Or Sustentacular Cells
2. Type II Cells
3. Type III Cells
4. Type IV Cells or Basal Cells.

Type I cells and type IV cells are supporting cells. Type III cells are the taste receptor cells. Function of type II cell is unknown.

Taste Receptor

Generally, taste receptor is a G-protein coupled receptor. However, several other receptors are also involved in taste sensation.



Cells Of Taste Bud

Primary Taste Sensations

Primary or fundamental taste sensations are divided into five types...

1. Sweet
2. Salt
3. Sour
4. Bitter
5. Umami (any taste which is delicious and tasty)

SENSATION OF SMELL

Nasal cavity is the organ of sensation of smell. The nasal cavity has a dual function, a passageway for respiration and sense of smell.

Olfactory nerves

These are the sensory nerves of smell.

Receptors of Smell

The olfactory receptor cells are located high in the roof of the nasal cavity in the specialized area's of the nasal mucosa called olfactory epithelium. Each nostril contains a small patch of pseudostratified columnar olfactory epithelium.

Mechanism Of Odor

There are two important theories which explain the excitation of olfactory cells.

Physical Theory

According to this theory the physical shapes of odorant molecules determine and stimulate the olfactory cells.

Chemical Theory

According to this theory the odorant molecules bind chemically to specific protein receptors in the membrane of olfactory cilia.

SENSATION OF TOUCH

Touch is considered one of the five traditional senses, the impression of touch is formed from several modalities including pressure, skin stretch, vibration and temperature.

SKIN AND TOUCH

Our skin acts as the protective barrier between our internal body systems and the outside world. Its ability to perceive touch sensations gives our brains a wealth of information about the environment around us,

such as temperature, pain, and pressure. Without our sense of touch, it would be very hard to get around in this world! We wouldn't feel our feet hitting the floor when we walked

SKIN ABILITY To SENSE TOUCH

Our sense of touch is controlled by a huge network of nerve endings and touch receptors in the skin known as the somatosensory system. This system is responsible for all the sensations we feel e.g. cold, hot, smooth, rough, pressure, tickle, itch, pain, vibrations, and more. Within the somatosensory system, there are four main types of receptors: mechanoreceptors, thermoreceptors, pain receptors, and proprioceptors.

Mechanoreceptors

These receptors perceive sensations such as pressure, vibrations, and texture.

Thermoreceptors

As their name suggests, these receptors perceive sensations related to the temperature of objects the skin feels.

Pain Receptors

These receptors detect pain or stimuli that can or does cause damage to the skin and other tissues of the body.

Proprioceptors

These receptors sense the position of the different parts of the body in relation to each other and the surrounding environment.

HORMONES

All the physiological activities are regulated by two major systems in the body

1. **Nervous System**
2. **Endocrine System**

These two systems interact with one another and regulate the body functions.

ENDOCRINE SYSTEM

The endocrine system is the system of glands, each of which secretes different types of hormone directly into the bloodstream to regulate the body. The endocrine system does not include exocrine glands such as salivary glands, sweat glands and glands within the gastrointestinal tract.

CHEMICAL MESSENGERS

The chemical messengers are the substances involved in cell signaling, these messengers are mainly secreted from endocrine glands.

Some chemical messengers are secreted by nerve endings and the cells of several other tissues. Generally the chemical messengers are classified into two types

- **Classical Hormones**
- **Local Hormones**

(Classical hormones secreted by endocrine glands)

(Local hormones secreted from other tissues)

ENDOCRINE GLANDS

Endocrine glands are glands, which synthesize and release the classical hormones into the blood. The endocrine glands are also called ductless glands because the hormones secreted by them are released directly into the blood without any duct.

These hormones are transported by blood to the target organs or tissues in different parts of the body where the actions are executed.

THE MAIN ENDOCRINE GLANDS INCLUDE

- | | |
|---------------------|----------------------------|
| • Pineal Gland | • Adrenal Gland |
| • Pituitary Gland | • Pancreas |
| • Thyroid Gland | • Ovaries (in female only) |
| • Parathyroid Gland | • Testes (in male only) |

HORMONES INTRODUCTION

These are chemical substances released by a cell or a gland into the bloodstream and have a physiological control effect on other cells of the body.

Some important hormones are growth hormone (GH), Testosterone, Estrogen, Progesterone, Oxytocin, Calcitonin, Aldosterone, Cortisol, and Insulin. Or

Hormones are the chemical messengers of the body. They are defined as organic substances secreted into blood stream to control the metabolic and biological activities. These hormones are involved in transmission of information from one tissue to another and from cell to cell.

These substances are produced in small amounts by various endocrine (ductless) glands in the body. They are delivered directly to the blood in minute quantities and are carried by the blood to various target organs where these exert physiological effect and control metabolic activities. Thus frequently their site of action is away from their origin.

CLASSIFICATION OF HORMONES

1. Based on the site of production/ accumulation
2. Based on the chemical nature

CLASSIFICATION OF HORMONES BASED ON THE SITE OF PRODUCTION/ ACCUMULATION

HORMONES OF PITUITARY GLANDS

HORMONES OF ANTERIOR PITUITARY GLANDS

- Growth hormone
- Thyroid stimulating hormone

HORMONES OF POSTERIOR PITUITARY GLANDS

- Oxytocin hormone
- Antidiuretic hormone (ADH)

HORMONES OF THYROID GLANDS

- Tri-iodothyronine (T3)
- Tetraiodothyronine (T4)
- Calcitonin

HORMONES OF PARATHYROID GLANDS

- Parathormone (PTH)

HORMONES OF ADRENAL GLAND

- Aldosterone hormone
- Cortisol hormone

HORMONES OF OVARY GLAND

- Estrogen hormone
- Progesterone hormone

HORMONES OF TESTIS

- Testosterone hormone
- Dihydrotestosterone hormone

HORMONE OF PANCREAS

- Insulin

CLASSIFICATION OF HORMONES BASED ON THE CHEMICAL NATURE

Chemically, most hormones belong to one of three major groups...

1. **Steroid Hormones**
2. **Protein Hormones**
3. **Derivative of the Amino Acid Called Tyrosine**

STEROID HORMONES

These are hormones formed from cholesterol or its derivatives, e.g. testosterone, aldosterone, estrogen, progesterone.

Steroid hormones help control metabolism, inflammation, immune functions, salt and water balance, development of sexual characteristics.

PROTEIN HORMONES

These are large or small peptide, e.g. growth hormone, oxytocin, insulin. Several important peptide hormones are secreted from the pituitary gland.

DERIVATIVE OF THE AMINO ACID CALLED TYROSINE

These are derivatives of amino acid, e.g. dopamine, adrenaline.

HORMONAL ACTIONS

Hormone does not act directly on the cellular structures. First the hormone combines with transmembrane (transmembrane existing or occurring across a cell membrane) receptors present on the target cells and form a hormone-receptor complex. This hormone-receptor complex induces various changes or reactions in the target cells.

The hormones receptors are situated either in cell membrane, cytoplasm or nucleus of the cells.

Cell Membrane

Receptors of protein hormones are situated in the cell membrane.

Cytoplasm

Receptors of steroid hormones are situated in cytoplasm of target cells.

Nucleus

Receptors of the thyroid hormones are in the nucleus of the cell.

Generally when a hormone is secreted in excess, the number of receptors of that hormone decreases this process is called down-regulation. During the deficiency of hormones, the number of receptors increases which is called up-regulation.

Proteins and peptides cannot enter the cell and so act via cell membrane receptors, producing their effects by 'second messengers', which are activated in the cell as soon as the hormone binds to the receptor. Thus peptide hormones can produce quite rapid responses. Steroid and thyroid hormones, by contrast, can enter the cell and bind to intracellular receptors, producing their effects by stimulating the production of new proteins. There is therefore a relatively long lag period before the response to these hormones is seen.

GROWTH HORMONE (GH)

Growth hormone (GH) is a peptide hormone that stimulates growth, cell reproduction and regeneration in humans and other animals. Growth hormone is a 191-amino acid, single-chain polypeptide that is synthesized, stored, and secreted by anterior pituitary gland. Its half life is about 20 minutes.

NORMAL FUNCTIONS OF GH

Effects of growth hormone on the tissues of the body can generally be described as anabolic (building up). Like most other protein hormones, GH acts by interacting with a specific receptor on the surface of cells. Increased height during childhood is the most widely known effect of GH.

EFFECT ON PROTEIN METABOLISM

Growth hormone has predominately anabolic effects on skeletal and cardiac muscles. It stimulates the synthesis of protein, RNA, DNA.

It promotes amino acid entry into cells.

It decreases the catabolism of protein because growth hormone mobilizes free fatty acids to supply energy.

EFFECTS ON CARBOHYDRATE METABOLISM

Growth hormone is one of an important chemical substance that maintains blood glucose within a normal range. Growth hormone is often said to have anti-insulin activity

EFFECTS ON FAT METABOLISM

Growth hormone enhances the utilization of fat by stimulating triglyceride breakdown and oxidation in adipose tissues.

EFFECTS ON INORGANIC METABOLISM

Growth hormone increases the retention of the phosphorus and calcium. It also causes the retention of sodium, potassium, and magnesium.

EFFECTS ON BONE, CARTILAGE, AND SOFT TISSUES

- It acts on cartilage and bone to stimulate the growth.
- It increases the deposition of connective tissue.
- It increases the thickness of skin.
- It increases the growth of important organs of the body like liver and kidney etc.

- It increases milk secretion in lactating animals.

VASOPRESSIN/ ANTIDIURETIC HORMONE (ADH)

The Antidiuretic hormone is the hormone of the posterior pituitary gland. It prevents excessive urine production. ADH is a polypeptide, containing 9 amino acids. Its half life is 18-20 minutes.

Vasopressin is responsible for regulating the body's retention of water by acting to increase water absorption in the collecting ducts of the kidney nephron.

It increases the permeability of the collecting tubules and ducts to water, increasing water absorption from the lumen of the collecting tubules and ducts.

ADH can also raise blood pressure by bringing about constriction of arterioles. It causes the contraction of all smooth muscles in the body such as the GIT, Bile Duct, and Uterus.

OXYTOCIN (OT)

Oxytocin (OT) is traditionally thought of as a 'female' hormone due to its role in milk ejection. However, OT is recognized as having roles in male reproduction. It is secreted in both males and females. Oxytocin is best known for its roles in sexual reproduction, in particular during and after childbirth.

This is a hormone of the posterior pituitary gland. It is polypeptide containing 8 amino acids. Its half-life is about 6 minutes.

ACTION IN FEMALES

In females, oxytocin acts on mammary glands and uterus. It causes ejection of milk from the mammary glands.

Oxytocin causes contraction of uterus and helps in the expulsion of fetus. It is released in large quantity just prior to delivery.

ACTION IN MALES

In male, the release of oxytocin increases during ejaculation. It facilitates release of sperm into urethra by causing contraction of smooth muscles fibers in reproductive tract.

INSULIN

Insulin is a peptide hormone, produced by beta cells of the pancreas, which acts to lower the blood glucose level, regulating carbohydrate and fat metabolism in the body.

Chemical Nature

Insulin is small soluble protein containing 51 amino acids.

EFFECTS OF INSULIN

EFFECTS OF INSULIN ON CARBOHYDRATE METABOLISM

- It increases the entry of glucose into cells by stimulating the process of facilitated diffusion, especially in muscles, adipose tissue, the heart, smooth muscles, of the uterus by activating glucokinase. But on the other hand insulin does not facilitate glucose entry into the brain and RBCs.
- It increases utilization of glucose for energy.
- It increases glycogen storage in cells
- It increases the conversion of glucose into fat to be stored in adipose tissues.

EFFECTS OF INSULIN ON FAT METABOLISM

- Insulin forms fatty acids from excess liver glucose.
- Fatty acids are utilized from triglycerides which are stored in adipose tissues.
- It inhibits hydrolysis of triglycerides in fat cells by inhibiting hormone sensitive lipase.

EFFECTS OF INSULIN ON PROTEIN METABOLISM

- It causes active transport of amino acids into cells.
- It promotes translation of mRNA in ribosomes to form new proteins.
- It promotes transcription of DNA in nucleus to form mRNA.
- It inhibits protein catabolism.

EFFECTS OF INSULIN ON GROWTH

Insulin is essential for growth as it increases protein formation.

TESTOSTERONE

This is the principle hormone of the testes which consists of 19 carbon atoms. It is responsible for the proper development of male sexual characteristics. Testosterone is also important for maintaining muscle bulk, adequate levels of red blood cells, bone growth, a sense of well-being, and sexual function.

Nature

Steroid in nature

EFFECTS OF TESTOSTERONE

EFFECT ON THE MALE REPRODUCTIVE SYSTEM

During intrauterine life, testosterone is secreted by the genital ridge. Later on it is secreted by the placenta. At this stage it causes the development of male sex organs including the penis, scrotum prostate, seminal vesicle, and male genital duct.

This hormone also causes descent of the testes (during last 2 months of gestation) and suppresses the formation of female genital organs. This hormone causes the enlargement of the male sexual organs. It acts on different male sex organs, increasing spermatogenesis and maintaining the motility and fertilizing power of sperm.

EFFECTS ON SECONDARY SEX CHARACTERISTICS

The effects of testosterone on secondary sex characteristics are as follow. Growth of hairs on the face, chest, and pubis are increases, while decreased on top of the head, voice becomes deeper. Testosterone causes thickness of the skin, roughness of the subcutaneous tissue. Testosterone is also responsible for aggressive moods, active attitudes and interest in the opposite sex.

EFFECT ON PROTEIN METABOLISM

- It increases protein synthesis and build up the musculature.
- Causes positive N- balance.
- Decreases blood urea levels.

EFFECT ON BONE

- Increases thickness of bones
- Increases total quantity of bone matrices.
- Increases the deposition of calcium salts in bones.
- Narrows the length of the male pelvis outlet.
- Increases the length of the male pelvis and makes it funnel shaped.
- Increases the strength of the pelvis and makes it strong.

EFFECT ON RBCs

Testosterone increases the number of RBCs (15-20%). However this difference may be due to the increased metabolic rate following testosterone administration rather than to a direct effect of testosterone on RBC production.

EFFECT ON ELECTROLYTE AND WATER BALANCE

Testosterone can increase the reabsorption of Na^+ and water in the distal tubules of the kidneys. This effect of testosterone is of a minor degree.

ESTROGEN

Estrogen is a group of hormones that play an important role in the normal sexual and reproductive development in women. They are also called sex hormones. The woman's ovaries produce most estrogen hormones, although the adrenal glands also produce small amounts of the hormones.

Nature

An 18 carbon steroid

ACTIONS OF ESTROGENS

- Increases the size of the vagina
- Increases the size of the uterus
- Causes growth of the uterine glands

- Causes enlargement of the musculature of the walls of the vagina
- Increases the size of the clitoris and labia minora
- Promotes the development of the tubular duct system
- Increases vascularity of the skin. Causes softness and smoothness of the skin (This is why estrogen is used in creams, soaps and oils for cosmetic purposes)
- The larynx of a female retains its prepubertal, so size the voice remains high pitched
- Causes broadness of the pelvis
- Increases the synthesis and deposition of proteins
- Increases the synthesis of fat
- Increases the deposition of fat in subcutaneous tissue especially the breasts medial side of the thigh and buttocks
- It increases the retention of Na⁺ and water increasing the E.C.F.
- This hormone is responsible for the proliferative phase of the menstrual cycle
- Decreases blood cholesterol levels

COURSE OUTLINE

ANATOMY AND PHYSIOLOGY (WRITTEN)

Paper 1	Part-1	100 (20+80) Marks
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Anatomy

1. Introduction to Anatomy.
2. Anatomical Terminologies.
3. Surface Anatomy.

Physiology

1. Introduction to physiology.
2. Structure of Cell and Tissues of the body.
 - i) Bone Structure, types of bones and joints.
 - ii) Muscles (structure of skeletal, smooth and Cardiac muscle).
3. Blood-Composition of blood (RBC, WBC and Platelets). Fate of Red Blood cells, blood groups, RH factors, E.S.R Blood coagulation, Anaemias.
4. Circulatory system-Properties of the cardiac muscle. Heart beat cardiac cycle ECG, Blood pressure, Pulse, Hemorrhages, and Lymph.
5. Respiratory system—Mechanics of respiration. Pulmonary ventilation. Lungs volume and capacities. Carriage of O₂ and CO₂ by the blood. Regulation of breathing (Nervous and chemical control).
6. Skin—Structure, Function of skin, Temperature regulation by skin.
7. Digestive system—Introduction of digestive juices saliva Gastric juice, pancreatic juice, Bile and intestinal juices their composition. Movements of the stomach and intestines. Functions of liver and gall bladder.
8. Urinary System—Urine formation and composition of urine.
9. Physiology of nerve and muscle—General introduction to Nervous and muscular system.
10. Nervous system—General introduction to nervous and muscular system.
11. Special sense—Introductory knowledge of structure and functions of the special senses.
12. Endocrinology—Definition of hormone, nature, function and action of hormone.