- HUMAN ANATOMY AND PHYSIOLOGY1

- **Summary of Syllabus**
- The structure in relation to the physiology of important functions and processes within mammalian body.
- Cells and tissues in mammals. Relations of tissue structure to functions
- Digestive, Respiratory, cardiovascular, Immune and musculoskeletal system
- Associated malfunctioning of these systems

- **Tissues-Definition and Classification**
- Tissues- a collection of similar cells that perform a specific role in the structuring and functioning of the body
- The study of tissues is referred to as **histology**
- Tissues cells are separated and bound together by a non-living intercellular matrix
- The intercellular matrix is secreted by the cells
- Matrix varies in composition from one tissue to another
- It may be liquid, semi-solid or solid

- For example, blood has a liquid matrix and this permits this tissue to flow through vessels
- Bone cells are separated by a solid matrix which enables this tissue to support the body
- Tissues in the body are classified into 4 main groups:
- 1. **Epithelial tissues-** these cover the body and organ surfaces, line body and lumen cavities., form glands
- 2. **Muscular tissues-** these contract to bring about movement

- 3. **Connective tissues**– include blood, cartilage, bone, cells of connective tissue proper and their products
- 4. **Nervous tissues-** a collection of cells which initiate and transmit impulses from one part of the body to another
- Characteristics common to all epithelia include:
- 1. An epithelium consists almost entirely of cells with little extracellular materials between them
- 2. Covers the body surface such as the outside of the body and the lining of the digestive tract, vessels, body cavities or forms structures such as

- glands eg. Salivary glands
- 3. Most of them have one free surface not associated with other cells and a basal surface., the basal surface of most epithelial tissue is attached to a basement membrane
- Some epithelial tissues do not have a free surface or basal surface with a basement membrane eg. cells of some endocrine glands
- The basement membrane is a specialized type of extracellular material secreted by the epithelial cell on the opposite side of their free surface and by connective tissue cells.

- 4. Specialized cell contacts such as tight junctions and desmosomes bind adjacent cells together
- 5. Blood vessels do not penetrate the basement membrane to reach the epithelium., thus all gases and nutrients in the blood reach the epithelium by diffusing across the basement membrane from blood vessels in the underlying connective tissues
- In epithelial cells with many layers of cells, the most metabolically cells are close to the basement membrane
- Cells die as they move further away from the

basement membranes

- Even though epithelia are avascular they are innervated (supplied by nerve fibres)
- 6. Regeneration: Epithelial cells retain the ability to undergo mitosis and therefore they are able to replace damaged cells with new ones
- Some epithelia are exposed to friction and their surfaces wear off
- Others are damaged by hostile substances in the environment eg bacteria, acids, smoke
- As long as epithelial cells receive nutrients they can replace lost cells by cell division

- **Classification of Epithelium**
- There are 2 major categories of epithelia: membranous and glandular epithelia
- **Characteristics of membranous epithelia**
- They line all body surfaces, cavities and lumina (hollow portions of body tubes)
- They are specialized for protection and absorption
- One side of a membranous epithelium is always exposed to a body, lumen or skin surface

- Some of them are derived from the ectoderm eg. the outer layer of the skin
- Some from the mesoderm eg. inside lining of blood vessels
- Others come from the endoderm eg inside lining of the gastrointestinal tract
- They may be one layer or several layers thick
- The upper surface may be exposed to gases (integumentary and respiratory systems., to liquids (circulatory and urinary systems)., or semi-solids as in the digestive tract

- Membranous epithelia are avascular and must be nourished by diffusion from the underlying connective tissues
- The cells are tightly packed together and there is little intercellular matrix between them
- **Functions**
- 1.Membranous epithelia that cover or line surfaces provide protection from pathogens
- 2. Those that line the GIT function in absorption of products of digestion
- 3. Those in the kidney allow for filtration

- 4.Epithelia in the air sacs of the lungs allow for diffusion
- 5. There are specialized neuro-epithelial cells in the taste buds and nasal region and these respond to chemical molecules and thus serve as chemoreceptors

Classification of membranous epithelia

- Classification of membranous epithelia is by the number of layers of cells and the shape of cells along the exposed surface
- Epithelia tissues composed of a single layer of

- cells are called simple., those that are layered are said to be stratified
- Squamous cells are flattened., cuboidal cells are cubed shaped., columnar cells are taller than they are wide
- **Simple Epithelium**
- These are composed of flattened, irregularly shaped cells that are tightly bound together
- Each cell contains an oval centrally located nucleus
- The cells range from thin, flattened cells to

columnar , depending on function

- The cells may exhibit surface specializations such as cilia and microvilli
- 1. **Simple squamous epithelium**
- This is made up of flattened, scale-like, irregularly shaped cells tightly bound together
- Each cell has a centrally located nucleus
- This epithelium is adapted for diffusion and filtration and absorption
- Occurs in places such as the air sacs, a portion of the kidney, where blood is filtered, the

inside lining of blood vessels

- Simple squamous epithelium lining the lumina of blood and lymphatic vessels is called endothelium
- Those that cover visceral organs and lines body cavities are called mesothelium

Simple Cuboidal

- This is composed of a single layer of tightly fitted hexagonal cells, as tall as they are wide
- Some cells have cilia(terminal bronchioles) and microvilli (kidney tubules)

- Found in small ducts and tubules that have excretory, secretory and absorptive functions
- It occurs on the surface of the ovaries, terminal bronchioles, choroid plexus of the brain, smallest ducts of kidney tubules
- **Simple columnar epithelium**
- This is composed of tall columnar cells., the height of the cells vary depending on the site and function of the tissue
- Some have cilia or microvilli on their free surface which help to move substances

- Each cell contains a single nucleus,usually near the basement membrane
- Specialized unicellular cells called goblet cells are dispersed throughout this tissue
- They secrete a lubricative and protective mucus along the free surface of the cells
- Location: it lines the digestive tract, from the stomach to the rectum, bronchioles, uterus, uterine tubes, gall bladder, bile ducts, ventricles of the brain

- **Simple ciliated columnar epithelium**
- Characterised by the presence of cilia along the free surface
- Cilia produce wave-like movements that transport materials through tubes
- Occurs in the uterine tubes of the female
- **Pseudostratified ciliated columnar epithelium**
- This is a single layer of cells, all of which are attached to the basement membrane. Some of the cells are tall and thin and reach the free

surface of the epithelium, others do not

- The epithelium has a stratified appearance because the nuclei of these cells are located at different levels, giving it a false impression that several cell layers are present
- Numerous goblet cells and a ciliated exposed surface are characteristic of this epithelium
- This epithelium is frequently called respiratory epithelium
- Function: Movement of fluid and mucus that contains foreign particles from the lower part

of the respiratory system

Stratified Epithelia

- These are tissues consisting of two or more layers of cells
- They regenerate from below; that is the basal cell divide and push apically to replace the older surface cells
- They are considerably more durable than simple epithelia

- Stratified epithelia are poorly suited for absorption and secretion because of their thickness
- They have protective function, which is enhanced by rapid mitotic activity
- They are classified according to the shape of the surface layer of cells since the layer of

cells in contact with the basement membrane is either cuboidal or columnar in shape

Stratified squamous epithelium

- Composed of a variable number of cell layers
- Its free surface cells are squamous; cells of the deeper layers are columnar or cuboidal
- Mitosis occurs only in the deepest layer (stratum basale)
- As the newly produced cells grow, they are pushed toward the surface, where they replace the cells that are removed

- There are 2 types: keratinized and non-keratinized (moist)
- Stratified squamous epithelium that is keratinized forms the epidermis of the skin
- Keratin, a protein strengthens the tissues
- This epithelium is durable and can withstand abrasion, desiccation and bacterial invasion

Non-keratinized

- This type of epithelium is called mucosa
- It is well adapted to withstand moderate abrasion but not fluid loss

- The cells on their free surface remain alive and are moistened
- Location: mouth, throat, larynx, oesophagus, anus, cornea etc
- **Stratified Cuboidal**
- Consists of only 2 or 3 layers of cuboidal cells forming a lining around a lumen
- This type of epithelium is confined to the lining of larger ducts of sweat glands, salivary glands, pancreas, ovarian follicular cells

- Function: Secretion ,absorption and protection against infection
- **Stratified columnar**
- Multiple layer of cells with tall thin cells resting on layers of cuboidal cells
- In the larynx, the cells are ciliated
- Function: Protection and secretion
- **Transitional epithelium**
- This is a unique type of stratified epithelium that lines the urinary bladder and ureters
- They are specialized to permit distension

(stretching) of the urinary bladder

- Cells of its basal layer are cuboidal or columnar
- The apical cells vary in appearance, depending on the degree of distention of the organ
- When the organ is distended with urine, the epithelium thins from six cell layers to three
- The dome-shaped apical cells flatten and become squamous-like

Body Membranes

- These are composed of thin layers of epithelial tissues
- They cover , separate and support visceral organs and line body cavities
- There are 2 basic types: mucous membranes and serous membrane
- Mucous membranes secrete a thick slimy substance called mucus., this lubricates or protect the organs where it is secreted

- Mucous membranes line body cavities and tubes that enter or leave the body eg nasal and oral cavities, tubes of the respiratory, urinary, reproductive and digestive systems
- **Serous membranes**
- These line the thoracic and abdominal cavities, cover visceral organs
- They secrete a watery lubricant called serous fluid
- 1. Pluerae are the serous membrane associated with the lungs., each pleura is divide into two

- Visceral pleura- adheres to the outer surface of the lung
- Parietal pleura lines the thoracic wall the thoracic walls and the surface of the diaphragm
- The space between the 2 is the pleural cavity
- **2.Pericardial membrane**
- This is the serous membrane of the heart
- A thin-walled visceral pericardium covers the surface of the heart
- A thick pareital pericardium is the durable

- covering that surrounds the heart
- Between the two membranes is the pericardial cavity
- **3. Peritoneal membranes**
- These are the serous membranes of the abdominal cavity
- A parietal peritoneum lines the abdominal wall
- Visceral peritoneum covers the visceral organs

- **Glandular epithelium**
- These are specialized tissues with secretory functions
- Most glands are composed of epithelium supported by a network of connective tissue
- Glands with ducts are called exocrine glands., their ducts are lined with epithelium
- Glands that have no ducts are called endocrine glands
- Their cellular products are called hormones

- Most exocrine glands are composed of many cells and are therefore called multicellular glands
- Those composed of a single cell are called unicellular eg Goblet cells of the respiratory system
- Glands that have duct with few branches are called simple., those with ducts that branch repeatedly are called compound
- Further classification is based on whether the ducts end in tubules,or sac-like structures called acini(cluster of grapes or small sacs)

- They may be described as alveoli-hollow sacs
- Exocrine glands can also be classified according to how the products leave the cell
- 1. Merocrine glands- secrete products with no loss of actual cellular material
- Secretions are transported or released by exocytosis at the surface of the cell eg sweat glands, exocrine portion of pancreas
- 2. Apocrine- discharge fragments of the gland cells in the secretions. Products are retained within the cell, large portions of the cell are

- pinched off to become part of the secretion eg mammary glands
- **3. Holocrine glands**
- These shed the entire cells., substances accumulate in the cytoplasm of each epithelial cell; the cell ruptures and dies; the entire cell becomes part of the secretion eg sebaceous gland of the skin
- **Connective Tissues**
- Consists of cells separated from each other by extracellular matrix; the non-living matrix

- is the basis for classification of connective tissues
- With the exception of mature cartilage, connective tissues are highly vascular and well nourished
- They are able to replicate and so are responsible for the repair of body organs
- Connective tissues contain considerably more matrix(intercellular material) than cells
- They do not occur on free surfaces of the body cavities or on the surface of the body

- Connective tissues are derived from the mesoderm
- **Connective tissue cells**
- The specialized cells of the various connective tissues produce the extracellular matrix
- The names of the cells end with suffixes that identify the cell function eg -blasts create the matrix; -cytes maintain it ,whilst -clasts break it down
- Thus fibroblast are cells that form fibrous connective tissue

- Chondrocytes are cells that maintain cartilage; osteoblasts form bone
- The extracellular matrix has three components
- 1. Protein fibres 2. Ground substance (consisting of nonfibrous protein and other molecules) 3. Fluid
- The protein fibres consists of collagen, reticular and elastic fibres. These contribute to the formation of connective tissues
- Collagen is the most common protein in the body,accounting for ¼-1/3of total body protein

- Collagen consists of 3 polypeptide chains coiled together
- It is very strong and flexible but quite inelastic
- 2. Reticular fibres(net-like)
- They are actually very fine collagenous fibres
- They are very short, thin fibres that branch to form a network
- They are not as strong as most collagenous fibres
- 3.Elastin- this protein is elastic, with the ability to return to its original shape after

- being distended or compressed
- **Classification of Connective Tissues**
- 1. Embryonic connective tissues
- At the beginning of the embryonic period, all connective tissues appear the same- known as mesenchyme
- Mesenchyme is undifferentiated connective tissue derived from the mesoderm
- The tissue is made up of irregularly shaped cells lying in large amounts of homogenous jelly-like matrix

- Before the end of the embryonic period, mesenchyme migrates to appropriate positions where it differentiates and form all other kinds of connective tissues
- **Connective Tissue Proper**
- There are 6 basic types of connective tissue proper:
- 1.Loose(Areolar)
- Act as binding and packaging material
- Binds the skin to the underlying muscles
- It is highly vascular

- Loose connective tissue surrounding muscle fibre and muscle groups is known as fascia., they also surround blood vessels and nerves
- Specialized cells, called mast cells are dispersed throughout this tissue
- Mast cells produce heparin, an anticoagulant that prevent blood from clotting within the vessels
- They also produce histamine which is released during inflammation., also acts vasodilator

- The cells are predominantly fibroblasts, with collagenous and elastic fibres dispersed in the ground substance
- 2. Dense regular connective tissue
- Characterised by large amounts of collagenous fibres
- They are sometimes called white fibrous connective tissue because this tissue is silvery white in appearance
- It occurs where strong flexible support is required

- Tendons(muscle-bone) and ligaments(bone-bone) are composed of this tissue
- 3. Dense irregular connective tissue
- Characterised by large amounts of densely – packed collagenous fibres, interwoven to provide tensile strength
- Found in the dermis of the skin, submucosa of GIT,also makes up the matrix of bones-osteiod
- 4. Elastic connective tissue
- Mainly made up of elastic fibres; yellowish in colour

- Found in the walls of large arteries; portions of the larynx, trachea, bronchial tubes of the lungs
- 5. Reticular connective tissue
- Characterised by a network of reticular fibres woven through a jelly-like matrix
- Specialized cells within reticular tissues are phagocytic
- Found in the liver, spleen, lymph nodes, bone marrow etc
- 6. Adipose tissue- specialized type of loose

- connective tissue that contain large amounts of adipose cells or adipocytes
- Adipose cells store fat in their cytoplasm, causing them to swell
- They are found throughout the body ,but they are concentrated around the kidneys, hypodermis of the skin, breasts of sexually matured females
- **Cartilage**
- Cartilage tissue consists of cartilage cells or chondrocytes; has semi-solid matrix and

- and imparts elastic properties to the tissue
- Cartilage is a supportive and protective connective tissue frequently associated with bone
- Cartilage persists at articular surfaces of bones of all movable joints
- The cartilage cells, chondrocytes are located in cavities called lacunae within the matrix
- Most cartilage is surrounded by dense regular connective tissue called perichondrium
- Mature cartilage at articular surfaces of bones

- lack perichondrium
- Mature cartilage is avascular; they receive nutrients from perichondrium and surrounding tissue through diffusion
- Cartilage has slow rate of mitosis and if damaged, heals with difficulty
- There are three types of cartilage:
- **Hyaline cartilage**
- Has bluish white matrix with fine collagenous fibres; it covers the articular surfaces of bones; supports the tubular trachea and bronchi of

- the respiratory system
- Most of the bones of the body form first as hyaline cartilage and later become bone by ossification
- 2. Fibrocartilage
- Has a matrix strengthened with collagenous fibres
- It is a durable tissue adapted to withstand tension and compression
- Found at the pubic symphysis and between the vertebrae

- 3. Elastic cartilage: This is similar to hyaline cartilage except for the presence of elastic fibres
- These make it very flexible whilst maintaining strength
- The presence of elastic fibres give it a yellowish appearance
- Location: outer ear, portions of the larynx, auditory canal.
- Bone Tissue-osseus connective tissue
- This is the most rigid of the connective tissues

- Bone has rich vascular supply and is a site of considerable metabolic activity
- The hardness of bone is due to the presence of calcium phosphate deposited within its matrix
- Many collagenous fibres within the matrix give some flexibility to bone
- There are 2 types of bones;
- 1. Compact(dense) bone tissue is the hard outer layer
- 2. Spongy(cancellous) bone is the porous highly vascularised inner portion

- Compact bone is covered by the periosteum and provides surfaces for the attachment of muscles; protects and strengthens the bone
- Spongy bone makes bone lighter; provides a space for bone marrow where red blood cells are manufactured
- In compact bone tissue, the mature bone cells (osteoblasts) are arranged in concentric layers around a central (harvesian) canal
- The central canal contains blood vessels and nerves

- Each osteocyte occupies a cavity called lacuna
- Radiating from each lacuna are minute canals called canaliculi., they pass through the dense matrix to adjacent lacunae
- Nutrients diffuse through the dense matrix to adjacent lacunae
- The inorganic matrix is deposited in concentric layers called lamellae
- **Vascular connective tissue**
- This is a specialized connective tissue; its cells or formed elements are suspended in liquid

- plasma matrix
- Blood plays a vital role in maintaining internal homoestasis
- Function: Transports oxygen, carbon dioxide, hormones nutrients, waste products. Protects the body from infections; involved in temperature regulation
- **Muscle tissues**
- The major characteristic of muscle tissue is that it is contractile and therefore responsible for movement

- Muscle cell or fibres are elongated in the direction of movement
- Muscle tissues are derived from the mesoderm
- The three types of muscle tissue are skeletal, cardiac and smooth muscles
- The types of muscle tissues are grouped according to both structure and function
- Muscle tissue grouped according to structure is either striated(microscopic bands can be seen) or non-striated
- In terms of function a muscle is voluntary ie.

- consciously controlled or involuntary ie not consciously controlled1. skeletal muscle
- Attaches to skeleton, responsible for voluntary body movements
- They are elongate, multinucleated fibre, peripherally located nuclei with transverse striations
- Fibres of this muscle are grouped into parallel fasciculi(bundles)
- Function: movement of the body under voluntary control

- Smooth muscle
- They lack striations; the cells are long spindle shaped with single centrally-placed nucleus
- Located in the wall of the GIT, providing the power for peristaltic movement involved in mechanical digestion of food
- Also found in the walls of arteries; walls of respiratory passages, urinary and reproductive tracts.
- Contraction of this muscle is under involuntary control

- **Cardiac muscle**
- Cells are cylindrical and branching with a single centrally-located nucleus
- Cells are connected to each other by specialized gap junctions called intercalated disks
- Cardiac muscles are striated
- Located in the heart and experiences rhythmical involuntary contractions to pump blood

- Nervous Tissue
- Found in the brain, spinal cord and nerves
- They are characterised by the ability to conduct electric signals called action potentials
- Nervous tissue is composed of neurons, which respond to stimuli and conduct impulses to and from all body organs; and neuroglia which functionally support and physically bind neurons
- A neuron has 3 principal parts: 1. cell body

- 2. dendrites 3. axon
- Dendrites receive stimuli and conduct impulses to the cell body
- Cell body contains the nucleus, specialized organelles and microtubules
- Axon is the cytoplasmic extension that conducts impulses away from the cell body
- **Neuroglia**
- These are the supporting cells of the brain, spinal cord and peripheral nerves., they are 5 times as abundant as neurons, with limited

- mitotic ability
- They do not transmit impulses but nourish, protect and insulate neurons
- They also bind neurons together
- Some neuroglial cells are phagocytic

- **DIGESTIVE SYSTEM**
- Anatomically and functionally the digestive system is divided into 2:
- . A tubular gastrointestinal (GI) tract ie alimentary canal and its accessory structures

- The principal function of the digestive system is to prepare food for cellular utilization
- This involves the following activities:
- 1.Motility: movement of food through the digestive tract and includes the following processes: ingestion, mastication, swallowing(deglutition), peristalsis
- 2. Secretion-both exocrine and endocrine secretions. The exocrine secretions include water, HCl, HCO_3^- and many enzymes are secreted into the GIT eg the stomach alone secretes 2-3 litres of gastric juice a day

- Endocrine secretion- the stomach wall and small intestine secrete a number of hormones that help to regulate the digestive system
- 3. Digestion-breakdown of complex food molecules into smaller units which can be absorbed
- 4. Absorption- passage of food molecules into the blood or lymph
- The organs of the GIT include the oral(buccal) cavity, pharynx, oesophagus, stomach, small intestine and large intestine

- The accessory digestive organs include the teeth, tongue, salivary glands, liver, gall bladder and pancreas
- **Layers of the GIT**
- The GIT, from the stomach to the anal canal is composed of four layers(tunics)
- Each layer contains a dominant tissue type that performs a specific function in the digestive process
- The 4 tunics, from inside out are the mucosa, submucosa, muscularis and the serosa

- **Mucosa**
- This surrounds the lumen of the GIT and is the absorptive and major secretory layer
- It consists of simple columnar epithelium and contains goblet cells which secrete mucus
- The epithelium is supported by a thin layer of connective tissue called lamina propria
- The lamina propria contains lymph nodules which are important in protecting against diseases
- Below the lamina propria is a thin layer of

- Smooth muscle called muscularis mucosa
- 2. **Submucosa**
- This is a relatively thick, highly vascular layer of connective tissue that serves the mucosa
- Absorbed molecules that pass through the mucosa enter into the blood vessels and lymph ductules of the submucosa
- In addition the submucosa contains glands and nerve plexuses. The submucosal(Meissner's) plexus provides autonomic innervation to the muscularis mucosa

- **3. Muscularis**
- This layer is responsible for the segmental contractions and peristaltic movement through the GIT
- It has an inner circular layer and outer longitudinal layer of smooth muscle
- Contraction of these muscles move the food peristaltically through the GIT
- Located between the 2 muscles layers is the myenteric(Auerbach’s) plexus., it provides the major nerve supply to the GIT

- It includes fibres and ganglia from both the sympathetic and parasympathetic divisions of ANS
- 4. Serosa/Adventitia
- It is a binding and protective layer consisting of loose connective tissue
- The layer is covered by simple squamous epithelium and sub-adjacent connective tissue
- This layer is actually the visceral peritoneum of the abdominal cavity

- **Mouth, Pharynx and Associated Structures**
- The mouth and associated structures initiate mechanical digestion of food through mastication
- The mouth/oral cavity is formed by the cheeks, lips hard and soft palate and tongue
- The opening between the oral cavity and the pharynx is called the fauces
- The pharynx serves as a common passageway for both the respiratory and digestive systems
- Both the mouth and pharynx are lined with

- Non-keratinized stratified squamous epithelium(mucus)
- **Tongue**
- It functions to move food around in the mouth during mastication and assists in swallowing
- It contains taste buds, through which various food tastes are sensed
- The tongue is a mass of skeletal muscle covered with mucous membrane
- Extrinsic tongue muscles(inserts upon the tongue) move the tongue from side to side

- in and out
- Only the anterior 2/3 lies in the buccal cavity., the remaining 1/3 lies in the pharynx
- There are round masses of lingual tonsils on the posterior surface of the tongue
- On the surface of the tongue are small elevations called papillae, making the surface rough; this makes the easier to handle food
- The papillae also contain taste buds with sweet, sour, salty and bitter sensation
- There are three types of papillae;

- Filiform-has tapered tip., sensitive to touch
- Fungiform- rounded
- Vallate- V-shaped
- **Salivary Glands**
- They are accessory digestive glands that produce saliva
- Saliva functions as a solvent in cleansing the teeth and dissolves food molecules so that they can be tasted
- It contains starch-digesting enzyme and mucus that lubricates the pharynx to facilitate

- swallowing of food
- There are minor salivary glands called buccal glands which are located in the mucous membrane of the palatal region
- Most saliva is however, produced by 3 pairs of salivary glands located outside the oral cavity
- These are parotid, submandibular and sublingual.1. The parotid is the largest of the salivary glands;positioned below and in front of the ear. The parotid gland becomes infected and swollen with mumps

- 2. Submandibular- located inferior to the mandible, on the inner side of the jaw
- The submandibular(Wharton) duct empties onto the floor of the mouth
- 3. Sublingual- located under the mucosa , in the floor of the mouth on either side of the tongue
- Associated with each sublingual gland are sublingual(Rivinus's) ducts that empty into the floor of the mouth
- Serous, a watery fluid containing digestive

- enzymes and mucous cells are found in all salivary glands
- The salivary glands are innervated by both divisions of the autonomic nervous system
- Sympathetic impulses stimulate small amounts of viscous saliva
- Parasympathetic stimulation causes secretion of large volumes of watery saliva
- **The Pharynx**
- The pharynx connects the oral and nasal cavities to the oesophagus and the trachea

- It has both respiratory and digestive functions
- It is made up of 3 regions:
- 1. Nasopharynx- has respiratory functions only
- 2. Oropharynx- the base of the tongue forms the anterior wall of the oropharynx
- There are paired palatine tonsils located on the lateral wall of the oropharynx
- Lingual tonsils are located at the base of the tongue
- The oropharynx has both respiratory and digestive functions

- 3. Laryngopharynx- this is the lowest portion of the pharynx
- Swallowed food and liquid are directed into the oesophagus, whereas inhaled air is moved into the larynx
- **Oesophagus**
- It is the portion of the GIT that connects the pharynx to the stomach
- It is a collapsible muscular tube, 25 cm long
- It is posterior to the trachea
- It passes through the diaphragm by means of

- of an opening called the oesophageal hiatus
- The oesophagus is lined with non-keratinized stratified squamous epithelium
- Its walls contain either skeletal or smooth muscle
- The upper 1/3 contains skeletal muscle, the middle third contains both skeletal and smooth muscles whilst the terminal portion contains only smooth muscle
- **The Stomach**: This is a muscular bag capable of stretching; it is the most distensible part of

- the GIT
- The functions of the stomach are to store food, initiate the digestion of protein and converts food into chyme
- The stomach can be divided into four regions:
- **Cardia** – the narrow upper region immediately below the lower oesophageal sphincter
- **Fundus-** the dome-shaped portion to the left of the cardia and in direct contact with the diaphragm

- **The Body-** the large central portion
- **Pylorus**: the funnel-shaped terminal portion
- The pylorus is linked to the duodenum through the pyloric sphincter
- **Stomach Wall**
- The wall of the stomach consists of the same 4 layers as in the other regions of the GIT, with certain modifications
- The muscularis is composed of 3 layers of smooth muscles i.e outer longitudinal layer, middle circular layer and inner oblique layer

- The inner surface of the stomach is thrown into long folds called gastric rugae
- The gastric mucosa is likewise folded., the opening of these folds into the stomach lumen are called gastric pits
- The cells that line the mucosa secrete various products into the stomach
- The gastric glands have several kinds of cells:
- 1. Goblet cells- these secrete mucus, a constituent of all intestinal juice., protects the tissues of the stomach from the action of

- digestive enzymes
- It is amphoteric in nature and can neutralise both acids and alkali
- 2. Parietal cells- secrete HCL to give the final concentration of approximately 0.1 molar, giving a pH of 2
- This acidity serves 3 digestive functions:
- 1. ingested proteins are denatured at low pH so that they become more digestible
- 2. under acidic conditions, weak pepsinogen partially digest each other, freeing the active

- pepsin
- 3. pepsin is more active under acidic conditions: its optimum pH is about 2
- The peptide bonds of ingested proteins are broken down by pepsin under acidic conditions
- HCL itself does not directly digest proteins
- Pepsin is an endopeptidase, attacking peptide linkages within the protein molecule
- Pepsinogen is secreted by Chief (Zymogen) cells

- Argentaffin cells- these secrete serotonin and histamine
- G cells secrete the hormone gastrin into the blood
- Renin is also found in gastric juice, particularly in young mammals
- In the presence of calcium salts it converts the soluble milk protein casein into paracasein
- In addition, the gastric mucosa secretes a polypeptide called the intrinsic factor, which is required for absorption of vitamin B12 in the

- small intestine
- **Small Intestine**
- It is that portion of the GIT between the pyloric sphincter of the stomach and the ileocaecal valve which opens into the large intestine
- The mucosa is folded into villi which project into the lumen
- The cells that line the villi have microvilli
- The small intestine is divided into 3 regions on the basis of function and histological

- structure: duodenum, jejunum and ileum
- The duodenum is C- shaped tube from the pyloric sphincter of the stomach to the duodenojejunal flexure
- The concave surface of the duodenun faces to the left, where it receives bile secretion through the common bile duct- from the liver and bile duct, as well as pancreatic secretion from the pancreas
- The 2 ducts unite to form the hepatopancreatic ampulla which drains into the duodenum from

- an elevation called the duodenal papilla
- It is at this point that bile and pancreatic juice enter the small intestine
- The duodenal papilla can be opened or closed by the action of the sphincter of papilla (sphincter of Oddi)
- Histologically it differs from the rest of the small intestine by the presence of duodenal (Brunner's) gland in the submucosa
- 2. Jejunum- this is approximately 1 m long, extending from the duodenum to the ileum

- The lumen is slightly larger than that of the ileum and has more internal folds
- The two regions are similar in their histological structure
- 3. Ileum- makes up the remaining 2m of the small intestine
- The terminal portion empties into the caecum through the ileocaecal valve
- The walls of the ileum have many lymphatic tissue., there are aggregates of lymph nodules called mesenteric (Peyer’s) patches

- **Structural modification for absorption**
- Absorption of carbohydrates, lipids, protein calcium and iron occurs in the duodenum and jejunum
- Bile salts, vitamin B12, water and electrolytes are absorbed primarily in the ileum
- The mucosa and submucosa form large folds called plicae circularis
- The surface area is further increased by miscroscopic folds of mucosa called villi and microvilli., the villi are covered with columnar

- Epithelial cells., among these are mucus-secreting goblet cells
- The lamina propria forms the core of each villus and contains lymphocytes, blood capillaries and a lympahtic vessel called lacteal
- Absorbed monosaccharides and amino acids enter the blood capillaries, whilst the absorbed fat enters the lacteals
- **Large Intestine:**The large intestine is about 1.5 m long., 6.5cm wide
-

- It begins at the terminal end of the ileum in the lower right quadrant of the abdominal cavity
- From here it leads superiorly on the right side just below the liver, crosses to the left and then descends into the pelvis and terminates at the anus
- It is supported along the posterior abdominal wall by a specialized mesentery called mesocolon
- It has little or no digestive functions., it does absorb water and electrolytes

- Additionally it forms, stores and expels faeces from the GIT
- Regions and Structures of the Large Intestine
- Structurally it is divided into the caecum, colon, rectum and the anal canal
- The caecum is the dilated pouch slightly below the ileocaecal valve
- The ileocaecal valve is a fold of mucous membrane at the junction of large and small intestines., it prevents backflow of chyme
- A finger like projection, the appendix is

- attached to the inferior margin of the caecum
- The appendix has abundant lymphatic tissue which may serve to resist infection
- The open superior portion of the caecum is continuous with the colon
- The colon consists of the ascending, transverse descending and sigmoid portions
- The ascending colon extends from the caecum along the right abdominal wall to the inferior (lower) surface of the liver
- Here it bends sharply to the left at the hepatic

- flexure; crosses the upper abdominal cavity as the transverse colon
- At the left abdominal wall is another angle bend known as the splenic flexure
- This marks the beginning of the descending colon
- The descending colon passes along the left abdominal wall to the pelvic region
- It then forms an S-shaped bend known as the sigmoid colon., the terminal 20cm of the GIT is the rectum

- The last 2-3 cm of the rectum is the anal canal
- Two muscle sphincter muscles guard the anal
- 1. internal anal sphincter , composed of smooth muscle fibres
- 2. external anal sphincter – composed of skeletal muscle
- The mucosa of the large intestine contains many lymphocytes and lymphatic nodules., covered by columnar epithelial cells and mucus –secreting goblet cells
- There are masses of varicose veins in the anal

- area known as haemorrhoids, also known as piles
- Intestinal Absorption of fluid and Electrolytes
- Most of the fluid and electrolytes in the lumen of the GIT are absorbed by the small intestine
- Although a person may drink about 1.5 l of water per day, the intestine receives 7-9 l per day as a result of fluid secreted by the salivary glands, stomach pancreas and liver
- Most of this fluid is absorbed by the small intestine and passes 1.5 to 2.0 l to the large

- intestine
- The large intestine absorbs about 90% of this remaining volume, leaving less than 200 ml of fluid to be excreted in faeces
- This reabsorption of water occurs passively as a result of osmotic gradient created by active transport of ions
- The epithelial cells of the intestinal mucosa contain Na^+/K^+ pumps
- Aldosterone, which stimulates salt and water reabsorption in the renal tubules also appears

- to stimulate salt and water reabsorption in the large intestine
- **Liver- Structure**
- The liver is the largest internal organ of the body; it is positioned immediately beneath the diaphragm
- The liver has 2 major lobes and 2 minor lobes
- Anteriorly, the right lobe is separated from the smaller left lobe by the falciform ligament
- Inferiorly, the caudate lobe is positioned near the inferior vena cava, and the quadrate lobe is

- adjacent to the gall bladder
- The falciform ligament attaches the liver to the anterior abdominal wall and the diaphragm
- The porta of the liver is where the hepatic artery, portal vein, lymphatics and nerves enter the liver and where the hepatic ducts exit
- The liver is only 1 or 2 cells thick; this is because the liver cells called hepatocytes form plates that are 1 or 2 cell thick
- The hepatic plates are separated from each other by large capillary spaces called sinusoids

- The sinusiods are lined with phagocytic Kupffer cells
- Because of the hepatic plate structure of the liver and the permeable nature of the sinusoids, each hepatocyte is in close contact with the blood
- **Liver Lobules**
- The hepatic plates are arranged into functional units called liver lobules
- In the middle of each lobule is a central vein, at the periphery of each lobule are branches of

- the hepatic portal vein and hepatic artery, and bile duct, together forming the hepatic triad
- The portal venous blood containing absorbed molecules mixes with arterial blood within the sinusoids as it flows from the periphery of the lobule to the central vein
- The central veins of different lobules converge to form the two hepatic veins that carry blood from the liver to the inferior vena cava
- Bile is produced by the hepatocytes and secreted into thin channels called bile caniliculi; these bile canaliculi are drained

- by bile duct, which in turn drain into hepatic ducts which a carry bile away from the liver
- Blood and bile do not mix in the liver lobules because blood travels in the sinusoids and bile travels in the opposite direction within the hepatic plates
- Functions of the Liver: **Read and makes Notes**

- **Gall Bladder**
- The gall bladder is a sac-like organ attached to the inferior surface of the liver
- It stores and concentrates bile which drains to it from the liver
- A sphincter valve at the neck of the gall bladder allows a storage of about 35-100ml of bile
- The inner mucosal layer of the gall bladder is arranged in rugue, and allows the gall bladder to expand

- Contraction of the muscularis ejects bile from the cystic duct into the common bile duct through which it is conveyed into the duodenum
- When the small intestine is empty of food, the sphincter of ampulla (sphincter of Oddi) closes and bile is forced up the cystic duct to the gall bladder for storage
- **Pancreas**
- The pancreas is a glandular organ that has both exocrine and endocrine functions

- The endocrine function is performed by pancreatic islets (Islets of Langerharns); these secretes insulin and glucagon
- The exocrine secretory units are called acini; each acinus consists of a single layer of epithelial cells surrounding a lumen, into which pancreatic juice is secreted
- Pancreatic juice contains: water, HCO_3^- and a number of digestive enzymes
- The enzymes include: **pancreatic amylase** similar in action to salivary amylase.

- This digests starch into the disaccharide maltose
- **Trypsin**: an endopeptidase which digests protein. Trypsin is secreted as trypsinogen, and activated by the enzyme enterokinase from the duodenum
- In its active form trypsin operates best at pH 8 and converts proteins into di-, tri- or polypepetides
- **Chymotrypsinogen**: an endopeptidase which is activated by trypsin to chymotrypsin; it cleaves

- internal peptide bonds
- **Carboxypeptidase**: an exopeptidase which act on peptide linkages next to a carboxyl group
- It works on small protein units (peptones) after they have been released by endopeptidases
- **Lipase-** digests tryglycerides into fatty acids and glycerol to release these into the duodenum
- All the enzymes of the pancreas work best at a pH of 8-9 and this alkaline medium is provided the bile

- **Digestion and absorption of carbohydrates**
- Digestion of starch begins in the mouth with the action of salivary amylase (ptyalin)
- Most people however, do not chew their food long enough for sufficient digestion of food in the mouth
- The digestive action of salivary amylase stops when the bolus enters the stomach because this enzyme is inactivated at the low pH of gastric juice
- Digestion of starch occurs mainly in the

- duodenum
- Salivary amylase cleaves starch to produce disaccharide maltose and the trisaccharide maltriose; oligosaccharides are released together with the above carbohydrates
- Maltose, maltriose and oligosaccharides are hydrolyzed to their monosaccharides by enzymes located in the small intestine
- **Sucrose** is hydrolyzed by the enzyme sucrase into glucose and fructose; **Maltose** is hydrolyzed by maltase into 2 glucose units

- Lactose is hydrolyzed by lactase into glucose and galactose
- These monosaccharides are then moved across the epithelial cell membrane by secondary active transport in which the glucose shares a common membrane carrier with Na^+
- They are finally secreted from the epithelial cells into the blood capillaries within the intestine
- **Protein Digestion**: this begins in the stomach with the action of pepsin

- Some free amino acids are liberated in the stomach, but the major products of protein digestion are short chain polypeptides
- Most protein digestion occurs in the duodenum and jejunum
- Pancreatic enzymes trypsin, chymotrypsin and elastase cleave peptide bonds within the interior of polypeptide chains
- These enzymes are therefore classified as endopeptidase
- Enzymes that remove amino acids from the

- end of peptide chains are classified as exopeptidases
- These include the pancreatic juice enzymes carboxypeptidase, which remove amino acids from carboxyl end of polypeptide chains; aminopeptidase which cleaves peptide bonds from the amino terminal end of polypeptide chain
- As a results of action of these enzymes polypeptide chains are digested into free amino acids, dipeptides and tripeptides

- The free amino acids are absorbed by co-transport into epithelial cells and secreted into blood capillaries
- Dipeptides and tripeptides may enter epithelial cells but they are then digested within these cells into amino acids which are then secreted into the blood
- **Digestion and absorption of Lipids**
- The arrival of fat in the duodenum serves as the stimulus for the secretion of bile
- Bile salts micelles act to break the large lipid

- molecules into tiny droplets of triglycerides in a process known as emulsification
- Fat digestion occurs by the action of pancreatic lipase, aided by a protein called colipase, also secreted by the pancreas
- Colipase coats the fat droplet and anchors the lipase enzyme to them
- Through the process of hydrolysis, lipase removes two of the three fatty acids from the triglycerides thus liberating free fatty acids and monoglycerides

- **CIRCULATORY SYSTEM**
- The circulatory system is made up of the cardiovascular system and the lymphatic system
- The cardiovascular system consists of the blood, blood vessels and the heart
- The lymphatic system is made up of lymph, lymphocytes, lymphatic vessels, lymph nodes, tonsils, the spleen and the thymus gland
- **Blood**: blood consists of a fluid plasma in which are suspended cellular elements

- About 45% of blood is made up of cells, the remaining 55% is plasma

Plasma: Plasma is straw coloured, about 90% water and 10% dissolved substances

The straw colour of plasma is due to the presence of bilirubin, a breakdown product of worn-out RBC

Plasma has the following composition:

1. Ions, mainly Na^+, but also includes Ca^{2+}, Cl^-, K^+ and HCO_3^-
2. Plasma proteins-constitutes 7-9% of plasma

- This include albumins, globulins and fibrinogen
- **Albumin** forms about 58% of plasma proteins
- It regulates the movement of water between the tissues and the blood
- Produces the osmotic pressure needed to draw water from tissue fluid into the capillaries
- **Globulins** form about 38% of plasma proteins.,there are three types: alpha, beta and gamma
- **Alpha** and **beta** globulins are produced by the

- liver ., they transport hormones, metals and lipids
- **Gamma** globulins are antibodies produced by lymphocytes
- **Fibrinogen:** forms about 4% of plasma protein., it is produced by the liver and is an important clotting factor
- **Hormones**, such as testosterone, oestrogen etc
- **Waste** products like urea, bilirubin
- **Gases** like carbon dioxide and oxygen
- **Enzymes**

- **Formed elements**
- **Erythocytes**: haematocrit- the percentage of red blood cells in a given volume of blood
- In males it is 44%-54%, whilst in females it is 38%-48%
- **Structure**: RBC's are flattened biconcave disks, 7microns in diameter and 2 microns thick
- There are between 5and 6 million RBC in every cubic millilitre of blood
- A newly formed RBC has a nucleus, but lacks

- nuclei and mitochondria at maturity
- They have a maximum circulatory life span of 120 days, after which they are destroyed by phagocytic cells in the spleen, liver and bone marrow
- Erythrocytes develop from mother cells called haemocytoblasts
- Each erythrocyte contains about 280 million haemoglobin molecules
- Hb is made up of 4 polypeptide chains called globin and 4 iron-containing heme group

- For the formation of Hb, vitamin B12 and folic acid are required
- Erythocytes are manufactured in the marrow of bones by a process known as erythropoiesis
- The hormone erythopoietin (EPO) is responsible for the formation of erythocytes
- Polycaethemia is the overabundance of RBC
- It results in the increased blood viscosity, reduced flow rate and plugging of the capillaries

- **Leucocytes**
- They are amoeboid in shape, and are able to move
- They have nuclei and mitochondria at maturity
- Due to their amoeboid nature leucocytes are able to squeeze through pores in capillary walls and move to the site of infection
- On the other hand erythocytes are confined within blood vessels
- The movement of leucocytes is known as diapedesis

- There are between 5000 and 9000 leucocytes in every cubic millilitre of blood
- They are produced in the liver, spleen lymph nodes and in the bone marrow
- Grouped into 2 based on the presence or absence of granules in their cytoplasm
- Those with granules in their cytoplasm are granular leucocytes or granulocytes
- Those without granules are agranulocytes
- Granulocytes: 3 different types
- 1. Neutrophils- most bundant type of

- Leucocyte, accounting for 70% of all leucocytes., they have lobed nuclei
- They are phagocytic and are seen in large numbers at the site of infection
- They engulf and digest bacteria
- They are able to squeeze through capillary wall by diapedesis
- Many however succumb to the toxins of germs and are killed
- These dead corpuscles form the bulk of pus that collect at the site of infection

- **Acidophils/eosinophils**: forms about 2% of leucocytes and contain red-staining granules
- Found in large numbers in the blood when there is infestation with certain parasitic worms and certain cases of asthma
- **Basophils**: makes up between 0.5 and 1.0 % of leucocytes, with blue-staining granules
- **Agranulocytes**: Lymphocytes and monocytes
- Both are produced in the lymphatic tissues
- Lymphocytes produce globulin proteins, which include antibodies which attack and

- destroy disease-causing microorganisms
- They are the second most numerous leucocytes, accounting for 24% of leucocytes
- They are small, with large round nuclei, and little cytoplasm
- **Monocytes**: forms about 3% of leucocytes
- They are larger than RBC; between 10 and 15 microns in diameter
- They are phagocytic and act in conjunction with neutrophils

- **Platelets**
- They are the smallest of the formed elements, much smaller than erythrocytes
- They are produced when large bone marrow cells called megakaryocytes break up to form cell fragments
- The cell fragments that enter circulation as platelets lack nuclei and are capable of amoeboid movements
- There are between 250,000 and 400,000 platelets in every cubic millilitre of blood

- They survive for 5-9 days after which they are destroyed by the liver and the spleen
- They function to prevent bleeding by releasing vasoconstrictor hormone that assist the sealing of a cut vessel.They therefore assist in the clotting mechanism
- **Blood Vessels**
- The wall of arteries and veins are composd of 3 layers or tunics:
- The outermost layer is the tunica externa, composed of areolar (loose) connective tissues

- The middle layer is the tunica media, made up of smooth muscle
- The innermost layer is the tunica intima which consists of 3 parts:
- a) the innermost endothelium, made up of simple squamous epithelium
- b) basement membrane of the endothelium
- c) a layer of elastic fibres
- Although arteries and veins have the same basic structure, there are some important differences

- Artery: the aorta and other larger arteries contain many layers of elastic fibres between smooth muscle cells in the tunica intima
- These elastic fibres expand when pressure of the blood rises as a result of contraction of the heart muscle
- They recoil when blood pressure falls due to the relaxation of the heart muscle
- Small arteries and arterioles are less elastic but have thicker layer of smooth muscle in relation to their diameters

- Small arteries retain their diameters as pressure of blood rises and falls
- Since arterioles and small arteries have narrow lumina, they provide the greatest resistance to blood flow through the arterial system
- In some tissues, blood from the arterioles pass directly into venules through arteriovenous anastomoses
- In most cases however, blood from arterioles pass into capillaries

- **Veins**
- Most of the total volume of blood is contained in the veins
- Unlike the arteries which provide resistance to flow of blood from the heart, veins are able to expand to accumulate larger amounts of blood
- The average pressure of blood in veins is 2 mmHg, whilst arterial pressure averages 100 mmHg
- Low pressure is not sufficient to return blood to the heart, especially from the lower limbs

- Veins pass between skeletal muscle that produce a massaging action as they contract
- As the veins are squeezed by the contracting skeletal muscles, a one-way flow of blood to the heart is ensured by the presence of valves
- This mechanism aids the return of venous blood from the lower limbs to the abdominal veins
- Movement of venous blood from the abdominal to the thoracic veins is aided by the mechanism of breathing

- Contraction of the diaphragm increases the pressure in the abdomen, thus squeezing the abdominal veins and decreasing pressure in the thoracic cavity
- The pressure difference created forces blood into the thoracic veins that return venous blood to the heart
- **Capillaries**
- The arterial system branches to take blood to billions of capillaries in the body
- The walls of the capillaries are composed of

- only an endothelium which is one-cell thick, with narrow lumen
- There are no smooth muscles and connective tissue which permits the exchange of materials between the blood and the tissues
- **Types of Capillaries**
- Different organs have different types of capillaries, which are distinguished their differences in structure
- In terms of their endothelial lining, the capillary types include those that are:

- Continuous, discontinuous and fenestrated
- **Continuous** : adjacent endothelial cells are closely joined together
- They are found in muscles, adipose tissues and in the central nervous system
- They have large intercellular channels that allow the passage of molecules other than proteins between the capillary bed and tissue fluid
- **Fenestrated**: this is characterized by wide intercellular pores covered by a layer of

- mucoprotein which serves as a diaphragm
- Located in the kidneys, endocrine glands, small intestine
- Discontinuous: the distance between the endothelial cells is so great that the capillaries appear as sinusoids in the organs in which they are found
- Sinusoids are terminal blood vessels having larger diameter than an ordinary capillary
- Found in the bone marrow, liver, spleen etc

- **Structure of the Heart**
- The heart is located in a region known as the mediastinum- between the sternum, lungs and the thoracic vertebrae
- The heart is enclosed and protected by dense regular connective tissue called the parietal pericardium
- This tissue separates the heart from other thoracic organs and also forms the wall of the pericardial cavity
- The wall of the heart is composed of 3 layers:

- 1. **Epicardium**: forms the outermost layer and forms the visceral pericardium; this layer is composed of epithelial and connective tissues
- The space between this layer and the parietal pericardium forms the pericardial cavity
- It contains serous fluid which reduces friction between the outer surface of the heart and the parietal pericardium
- 2. **Myocardium**: this is the middle layer of the heart, composed of cardiac muscle tissue
- It is the thickest of the three layers

- The muscle tissues are arranged to form a bundle of muscle fibres
- The thickness of the myocardium varies in different chambers depending on the force needed to eject blood
- It is thinner in the atria because blood in the atria has to flow only a short distance into the ventricles
- **Endocardium**: this is the innermost layer of the heart and consists of endothelium and connective tissue
-

- The endocardium is continuous with the endothelium of blood vessels
- The endocardium also forms the valves of the heart and serves as protective inner lining of the chambers of the heart
- **Heart chambers and valves**
- The interior of the heart is divided into four chambers; 2 upper chambers, the atria (auricles) and 2 lower chambers the ventricles
- The atria contract and empty simultaneously into the ventricles, which contract in unison

- The atria are separated by thin interatrial septum
- The ventricles are separated by thick interventricular septum
- Left and right artrioventricular valves are located between the atria and ventricles
- The aorta and pulmonary artery have semi lunar valves at their bases
- The right atrium receives venous blood from superior vena cava- drains the upper part of the body; and inferior vena cava which drains

- the lower part of the body
- **Right Ventricle**
- Blood from the right atrium passes though the tricuspid valve into the right ventricle
- The tricuspid valve consists of 3 valves or cusps
- Each valve is held in place by fibrous cords known as chordae tendineae
- These are attached to the ventricular wall by papillary muscles
- These prevent the valves from moving into the

- auricle when the ventricle contracts
- When the ventricle contracts the tricuspid valve closes so that blood is forced through the pulmonary trunk
- Semilunar valves at the base of the pulmonary artery prevents the backflow of blood into the ventricle when it relaxes
- **Left atrium**
- Oxygenated blood is returned to the left atrium through the 4 branches of the pulmonary vein
- Contraction of the left atrium forces blood

- from the atrium into the left ventricle
- Left ventricle
- The left ventricle receives blood from the left atrium
- These two chambers are separated by the bicuspid or mitral valve
- When the ventricle is relaxed, the valve opens to allow blood from the atrium into the ventricle
- When the ventricle contracts the mitral valve closes to prevent the backflow of blood into

- the atrium
- The walls of the left ventricle is thicker than those of the right ventricle
- The endocardium of both ventricles is characterized by ridges called trabeculae carneae which serve to reinforce the endocardium
- Oxygenated blood is pumped out of the left ventricle through the ascending portion of the aorta. Aortic semilunar valves at the base of the ascending aorta closes when the ventricle

- Relaxes preventing the backflow of blood into the relaxed ventricle
- **Circulatory Routes**
- The circulatory route is divided into pulmonary and systemic circulations
- **Pulmonary circulation**: consists of blood vessels that transport blood from right ventricle through the pulmonary trunk which takes blood to the lungs
- It includes the 4 pulmonary veins that transport oxygenated blood back to the heart

- **Systemic circulation**
- This involves the flow of blood though the system of blood vessels that carry oxygenated blood from the left ventricle through the aorta to the tissues and back to the heart through the right atrium
- It includes the aorta with its semilunar valves, all branches of the aorta, all capillaries other than those in the lungs and all the veins except the pulmonary veins

- All arteries of the systemic circulation branch directly from the aorta, made up of 3 branches: ascending aorta, aortic arch and descending aorta
- 1. Ascending aorta-passes superiorly from the left ventricle; right and left coronary arteries branch from the base of ascending aorta and supply blood to the cardiac muscles
- 2. Aortic arch- the aorta arches posteriorly to the left as aortic arch; it has 3 major arteries that carry blood to the head and upper limbs

- These are brachiocephalic artery, left common carotid artery and left subclavian artery
- 3. Dorsal/descending aorta- the longest part of the aorta; made up of two parts;
- **Thoracic aorta-**extend through the thorax to the diaphragm
- **Abdominal aorta-** extends from the diaphragm to the point where it divides into 2 common iliac arteries
- Heartbeat: consists of 2 stages: Systole- contraction of the heart muscle

- Diastole, the relaxation of the heart muscle
- Systole: during systole, the two atria are filled with blood and contract simultaneously
- Pressure created forces the artrioventricular valves to open
- Deoxygenated blood flows from the right atrium into right ventricle; oxygenated blood from the left auricle flows into the left ventricle
- This is followed by the simultaneous contraction of both ventricles which send

- Blood through the pulmonary trunk and aorta to the lungs and various organs respectively
- The artrioventricular valves close when the ventricles contract
- Diastole: during diastole, blood enters all four chambers
- During this time, both the atria and ventricles are relaxed and venous blood fills the atria
- Pressure build up causes the artrioventricular valves to open and blood flows from the atria into the ventricles

- The ventricles are about 80% filled with blood, even before the atria contract
- Contraction of the atria add the final 20% to the end-diastolic i.e volume of blood in the ventricles at the end of diastole
- The series of events is called the cardiac cycle which is the repeated cycle of contraction and relaxation of the muscles of the heart
- **Heart Sounds**
- Closing of the atrioventricular valves and semilunar valves produces sounds that can be

- Heard at the surface of the chest with a stethoscope
- These sounds are often described as ‘lub-dub’
- The ‘ lub’ or first sound is produced by closing of the AV valves during the contraction of the ventricles
- The dub’ or second sound is produced by closing of the semilunar valves when the pressure in the ventricle falls below the pressure in the arteries
- The first sound is thus heard when the

- Ventricles contract at systole ; the second sound is heard when the ventricles relax at the beginning of diastole
- **Electrical activity of the heart**
- In the heart there is only one region that demonstrates electrical activity and as a result functions as pacemaker
- This pacemaker region is called the sinoatrial node, or SA node
- The SA node is located in the right atrium near the opening of the superior vena cava

- Action potentials that originate in the SA node spread to adjacent myocardial cells of the right and left atria
- The myocardium of the atria are separated from the myocardium of the ventricles by a fibrous skeleton of the heart
- Thus impulses cannot be conducted directly from the atria to the ventricles
- Specialized conducting tissues composed of specialized myocardial cells are required
- These cells form the atrioventricular node

- (AV node), which is located on the inferior portion of the interatrial septum
- Once the impulse spreads through the atria, it passes to the atrioventricular node (AV node) located at the inferior portion of the interatrial septum
- The AV node is smaller than the SA node
- From here, the impulse continues through the atrioventricular bundle (bundle of His) beginning at the top of the interventricular septum

- This conducting tissue pierces the fibrous skeleton of the heart and continues to descend along the interventricular septum
- The atrioventricular bundle divides into the left and right branches, which are continuous with the conduction myofibres or Purkinje fibres within the ventricular walls
- Stimulation of these fibres causes both ventricles to contract simultaneously to eject blood into the pulmonary and systemic circulations

- Lymphatic system
- The lymphatic system includes lymph, lymphocytes, lymphatic vessels, lymph nodes, tonsils, the spleen and the thymus gland
- **Functions:**
- 1 Fluid balance: approximately 30L of fluid pass from the blood capillaries into the interstitial spaces each day, whereas about 27L pass from the interstitial spaces back into the blood capillaries
- If the extra 3L is allowed to remain in the

- Interstitial spaces, oedema results, damaging the tissues and resulting in death
- Instead the 3 L of fluid enters the lymph capillaries where the fluid is called lymph
- 2. **Fat absorption**: The lymphatic system absorbs fats and other substances from the digestive tract. Special lymphatic vessels called lacteals are located in the small intestine Fats enter the lacteals and pass through the lymphatic vessels to the venous circulation
- 3. **Defence**: Microorganisms and other foreign

- Substances are filtered from lymph by lymph nodes and from blood by the spleen. In addition, lymphocytes and other cells are capable of destroying microorganisms and other foreign substances
- **RESPIRATION**
- The term respiration refers to three separate but related functions:
- 1. Ventilation (breathing)
- 2. Gas exchange- occurs between the air and the blood and between the blood and other tissues

- 3. Oxygen utilization by the tissues- cell respiration
- Ventilation and the exchange of gases between the air and the blood are collectively called external respiration
- Gas exchange between the blood and other tissues and oxygen utilization are collectively called internal respiration
- **Respiratory System**
- The respiratory system consists of the nose, nasal cavity, pharynx, larynx, trachea, bronchi

- bronchioles and the lungs
- **Nose and nasal cavity**
- The nose includes the external portion that protrudes out from the face and an internal nasal cavity for the passage of air
- The external portion of the nose is supported by paired nasal bones (forming the nose bridge) and cartilage
- Air enters the respiratory tract through the nostrils or the mouth
- The nostrils act as filters and warms the air

- before it enters the nasal chambers
- The surface area of the nasal chambers is increased by outfoldings of mucous membranes
- The mucous membranes secrete mucus to keep the nasal cavity moist
- The anterior openings of the nasal cavity are lined with stratified squamous epithelium
- The conchae (lateral walls) are lined with pseudostratified ciliated columnar epithelium
- The nasal cavity performs three functions:

- 1. The nasal epithelium warms, moistens and cleanses the air
- 2. The olfactory epithelium in the upper portion of the nasal cavity responds to inhaled chemicals during olfaction
- 3. The nasal cavity is associated with voice phonetics by functioning as resonating chamber
- **Pharynx**
- The pharynx is a funnel-shaped passageway that connects the nasal and oral cavities to the

- larynx at the base of the skull
- The walls of the pharynx are composed of skeletal muscle and the lumen is lined with mucous membrane
- Within the pharynx are paired lymphoid organs called tonsils
- The pharynx has both respiratory and digestive functions and is divided into three regions on the basis of location and functions: nasal, oral and laryngeal
- The nasopharynx has respiratory function only

- It is the uppermost portion of the pharynx, posterior to the nasal cavity
- The paired auditory (eustachian) tubes connect the nasopaharynx with the middle ear cavities
- A collection of lymphoid tissue called pharyngeal tonsils, or adenoids are situated in the posterior wall of this cavity
- The **oropharynx** is the middle portion of the pharynx and the base of the tongue forms the anterior wall of the oropharynx
- Paired palatine tonsils are located along the

- Posterior lateral wall of the oropharynx and lingual tonsils are found on the base of the tongue
- This portion of the pharynx has both respiratory and digestive functions
- The laryngopharynx is the lowest portion of the pharynx
- It extends from the level of the hyoid bone to the larynx and opens into the oesophagus and larynx. Swallowed food and fluid is directed into the oesophagus, whereas inhaled air is

- moved into the larynx
- **Larynx**
- The larynx or voice box forms the entrance into the lower respiratory system as it connects the laryngopharynx with the trachea
- The larynx prevents food from entering the trachea and lungs during swallowing and to permit the passage of air while breathing
- It is shaped like a triangular box, composed of 9 cartilages; 3 are large and single and 6 are smaller, paired structures

- The largest of the unpaired cartilages is the anterior thyroid cartilage
- The spoon-shaped epiglottis has a cartilaginous framework. It is behind the root of the tongue and aids in closing the glottis during swallowing
- The lower end of the larynx is formed by the cricoid cartilage
- This third unpaired cartilage connects the thyroid cartilage above and the trachea below

- Trachea (windpipe)
- The trachea is a rigid tube about 12 cm long positioned anterior to the oesophagus and connects the larynx to the bronchi
- The wall of the trachea is supported by C-shaped rings of hyaline cartilage
- The open part of the C is positioned posteriorly covered by fibrous connective tissue and smooth muscle
- The cartilage provides a rigid but flexible tube that allows the airway to be permanently open

- The walls of the trachea are lined by mucous membrane and has ciliated epithelium containing goblet cells which secrete mucus
- Bronchial tree
- The trachea branches into 2 at its lower end into the left and right bronchus
- Each bronchus has hyaline cartilage rings surrounding its lumen to keep it open
- The bronchus divides deeper in the lungs to form secondary bronchi and tertiary bronchi
- These form the bronchial tree, so named

- Because it is composed of a series of respiratory tubes that branch into narrower tubes as they extend into the lungs
- The bronchial tree continues to branch into yet smaller tubules called bronchioles
- There is almost no cartilage in the bronchioles and the smooth muscles in their walls can constrict or dilate these airways
- Simple cuboidal epithelium lines the bronchioles rather than the pseudostratified epithelium that lines the bronchi

- There are many terminal bronchioles in the alveoli. These mark the end of the air conducting pathway
- **Mechanism of Breathing**
- Breathing, also called pulmonary ventilation has 2 phases: inhalation and exhalation
- Movement of air results from the rhythmic increase and decrease in the volume of the thoracic cavity
- The mechanism of inhalation operates in the following ways:

- 1. Contraction of muscles- the main ones are the diaphragm and the intercostal muscles
- There are 2 sets of intercostal muscles: external intercostal muscles which contracts and internal intercostal muscles which relax
- When the external intercostal muscles contract, they pull the ribs closer, causing the enlargement of the thoracic cavity
- The increase in the thoracic cavity is further enhanced when the diaphragm contracts and flattens

- The increased size of the thoracic cavity causes the pressure of air in the thoracic cavity to drop below atmospheric pressure, allowing air to rush into the lungs causing the to inflate
- During exhalation, the external intercostal muscles relax, whilst the internal intercostal muscle contract
- This allows the thoracic cavity to return to its original size, increasing the pressure in the thoracic cavity.The abdominal muscles contract, pushing the

- abdominal organs against the diaphragm, which relaxes, decreasing the volume of the thoracic cavity and increasing the pressure within the thoracic cavity
- The above processes cause the lungs to contract and compress the air in the alveoli
- With this compression, the alveolar pressure becomes greater than atmospheric, causing air to be expelled from the lungs
- **ASSIGNMENT:** Read about exchange of gases in the alveoli

- **Erythrocytes and transport of oxygen**
- Erythrocytes are important because they carry oxygen from one part of the body to another
- They are able to do this because they contain the pigment haemoglobin, which belongs to a group of substances called respiratory pigments
- Hb is a complex molecule consisting of a protein, globin to which is attached the coloured pigment , haem- made up of iron and porphyrin (complex organic substances which

- contain carbon, hydrogen and nitrogen)
- In the lungs, haemoglobin in the red blood cells combines with oxygen to form oxyhaemoglobin
- As blood takes up oxygen it becomes brighter red in colour
- This oxygenated blood is returned to the heart through the pulmonary veins and distributed to various parts of the body through the aorta and its branches

- **Oxygen dissociation curve of haemoglobin**
- Large amounts of oxygen can be carried by the blood haemoglobin
- 100 ml of water in contact with alveolar air hold 1/3 ml of oxygen, whereas the same volume of blood holds 20ml of oxygen
- The average human body contains about 6L of blood and can therefore carry 1200 ml of oxygen
- The amount of oxygen held by the blood depends on the partial pressure of oxygen

- in the surrounding medium
- The relationship between the amount of oxygen held by the blood and the partial pressure of oxygen in the surrounding has been studied by placing known volumes of blood into bottles and then admitting air containing known partial pressures of oxygen
- The bottles are suspended in a water bath at constant temperature and rotated so that the blood comes into contact with the air
- After a fixed time samples of blood are taken to determine the

- oxygen content
- When the % saturation of the blood with oxygen is plotted against the partial pressure of oxygen in air, a sigmoid shaped graph is produced , called the dissociation curve of oxyhaemoglobin
- In the lungs of man the partial pressure of oxygen is 100 mmHg; at this level, the blood in the lungs is 95% saturated
- The oxygen tension at which the Hb is 95% saturated is called the loading tension or tension of saturation

- The flat upper part of the curve, at oxygen pressures above 80mm Hg means that the arterial blood will remain almost saturated in spite of wide variations of oxygen in the air
- If there was a fall of 20 mmHg in partial pressure of oxygen in the air the blood will almost be saturated with oxygen
- The tension at which the pigment is 50% saturated is called the unloading tension/half saturation and this occurs in the tissues

- The dissociation curve of haemoglobin is influenced by a variety of factors such as carbon dioxide and temperature
- When there is a rise of carbon dioxide and temperature, the haemoglobin will hold less oxygen for a given partial pressure of oxygen
- This is indicated by a shift of the curve to the right
- The affinity of Hb for oxygen is decreased when the pH is lowered and increased when the pH is raised. This phenomenon is called the Bohr effect

- When the affinity of Hb for oxygen is reduced, there is slightly less loading of the blood with oxygen in the lungs but greater unloading of oxygen in the tissues
- The net effect is that the tissues receive more oxygen when the blood pH is lowered
- Since the pH can be decreased by carbon dioxide, the Bohr effect helps to provide more oxygen to the tissues when carbon dioxide is increased
- This has the important effect of increasing the

- amount of oxygen liberated from Hb in the tissues where the carbon dioxide content is high
- In this case the oxyhaemoglobin dissociation curve shifts to the right
- **Assignment: Read about respiratory pigments**
- **Tissue Respiration**
- Tissue respiration occurs in 3 stages: 1.Glycolysis 2. Kreb's (tricarboxylic acid) cycle 3. Electron transport system

- Glycolysis: This is an anaerobic process which occurs in the cytoplasm of the cell
- The first stage involves the phosphorylation of glucose using ATP
- Glucose becomes converted into glucose-6-phosphate under the influence of the enzyme hexokinase
- The next stage involves the conversion of glucose-6-phosphate to fructose-6-phosphate (5 membered ring)
- This compound is phosphorylated by another

- ATP to yield fructose 1, 6, diphosphate
- Fructose 1,6 diphosphate splits into 2 three carbon fragments: dihydroxyacetone phosphate and glyceraldehyde 3- phosphate (3- phosphoglyceraldehyde)
- Only 3 phosphoglyceraldehyde can be used as a source of energy
- Dihydroxyacetone phosphate can be converted to 3- phosphoglyceraldehyde by an enzyme phosphotriose isomerase
- 3 phosphoglyceraldehyde becomes oxidized

- by the coenzyme NAD in the presence of phosphoric acid to form diphosphoglyceric acid. It is an oxidation process
- There is redistribution of energy within the molecule with the formation of high energy phosphate group
- The phosphate group is transferred to ADP forming ATP and phosphoglyceric acid
- There is an internal molecular rearrangement of phosphoglyceric acid to produce phosphoenol pyruvic acid containing a

- phosphate group, which is transferred to ADP to yield ATP and enol pyruvic acid
- This passes to a more stable form, keto-pyruvic acid
- Since fructose 1,6- diphosphate gave 2, 3C fragments it can be seen that 4 molecules of ATP are produced in the breakdown of glucose to pyruvic acid
- However, since 2 molecules of ATP were utilized in the formation of fructose diphosphate, the net yield is 2 ATP molecules

- for each molecule of glucose broken down to produce pyruvic acid
- In the absence of oxygen to accept the hydrogen carried by NAD, the reduced coenzyme accumulates in the cell
- There is only a limited amount of NAD in the cell and for the breakdown of glucose to continue, NAD must pass its hydrogen to other hydrogen acceptor
- In mammalian muscle tissue, in the absence of oxygen, $NADH_2$ passes its hydrogen on to

- pyruvic acid to produce lactic acid
- **Tricarboxylic acid (Kreb's) cycle**
- Pyruvic acid from glycolysis undergoes decarboxylation and dehydrogenation to form a 2C compound, Acetic acid
- This combines with co-enzyme A to form acetyl CoA, which enters the mitochondrion
- Acetyl CoA enters the TCA cycle by combining with a 4C compound, oxaloacetic acid

- The hydrogen acceptor for four out of five dehydrogenations is NAD, but that for the stage between succinate and fumarate is FAD
- One molecule of ATP is formed during the cycle
- **Electron transport System and Oxidative Phosphorylation**
- At the end of glycolysis and tricarboxylic acid cycle, there will be a pool of hydrogen carriers, $NADH_2$ and $FADH_2$
- The transfer of the energy contained in the

- hydrogen carriers , with the ultimate reduction of oxygen to yield water, yields by far the greatest amount of energy
- The components of the electron transport system are located in the cristae of the mitochondrion
- The electron transport chain consists of flavoproteins, coenzyme Q and the cytochromes (iron-containing pigments) eg cytochrome b, c a-a_3
- During the ETS, $NADH_2$ enters the

- Respiratory chain and transfers electrons to the flavoproteins (proteins using flavin as prosthetic group)
- Hydrogen is then transferred between the flavoproteins and the cytochromes through coenzyme Q (a stronger oxidizing agent than flavoproteins but a weaker one than cytochrome b
- The electrons from hydrogen are transferred to cytochrome b which changes from oxidized Fe $^{3+}$) to its reduced form (Fe $^{2+}$)

- The electrons continue via cytochrome c and a-a_3 in each case changing from the oxidized to the reduced form
- The final stage is the formation of water by combination between 2 hydrogen atoms and a single oxygen atom
- In the biochemical route followed so far the generation of ATP has come from the following sources
- 1. Glycolysis 2ATP
- 2NADH2 6ATP

- 2. TCA (Two pyruvate molecules)
- b/n α-ketoglutaric acid and succinic acid 2ATP
- b/n succinic acid and fumaric acid 2FAD → $2FADH_2$
- Generation of $4NADH_2$ twice gives $8NADH_2$
- 3. Oxidative phosphorylation (ETS)
- $2FADH_2$ yields 2x2 = 4ATP
- $8NADH_2$ yields 8x 3 = 24ATP
- Total 38 ATP

- **IMMUNE SYSTEM**
- The immune system includes all structures and processes that provide defence against potential pathogens
- It is grouped into non-specific and specific categories
- The non-specific or innate defence mechanisms are inherited as part of the structure of the organism
- For example epithelial membranes that cover the body surface restrict infection by most

- pathogens
- The strong acidity of gastric juice helps to kill microoganisms before they can invade the body
- Pathogens that cross the epithelial barriers enter the connective tissues
- These invaders or their toxins may enter the blood or lymphatic capillaries and carried to all parts of the body
- To be able to counter the invasion and spread of infection, non-specific immunity are

- employed
- If these are not sufficient to destroy the pathogens, lymphocytes may be used
- **Phagocytes:**
- There are 3 major groups of phagocytic cells:
- 1. Neutrophils
- 2. Mononuclear phagocyte system- monocytes and macrophages
- 3. Organ-specific phagocytes eg those located in the spleen, liver, lymph nodes, lungs etc

- Kupffer cells in the liver and phagocytic cells in the spleen and lymph nodes are fixed phagocytes
- These cells are fixed (immobile) in the walls of sinusoids within these organs
- As blood flows through the capillaries of the liver and spleen foreign chemicals are removed by phagocytosis and chemically inactivated within the phagocytic cells
- Connective tissues also have leucocytes eg neutrophils and monocytes are highly mobile

- within connective tissues
- These leucocytes move to the site of infection by a process known as chemotaxis i.e movement towards chemical attractants
- Fever: Fever is a component of non-specific defence system
- Body temperature is regulated by the hypothalamus, which is the thermoregulatory centre (thermostat)
- The hypothalamus coordinates skeletal muscle shivering and the activity of the

- Sympathoadrenal system to maintain the body temperature at about 37 ^{o}C
- The thermostat is reset upward in response to a chemical called endogenous pyrogen, secreted by leucocytes
- Endogenous pyrogen secretion is stimulated by a chemical called endotoxin, which is released by certain bacteria
- It is believed that mild to moderate fever may be a beneficial response that aids recovery from bacterial infections

- One theory is that elevated temperature may interfere with the uptake of iron by some bacteria
- Interferons: Discovered in 1957 that cells infected with a virus produce polypeptides that interferred with the ability of a second unrelated strains of virus to infect other cells of the same culture
- They produce a non-specific short acting resistance to viral infection
- There are three major categories of interferons:

- Alpha, beta and gamma
- Almost all cells in the body make alpha and beta interferons; these polypeptides act to protect other cell in the vicinity from viral infection
- Even though viruses are able to penetrate these other cells, their ability to replicate is inhibited
- On the other hand gamma interferons is only produced by particular lymphocytes related to cells called natural killer cells

- **Specific Immunity**
- In 1890, a German bacteriologist, Emil Adolf von Behling demonstrated that a guinea pig that had previously been injected with sublethal dose of diphtheria toxin could survive injections of lethal doses of that toxin
- He showed that this immunity could be transferred to a second non-exposed animal by injections of serum from the immunized guinea pig
- He concluded that the immunized animal had

- Chemicals in its serum, called antibodies that were responsible for the immunity
- These antibodies conferred immunity only to subsequent diphtheria infections
- The antibodies are therefore specific in their actions
- **Antigens**: These are protein molecules that stimulate the production of antibodies and combine with these specific antibodies
- Antigens are large molecules, foreign to the blood and other body fluids

- This is because the immune system can distinguish itself from non-self and normally mounts an immune response against non-self antigens
- Lymphocytes: Leucocytes, erythrocytes and platelets are derived from unspecialized cells in the bone marrow
- These stem cells produce the specialized blood cells
- They replace themselves by cell division so that stem cell population are not exhausted

- Lymphocytes produced in this manner seed the thymus, spleen and lymph nodes
- Lymphocytes that become seeded in the thymus become T. lymphocytes
- These have surface characteristics and immunological functions different from other lymphocytes
- The thymus in turn seeds other organs
- Between 65 and 85% of lymphocytes in the blood, lymph nodes and spleen are T lymphocytes

- Most of the other lymphocytes that are not T lymphocytes are called B lymphocytes
- Both T and B lymphocytes function in specific immunity
- Antibodies: Also known as immunoglobulins
- These belong to the gamma globulin class of plasma proteins
- There are five types of immunoglobulins(Ig)
- **IgG-** this is the main form of antibodies in circulation. Its production increase after immunization against a particular disease

- **IgA-** this the main antibody type in external secretions such as saliva and mother's milk
- **IgE-** responsible for allergic symptoms in hypersensitivity reactions
- **IgM-** function as antigen receptors on lymphocyte surface prior to immunization
- **IgD-** function as antigen receptor on lymphocyte surface prior to immunization
- **Active and Passive immunity**
- When a person is first exposed to a pathogen, the immune response may be insufficient to

- combat the disease
- In the process, the lymphocytes are stimulated to divide many times to produce a clone
- This is active immunity and can protect the person from getting the disease upon subsequent exposures
- **Active Immunity**
- The development of active immunity requires initial exposure to the specific antigens
- The initial response may cause the person to develop symptoms of the disease

- Immunization programmes induce responses by innoculating people with pathogens whose virulence has been destroyed, or using closely-related strains of micro-organisms that are antigenetically similar but less pathogenic
- This is also known as vaccination
- These procedures cause the development of lymphocyte clones that can combat the virulent pathogens by producing secondary responses

- **Passive Immunity**
- This refers to the immune protection that can be produced by the transfer of antibodies to a recipient from one person or from an animal
- In this case the donor has been actively immunized
- The person who receives the ready-made antibodies is thus passively immunized to the same antigens
- Passive immunity also occurs naturally in the transfer of immunity from mother to foetus

- during pregnancy
- The ability to mount a specific immune response, called immunological competence does not develop until about one month after birth
- The foetus therefore cannot immunologically reject the mother
- **MUSCULAR SYSTEM**
- Skeletal muscles are made up of individual muscle fibres that contract when stimulated by a motor neuron

- Skeletal muscles are usually attached to bone on each end by tough connective tissue, tendons
- When a muscle contracts , it shortens and this places tension on its tendons; this causes movement of the bones at the joint
- The points of attachment of a muscle are its origin and insertion
- At these point the muscle is connected to the bone by a tendon
- The origin(the head) is the most stationary end

- end of the muscle
- The insertion is the end of the muscle attached to the bone undergoing the greatest movement
- The part of the muscle between the origin and the insertion is the body
- **READ ABOUT THE STRUCTURE OF SKELETAL MUSCLE**
- Major components of muscles in the body
- Ocular muscles: movement of the eyeball is controlled by 6 extrinsic ocular muscles
- These are 4 rectus muscles that manoeuvre the

- eyeball; these are superior, inferior, lateral and medial
- There are 2 oblique muscles (superior and inferior) and these rotate the eyeball on its axis
- **Muscles for mastication**
- There are 4 pairs of muscles for mastication. They are some of the strongest muscles in the body
- Temporalis and masseter- these are found below the cheek
- Pterygoid muscles-2 pairs; these are deep to

- the mandible
- **Muscles of the tongue**
- The tongue consists of a mass of intrinsic muscles; they are entirely located within the tongue and function to change its shape
- Extrinsic muscles are located outside the tongue, but are attached to and move the tongue
- The three pairs of extrinsic muscle are genioglossus, styloglossus and hyoglossus
- Each of the extrinsic muscles is innervated by

- hypoglossal (12^{th}) cranial nerve
- **Muscles of the Neck**
- These muscles either support and move the head or are attached within the head region
- The posterior muscles includes: 1. 1.**Sternocleidomastoid** muscles; this muscle originates from the sternum and clavicle and inserts on the mastoid process of the skull
- Torticollis (twisted neck) results from injury to one of the sternocleidomastiod muscles
- This muscle is located on anterior and lateral

- sides of the neck
- When contracted it turns the head sideways in a direction opposite to where the head is located
- 2. **Trapezius-** it is primarily a muscle of the back, but extends over the posterior neck region
- 3. **Splenius capitus** is a broad muscle positioned on the trapezius
- When it contracts on one side the head rotates and extends to one side

- **Muscles of the Thorax**
- The muscles of the thorax are involved in the process of breathing
- The external intercostal muscles, when it contracts raise the ribs during inspiration
- The internal intercostal muscles contract during forced expiration
- The major movement in the thorax during quiet breathing is accomplished by the diaphragm; when it contracts it flattens, causing the volume of the thoracic cavity to

- increase and resulting in inspiration
- **Abdominal muscles**
- The anterolateral abdominal wall is composed of 4 pairs of flat muscles
- 1. **External abdominal oblique** is the strongest and most superficial of the muscles of the lateral body wall
- 2. **Internal abdominal oblique** lies deep to the external abdominal oblique
- 3. **Transverse abdominis**, the deepest of the abdominal muscles

- 4. **Rectus abdominis**; this is enclosed in a fibrous sheet-like tendon of the other three abdominal muscles
- The **linea alba** is a band of connective tissue on the midline of the abdomen that separates the two abdominus muscles
- **Muscles of the appendicular skeleton**
- Muscles that act on the Pectoral Girdle
- The connection of the upper limb to the body is through muscles
- The muscles that attach the scapula to the

- thorax and move the scapula include:
- 1. Trapezius. Levator scapulae, rhomboideus muscles, forming the posterior group
- 2. the anterior group include the serratus anterior, pectoralis minor and subclavius muscle
- These muscle act as fixators to hold the scapula firmly in position when the muscles of the arm contract
- The above muscles originate on the axial skeleton

- The non-axial muscles include:
- 1. Deltoid – attaches the humerus to the scapula and clavicle and also caps the shoulder joint
- 2. Supraspinatus- laterally rotates the humerus and is synergistic to the deltoid
- 3. Infraspinatus-rotates the humerus laterally
- 4. Teres major 5. Teres minor
- **Muscles that move the arm**
- The arm is attached to the thorax by pectoralis major and latissimus dorsi

- **Pectoralis major** is the large chest muscle that binds the humerus to the scapula; it is the principal flexor muscle of the arm
- **Latissimus dorsi** is the large flat triangular muscle that covers the lower half of the thoracic region of the back
- It is antagonistic to the pectoralis major
- It is commonly called the swimmers muscle
- **Muscles that act on the forearm**
- These muscles are divided into anterior and posterior compartments

- The triceps brachii, the primary extensor of the forearm occupies the posterior compartment
- The anterior compartment is occupied by the biceps brachii and the brachialis, forming the flexors of the forearm
- The brachioradialis, a posterior forearm muscle helps to flex the forearm
- The biceps brachii is antagonistic to the triceps brachii

- Muscles of the forearm
- Muscles that cause the wrist, hand and finger movement are positioned along the forearm
- These muscles act on two joints; the elbow and wrist
- 1. flexor carpi radialis- extends across the anterior surface of the forearm
- 2. palmis longus-superficial in position on the anterior surface of the forearm; it assists in flexing the wrist
- 3. flexor carpi ulnaris-positioned on medial

- anterior side of the forearm and assists in flexing the wrist
- 4. superficial digital flexor-lies directly beneath the 3 described
- 5. deep digital flexor- lies deep to the superficial digital flexor; these 2 muscles flex the wrist
- 6. flexor pollicis longus- deep lateral muscle of the forearm that flexes the thumb and assists in grasping

- **Lower limb muscles**
- Thigh muscles; muscles that move the thigh originate from the pelvic girdle and insert on the femur
- These muscles stabilize a highly movable hip joint
- These muscles are divided into anterior, posterior and medial groups
- The anterior muscles are iliacus and psoas, commonly called iliopsoas; flexes the thigh
- The posterior muscles that move the thigh

- include the gluteus maximus, gluteus medius and gluteus minimus and tensor fasciae latae
- The gluteus maximus is large and forms much of the buttocks; it is a powerful extensor muscle of the thigh

  Hamstring muscles- semitendinosus, biceps femoris and semimembranosus
- Leg muscles:
- The 13 muscles in the leg, with tendons extend into the foot
- The superficial muscles of posterior

- Compartment of the leg are the gastrocnemius and soleus; these form the bulk of the calf
- These muscle are the flexors involved in the flexion of the foot
- They join to form the calcaneal or Archilles tendon
- The lateral muscles of the leg, the peroneus are the primarily everters i.e turning the lateral side of the foot outwards
- The 20 muscles in the foot are called intrinsic foot muscles