MEDICAL LAB TECHNOLOGY- (E CONTENT)

A. LAVANYA M.Sc., PGDMLT

&

S. ASIFA TABASSUM M.Sc., PGDMLT

L. DHIVYA., Ph. D

Assistant Professor

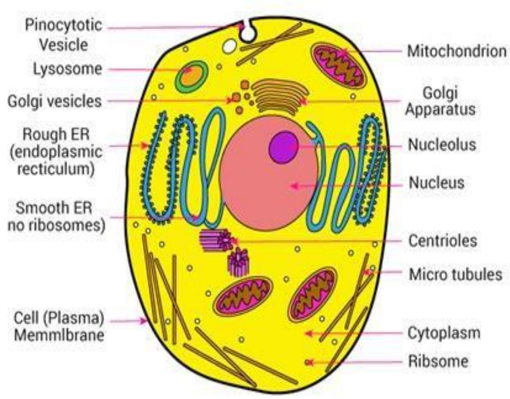
Department of Biotechnology

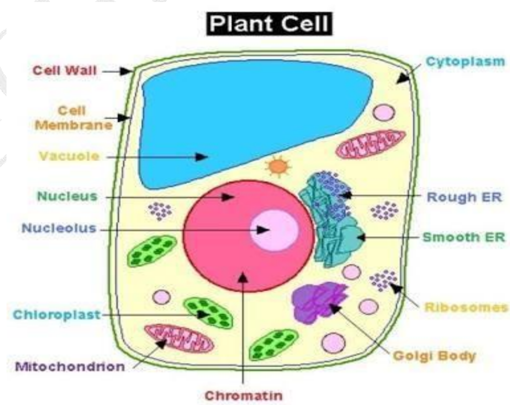
CELL- STRUCTURE AND FUNCTIONS

INTRODUCTION

All living things are composed of cells. Cells are the basic units of life and all tissues and organs are composed of cells. They are so small that they must be viewed with a microscope. There are different types of cells. Cells can either be eukaryotic or prokaryotic.

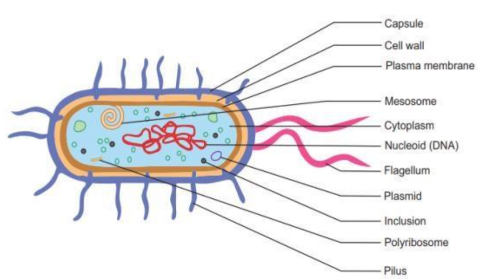
Eukaryotic cells have a nucleus and membrane bound organelles. Plant and animal cells are eukaryotes. Plant cells are generally a square shape while animal cells are usually circular. Plant cells and animal cells have evolved different organelles to perform specific functions. Plant cells have chloroplasts, a cell wall and a central vacuole. Animal cells lack these three organelles. Plant cells have chloroplasts because they make their own food. Plant cells have a cell wall so that they do not burst when the central vacuole fills up with water.





Animal cell   Plant cell

Prokaryotes do not have a nucleus and lack membrane bound organelles. They are the oldest cells on earth. Bacteria are prokaryotes. Prokaryotes often move using special structures such as flagella or cilia.



Structure of Bacterial cell

Cells have many structures inside of them called organelles. These organelles are like the organs in a human and they help the cell stay alive. Each organelle has its own specific function to help the cell survive. The nucleus of a eukaryotic cell directs the cell's activities and stores DNA. Eukaryotes also have a Golgi apparatus that packages and distributes proteins. Mitochondria are the power house of the cell and provide the cell with energy. Both plant and animal cells have mitochondria. Lysosomes are like the stomach of the cell. They contain enzymes that digest the cell's used parts. All of the cell's organelles must work together to keep the cell healthy.

The cell membrane is the protective barrier that surrounds the cell and prevents unwanted material from getting into it. The cell membrane has many functions, but one main function that it has is to transport materials (salts, electrolytes, glucose and other necessary molecules) into the cell to support necessary life functions. Not only does the membrane let molecules into the cell, but it also lets wastes such as carbon dioxide out of the cell. The cell membrane is made up of a Phospholipids bilayer. Each Phospholipids contains a hydrophilic or water loving head and a hydrophobic or water fearing tail. These properties that the phospholipids have and the specific orientation they are arranged in provide the cell with a selectively permeable barrier.

CELL

- Cell is the fundamental, Structural and functional unit of all living organisms.
- **Robert Hooke** (1665) – an English scientist who observed honeycomb like dead cells and coined the term ―CELL‖
- **Anton Von Leeuwen hock** first described a living cell (1667)
- **Robert Browne** discovered Nucleus (1833)

CELL THEORY:

- Mathias J Schleiden (1838); a German botanist and Theodore Schwann (1839); a British Zoologist proposed cell theory.
- All living organisms are composed of cells and product of cells
- All cells arise from pre- existing cells through the process of cell division
- The body of living organisms is made up of one or more cells

CELL NUMBER, SHAPE AND SIZE

- Unicellular organisms – Organisms with single cell, capable of independent existence and carries all functions like Digestion, Excretion, Respiration, Growth & Reproduction (A cellular). Examples – Amoeba & Euglena
- Multi cellular organisms – Organisms with more than one cell
- Cells in Multi cellular organisms vary in size & shape depending on function.

SHAPE:

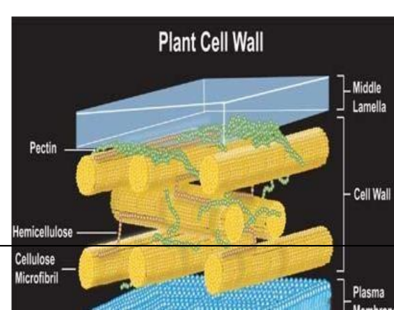
- Parenchyma - Polyhedral cells performs storage.
- Sclerenchyma - spindle shaped cells & provides mechanical support,
- Nerve cells- long and branched cells conducting nerve impulses
- RBC -Biconcave & helps in carrying oxygen
- Muscle cells- cylindrical or spindle shaped concerned with the movement of body parts.

SIZE:

- Varies from few microns (1cm= 10mm; 1mm=1000µm) to few cms
- Smallest living cell is PPLO (Pleuro Pneumonia Like Organism) - 0.1µm
- Largest living cell is Egg of an Ostrich, 170 to 180 mm in diameter.
- Bacteria – 0.1 to 0.5 µm
- Sclerenchyma fibre up to 60cms in length

CELL STRUCTURE AND FUNCTIONS:

- Cell has Non living outer layer called CELL WALL found only in plant cells
- Below cell wall is CELL MEMBRANE
- CELL MEMBRANE encloses PROTOPLASM
- PROTOPLASM has semi fluid matrix called CYTOPLASM and large membrane bound structure called NUCLEUS
- CYTOPLASM has many membrane bound organelles like Endoplasmic Reticulum, Golgi Bodies, Mitochondria, Plastids and Vacuoles.
- They also have non membrane bound structures called Ribosome's and Centrosomes
- Cytoplasm without Cell organelles is called Cytosol.

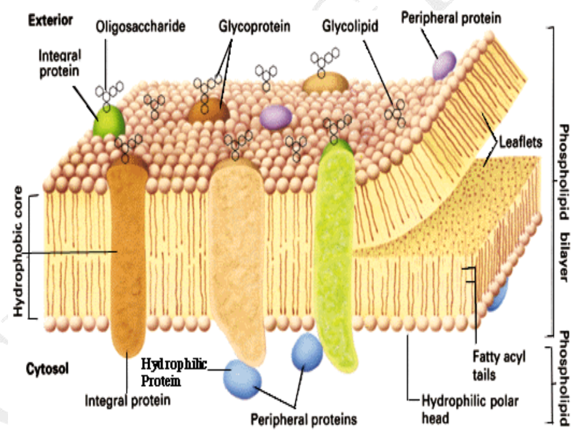


CELL WALL:

- Outer most layer, non living ,rigid & Permeable
- Found in bacterial cells, fungal cells and plant cells.
- Made up of cellulose (in bacteria- Peptidoglycans, in fungus- Chitin)

Function: Rigidity, mechanical support and protection

CELL MEMBRANE OR PLASMA MEMBRANE:



- Present in all cells, just below the cell wall in plant cells, outer most membrane in animal cells
- Semi-permeable
- Made up of phospholipids, proteins, carbohydrates and Cholesterol

Function:

- It allows outward and inward movement of molecules across it like diffusion, osmosis,
- active transport, Phagocytosis and Pinocytosis

PROTOPLASM:

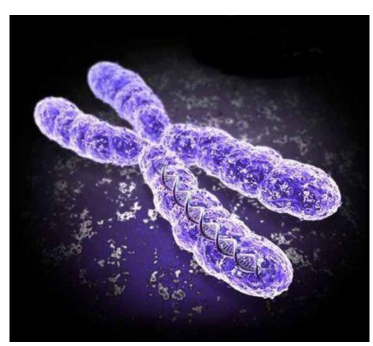
- According to Huxley , protoplasm is ―physical basis of life‖
- Includes organic and inorganic molecules

1. **CYTOPLASM**

- Semi fluid matrix present between cell membrane and nuclear membrane
- It has various living cell inclusions called cell organelles and non living substances called Ergastic substances

2. **NUCLEUS**

- Largest cell organelle present in eukaryotic cells
- It is usually spherical
- It has double layer nuclear membrane with nuclear pores
- It has transparent granular matrix called Nucleoplasm, chromatin network composed of DNA and Histone proteins



- It also has a spherical body called Nucleolus

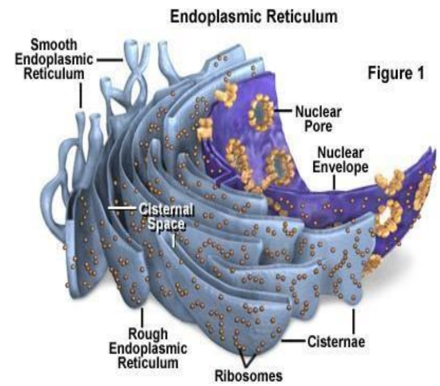
Function:

- It is the control centre of the cell.
- It contains genetic material DNA which regulates all metabolic activities of the body

3. **CHROMOSOME (VEHICLE OF HEREDITY)**

- Nucleus of a non dividing cell has network of fibres called chromatin.
- During cell division, chromatin condenses to form distinct chromosomes.
- Chromosomes help in transmission of characters or genes
- Chromosome has centromere at the centre & arms on either sides called chromatids
- Chromatids- Thread like chromonema

MEMBRANE BOUND CELL ORGANELLES:



1. **ENDOPLASMIC RETICULUM:**

- ER is a network of membrane bound tubular structures in cytoplasm
- It extends from cell membrane to nuclear membrane
- it exists as flattened sacks called Cisternae, unbranched tubules and oval vesicles
- There are two types of ER, ROUGH ER and SMOOTH ER.

Functions

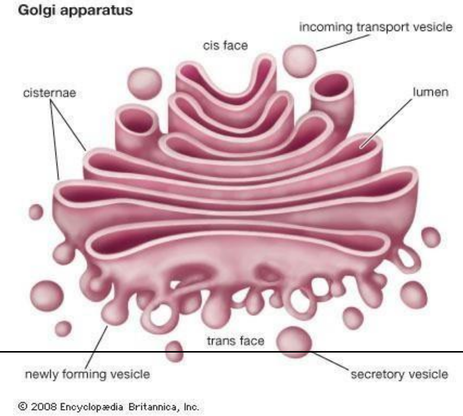
- Helps in intracellular transportation
- It provides mechanical support to cytoplasmic matrix
- It helps in the formation of micro bodies, nuclear membrane and Golgi complex.
- It helps in detoxification of metabolic wastes

2. **GOLGI APPARATUS**

- It has a group of curved, flattened plate like compartments like Cisternae.
- The Cisternae produce a network of tubules from the periphery
- These tubules end in spherical enzyme filled vesicles.
- Commonly called packaging centre of the cell

Functions

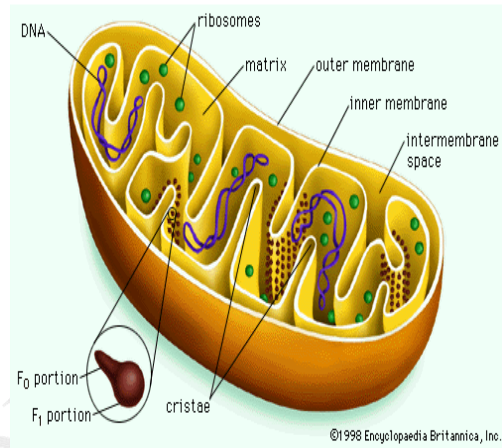
- They store the product of ER
- They produce Lysosomes



- They secrete various Enzymes, hormones and cell wall material

3. **MITOCHONDRIA**

- Spherical or rod shaped
- It has two membranes, outer membrane is smooth, inner membrane produces finger like infoldings called Cristae
- Inner membrane also has stalked particles called
- Racker's particles or Oxysomes
- The mitochondria is filled with granular mitochondrial matrix
- Matrix has circular mitochondrial DNA, RNA, 70s Ribosome, proteins, Enzymes and lipids



Function:

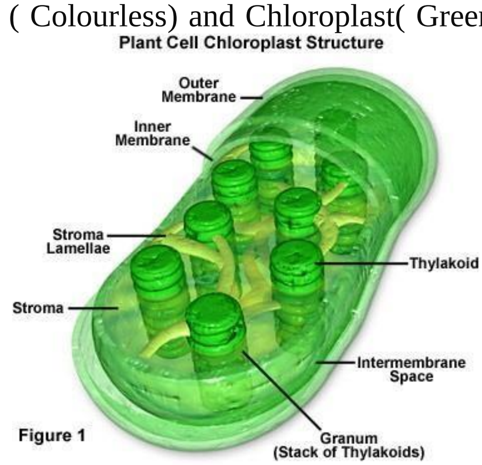
- Synthesizes and stores energy rich molecules
- ATP(Adenosine Tri phosphate) during aerobic respiration

4. **PLASTIDS**

- Present in plant cells, photosynthetic bacteria and Euglena (bacteria can be chemosynthetic also)
- 3 types- Chromoplast (different colored plastids), Leucoplast (Colourless) and Chloroplast(Green colored plastids)

5. **CHLOROPLAST (kitchen of the cell)**

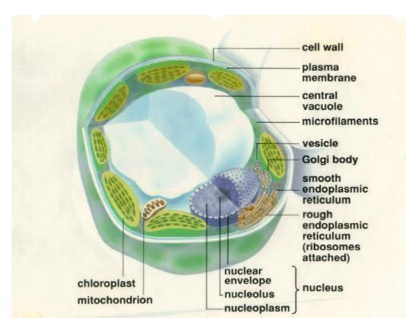
- Contains green colour pigment called Chlorophylls
- Chloroplast has double membrane
- Matrix is called Stroma
- Stroma has membranous sacks called Thylakoids
- Thylakoids are arranged one above the other to form granum
- Grana are interconnected by Frets



Function: Helps in photosynthesis

6. **VACUOLES**

- Single membrane bound sack like vesicles
- Absent in animal cells
- Plant cells have large vacuoles- distinct character
- Also present in lower organisms
- The membrane of vacuole is called tonoplast
- Vacuole is filled with watery fluid called cell sap which has dissolved salts, sugars, enzymes etc



Generalized sketch of a plant cell.

7. **LYSOSOMES (suicidal bags of cell)**

- Single membrane bound vesicles filled with hydrolytic enzymes found only in animal cells.
- Produced from Golgi complex
- 4 types- Primary, secondary, residual & auto Lysosomes

Function:

- Intracellular digestion
- Destroy old and non functional cells
- Recycles worn out cells

NON MEMBRANE BOUNDED CELL ORGANELLES

1. **RIBOSOMES (Protein factories of the cell)**

- Present in Cytoplasm, Mitochondria, Chloroplast & also found attached to rough ER & Nuclear membrane
- They are made up of r RNA and proteins
- Prokaryotes have 70s Ribosome's, Eukaryotes have 80s Ribosome's.

Function: These are sites of protein synthesis

2. **CENTROSOMES**

- Found in animal cells & in motile algae.
- It has two cylindrical structures called centrioles surrounded by centrosphere.
- Centrioles are arranged at right angles
- They are made up of micro tubules

Function: Helps in cell division.

NON LIVING CELL INCLUSIONS:

- Ergastic substances
- Cytoskeleton

TISSUES -EPITHELIUM, CONNECTIVE, SCLEROUS MUSCLE

Tissue = collection of specialized cells that perform limited number of functions

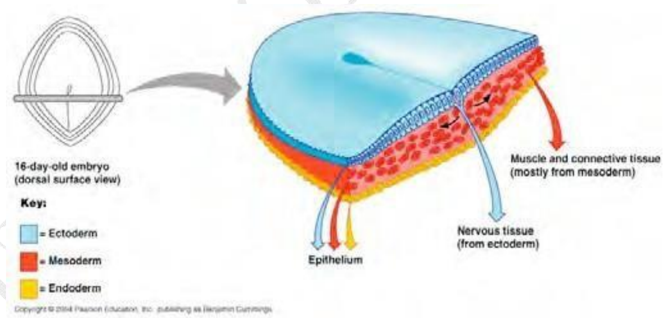
Histology = the study of tissues

FOUR MAIN TYPES OF TISSUE:

1. Epithelial tissue – (covering) surfaces, linings, glands
2. Connective tissue - (support) fill space, structure, strength, transport, storage
3. Muscle tissue - (movement)
4. Nervous tissue - (control) transmit information

Primary Germ Layers = Embryonic layers, give rise to all four tissue types in adult.

1. Ectoderm: nervous, epithelial (epidermis)
2. Mesoderm: muscle, connective, epithelial (endothelium + mesothelium)
3. Endoderm: epithelial (mucosa)



1. EPITHELIAL TISSUE

2 categories:

1. Epithelia - covering
2. Glands -produce fluid secretions

Features:

- Cellularity: little extracellularmatrix, mostly cells
- Contacts: cells linked by strong junctions
- Polarity: apical + basal surfaces, separate functions
- Attachment: attached to CT via basal lamina
- Avascularity: diffusion from CT
- Regeneration: high turnover, stem cells at basal surface

Functions:

- Provide physical protection: abrasion, dehydration, infection
- Control permeability: semi-permeable, covers all surfaces
- Provide sensation: sensory neurons
- Producespecializedsecretions:(glandular) protection, chemical messengers

Structure

- Apical surface: exposed to environment may have:
- microvilli: absorption or secretion & cilia: fluid movement
- Basolateral surface: attachment to neighboring cells via intercellular connections

Classification (based on shape and layers)

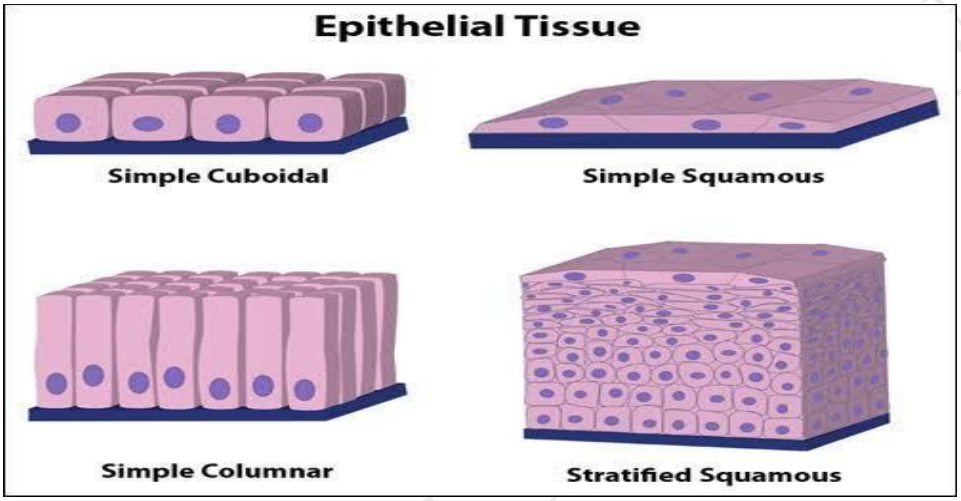
Shape: (all are hexagonal from the top)

- Squamous: flat, disc shaped nucleus
- Cuboidal: cube, center round nucleus
- Columnar: tall, basal ovalnucleus

Layers:

- Simple: one cell layer, absorption, secretion, filtration
- Stratified: 2 or more protection

In stratified, name for apical cell shape



TYPES OF EPITHELIAL TISSUE

1. Simple Squamous Epithelium: -it is thin and delicated tissue, it is in protected region of body

Locations: Mesothelium (serosa), endothelium (blood vessels, heart), kidney tubules, conjunctiva & alveoli of lungs

Functions: Absorption, diffusion, filtration or secretion

2. Stratified Squamous Epithelium: basal cells look Cuboidal, apical cells squamous

-It is located on exposed surfaces of skin layers

Two Types are: keratinized and non keratinized

- Keratinized = epidermis, dry, apical cells dead, cells contain keratin protein to resist dehydration
- Non keratinized = mucosa, kept moist, all cells nucleated

Locations: mouth, esophagus, anus, vagina

Functions: provide protection from abrasion, pathogens, chemicals

3. Simple Cuboidal Epithelium
Locations: kidney tubules, pancreas, salivary glands, thyroid

Functions: secretion or absorption

4. Stratified Cuboidal Epithelium: rare
Locations: some sweat glands & some mammary glands
Functions: secretion or absorption

5. Transitional Epithelium: relaxed: looks like stratified Cuboidal & stretched: looks squamous

Locations: urinary bladder & ureters

Function: tolerate excessive stretching

6. Simple Columnar Epithelium:

- nuclei line up near basal lamina
- apical surface of cells often has microvilli = –brush border‖ (in intestine)
- goblet cells often present: secrete mucus

Locations: stomach, intestine, gallbladder, uterine tubes, collecting ducts of kidney
Functions: absorption or secretion
7. Pseudostratified Columnar Epithelium

- all cells contact basal lamina
- some too short to reach apical surface
- nuclei scattered so it appears stratified
- tall cells have cilia on apical surface
- goblet cells (mucus) often present

Locations: nasal cavity, trachea, bronchi, male reproductive tract, female uterine tubes
Functions: move material across surface
8. Stratified Columnar Epithelium: rare, two layers or multiple layers with only apical layer columnar

Locations (tiny parts of): pharynx, epiglottis, anus, mammary glands, salivary glands, urethra

Functions: minor protection

Glandular Epithelium: for secretion, makes up glands

➢ **Endocrine glands: "internally secreting"**

It is secrete into interstitial fluid →blood secretions =hormones
It is regulate and coordinate activities of human being
E.g. pancreas, thyroid, thymus, pituitary

➢ Exocrineglands:—externallysecreting‖

It is secrete into duct → epithelial surface
E.g. digestive enzymes, perspiration, tears, milk, mucus

Classified three ways:

a. mode of secretion
b. type of secretion

A. Mode of secretion

1. Merocrine secretion
   -product released from secretory vesicles
   By exocytosis
   E.g. mucus, sweat
2. Apocrine secretion
   -product accumulates in vesicles
   -apical region of cell with vesicles is shed to release product
   E.g. milk
3. Holocrine secretion
   -product accumulates in vesicles
   -whole cell is lysed to release product
   -cell dies, must be replaced by stem cells
   E.g. sebum

B. Type of secretion

- Serous glands: water + enzymes
  E.g. parotid salivary gland
- Mucus glands:mucin (+water =mucus)
  E.g. goblet cell
- Mixed exocrine glands: serous + mucus secretion
  E.g. submandibular salivary gland

C. Gland structure

- Unicellular gland: 1 cell. e.g. goblet cell
- Multicellular gland: group of cells named for shape and structure

2. CONNECTIVE TISSUE

Features:

-never exposed to environment
-usually vascularized
-consists of cells in a matrix

Components*:*

1. Specialized cells:Produce matrix, provide protection
2. Extracellular protein fibers: support, strength
3. Ground substance: gel fluid, consists of:Interstitial fluid, CAMs, GAGs (glycosaminoglycans) proteoglycans that gel

Fibers + Ground substance = Matrix

Functions

1. Establish structural framework
2. Transport fluid and dissolved materials
3. Protect organs
4. Support, surround, interconnect tissues
5. Store energy reserves
6. Insulate body
7. Defend against pathogens

Classification: based on physical properties

1. Connective Tissue Proper:
   Many cell types and fiber types in thick ground substance
   A. Loose: open fiber framework
   B. Dense: tightly packed fibers
2. Fluid Connective Tissue:
   Many cell types in watery matrix with soluble fibers
3. Supporting Connective Tissue:
   Limited cell population in tightly packed matrix

1. CONNECTIVE TISSUE PROPER

-viscousgroundsubstance

-varied extracellular fibers

-varied cell population

Ground substance: rich in GAGs

-viscous, prevents microbe penetration

Fiber types:

1. Collagen fibers: collagen protein-rope like, long, straight

-resists force

-most common

2. Reticular fibers: collagen protein

-branchy, forms framework of an organ = Stroma (functional cells of an organ = Parenchyma)

3. Elastic fibers: elastin protein

-wavy, flexible

-designed to stretch

Cell Types:

1. Fibroblasts

-most common, most abundant

-secrete ground substance: hyaluronan + proteins = GAGs

-secrete fiber proteins (collagen, elastin)

-some specialized types: chondrocytes (cartilage) osteocytes (bone)

2. Mesenchymal cells

-stem cells

-differentiate to replace CT cells after injury (e.g. fibroblasts, adipocytes)

3. Adipocytes (fat cells)-store triglycerides

-organelles pushed to periphery

-number, size and location of cells varies

4. Macrophages-phagocytic for defense

-some fixed in tissues

-others migrate from blood to tissues after injury

5. Microphages-neutrophils and eosinophils

-phagocytic

-migrate from blood to site of injury

6. Lymphocytes: B and T cells-involved in immune response

-make antibodies, attack foreign cells

-increase in number during infection

-constantly migrate between blood and tissues and lymph

7. Mast cells-contain histamine and heparin

-stimulate inflammation in response to injury

A. Loose Connective Tissue

- -highly vascularized
- -varied cell types

Functions

- fill space
- cushion & support tissues store fat
- feed epithelial layers

1. **Areolar CT**-most common

-least specialized

-open framework:

Matrix mostly ground substance

-all fiber types

Location:-deep to epithelium Functions:reservoir for water & salts**,** absorbs shock & distortion, fills space**,** feeds epithelium

2. **Adipose Tissue**

-90% adipocytes

Locations:-deep toskin-surrounding**,** eyeballs, kidneys, heart

Functions:-padding & insulation**,** energy storage

-Two types:

- white fat: adults, triglyceride storage
- brown fat: infants, high mitochondria content for heat generation

3. **Reticular Tissue**

-Stroma of organs

-consists of reticular fibers

Locations: some organs:

E.g. lymph nodes, bone marrow, liver Function:

Support parenchyma cells

B. <u>Dense Connective Tissue</u>

-poorly vascularized

-mostly fibers, little ground substance

-only fibroblasts

1. **Dense Regular CT**

-bundles of parallel collagen fibers, aligned with direction offorce

Locations:-tendons (muscle to bone)**,** ligaments (bone to bone)**,** muscle coverings**,** fascia

Function:-high strength attachment, stabilize positions

2. **Dense Irregular CT**

-mesh of collagen fibers

Locations:

-capsules of organs & fascia

-periosteum (sheatharound bone)

-perichondrium (around cartilage)

-dermis (deep skin)

Function:-resist tension from many directions, attachment

3. **Elastic CT**

-mostly elastic fibers, some collagen

Locations:-vertebral ligaments, artery walls Function:strength with stretch and flex

2. FLUID CONNECTIVE TISSUE

1. **Blood**

Matrix = plasma: serum(fluid)+ plasma proteins (produced by liver) fibers are soluble until clotforms

Cells = formed elements originate from hemocytoblast (stem cell) in bone marrow

Formed Elements:

- Erythrocytes (RBCs): carry O_2
- Leukocytes (WBCs): defense Neutrophils, Eosinophils, Basophils, Lymphocytes (B and T cells), Monocytes (Macrophages)
- Platelets: carry clotting factors

Location: -contained in blood vessels

Function:-transport nutrients, wastes and defense cells throughout body

Plasma→ Interstitial fluid→Lymph→ Plasma

2. **Lymph**

Matrix = lymph (recollected plasma fluid) Cells = lymphocytes (immune defense)

Location: contained in lymphatic vessels

Function: purify and return fluid to blood

3. SUPPORTING CONNECTIVE TISSUE

-strong framework, few cells, fibrous matrix

Function: support and shape

-mature cells in lacunae

A. Cartilage

Composition:

-Matrix: 80% water, firm gel of GAGs made of chondroitin sulfate and hyaluronic acid, + fibers

-Cells: chondrocytes (in lacunae) (cells formed the matrix)

Structure:

-no innervation

-avascular (antiangiogenesis factor)

-surrounded by perichondrium: outer layer = dense irregular CT

Protection, attachment

Inner layer = cellular (fibroblasts) growth and repair

Growth of cartilage: (not common in adults)

1. Interstitial growth (embryos)

-chondroblasts in matrix divide

-daughters produce more matrix (mature cells = chrondrocytes)

2. Appositional growth(children, minor repair in adult)

-new layers added by cells of inner perichondrium

Serious injury = scar: cartilage replaced by fibrous collagen

Types of cartilage:

1. **Hyaline Cartilage**

-matrix contains fine, closely packed collagen fibers

-tough, springy

Locations: ribs, nose, respiratory tract

-articularsurfaces(noperichondrium)

Function: provide stiff flexible support, reduce friction between bones

2. **Elastic Cartilage**

-matrix contains elastic fibers, flexible

Locations: auricle of ear, epiglottis

Function: resilient, flexible, shape holding support

3. **Fibro cartilage**

-matrix contains dense interwoven collagen fibers with little ground substance

-tough, durable

Locations: knee (meniscus)**,** pubic symphasis**,** intervertebral discs

Functions: resist compression, absorb shock

A. <u>Bone / Osseous Tissue</u>

-highly vascularized

-little ground substance

-matrix = 2/3 calcium salts for strength (calcium phosphate + calcium carbonate) 1/3 collagen for flexibility to resist shatter

-cells = osteocytes (cells formed the matrix)

-located in lacunae

-connectedbycytoplasmic extensions that extend through canaliculi

-canaliculi necessary for nutrient & waste exchange, no diffusion through calcium

-surrounded by periosteum: outer fibrous layer for attachment, inner cellular layer for growth and repair

Location: bones

Functions: support & protection, levers for movement, storage of minerals

<u>Special Connective Tissue Structures</u>

<u>1. Fascia</u>

-Connective tissue that provides a framework to connect organs to the body

Functions: provide strength and stability, maintain the position of the organs, anchor blood vessels, lymphatic vessels and nerves

Three layers:

A. Superficial fascia

-located between cutaneous membrane and organs

-composed of areolar CT and adipose

-a.k.a. subcutaneous layer/hypodermis

-functions to provide insulation and padding

B. Deep fascia
-forms strong framework of dense CT

-creates capsules around organs, binds capsules, tendons, ligaments to hold tissues together

-functions to resist force and anchor positions of organs

C. Subserous fascia
-between serous membranes and deep fascia

-composed of areolar CT

-functions to prevent distortion of organs by muscles

2. Membranes

-typically epithelium plus supporting CT

A. Mucous Membranes / Mucosa

-epithelium + areolar connective tissue called lamina propria

-line passageways that connect to external environment

-epithelium kept moist with mucus secretions

B.**Serous Membranes / Serosa**

-mesothelium + areolar connective tissue

-lines body cavities to reduce friction (pleura, peritoneum, pericardium)

-parietal layer lines cavity, visceral layer around organ

-epithelium kept moist by serous fluid / transudate

C.Cutaneous Membrane (epidermis + dermis = ―skin‖)

-keratinized stratified squamous epithelium

+ areolar and dense irregular connective tissue

-only dry membrane

D. Synovial Membranes

-areolar connective tissue with woven collagen, proteogycansandglycoproteins in matrix

-lines joint capsules

-produces synovial fluid to reduce friction of articular cartilage

-only membrane with no epithelium

3. MUSCLE TISSUE

Function:-produce movement

Features: highly vascularized

Contains actin and myosin for contraction

Types:

1. Skeletal Muscle (Striated Voluntary Muscle)

-cells = fibers

-up to 1 ft long

-multinuclear

-no cell division

-appear striated: actin and myosin organized into myofibrils

-some satellite cells (stem cells) present for minor repair after injury

Location: skeletal muscles (―meat‖)

Functions:-move skeleton, guard entrances/exits, generate heat

2. Cardiac Muscle: (Striated Involuntary Muscle)

-cells = cardiocytes

-long, branched

-usually single nucleus but up to 5

-no cell division

-striated

-neighboring cells connected by intercalated discs: desmosomes + intercellular cement + gap junctions

*desmosomes & cement provide tight linkage of neighboring cells *gap junctions allow exchange of ions to coordinate contraction

Location: majority of heart

Function: move blood through body

3. Smooth Muscle (Nonstriated Involuntary Muscle)

Cells small, spindle shaped

-uninuclear

-capable of cell division

-no striations: no myofibril organization

Locations: walls of blood vessels, walls of hollow organs, digestive, respiratory, urinary and reproductive tracts

Function:-move materials through the organ

4. NERVOUS TISSUE

Function:-conduct nervous impulses to relay information

Location: most in brain and spinal cord: CNS**,** 2% in PNS

Cells:

1. Neuroglia cells

-support, repair, and supply nutrients to nervous tissue

2. Neurons

-transmit information

-up to 3 ft long

-large soma (cell body)

-large nucleus, visible nucleoli

-many dendrites: receive info

-One axon: transmits info

-no cell division

TISSUE INJURIES

-maintain homeostasis: inflammation and repair

- **Inflammation**

Prevent spread of injury or infection

Characterized by: swelling, redness, warmth and pain

Process to remove necrotic cells and infectious agents

(Inflammation process on handout)

- **Injury and Cancer:**

-repeat or chronic inflammation causes damage

Dysplasia: change in normal shape, size, organization of tissue cells (reversible)

Metaplasia: more serious changes, abnormal division of stem cells (reversible)

Anaplasia: breakdown of tissue organization, genetic abnormalities of stem cells (irreversible)

NERVOUS SYSTEM –NEURON

The network of nerve cells and fibers which transmits nerve impulses between parts of body.

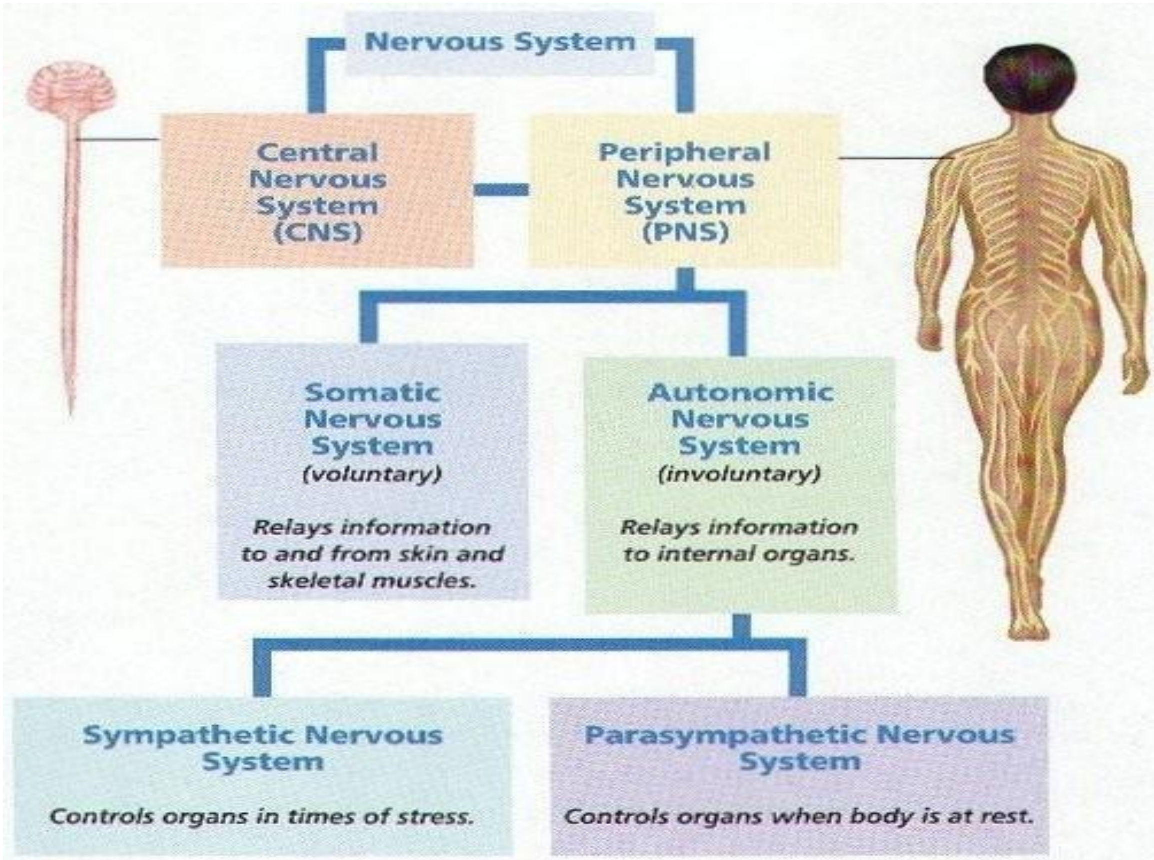
FUNCTIONS OF THE NERVOUS SYSTEM

- Gathers information from both inside and outside the body - Sensory Function
- Transmits information to the processing areas of the brain and spine
- Processes the information in the brain and spine – Integration Function
- Sends information to the muscles, glands, and organs so they can respond appropriately – Motor Function

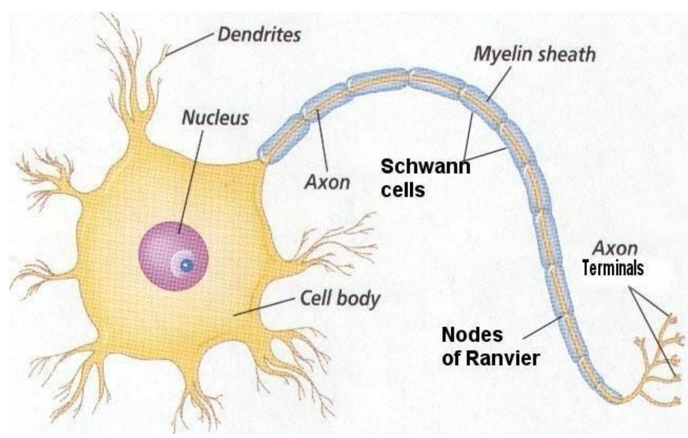
It controls and coordinates all essential functions of the body including all other body systems allowing the body to maintain homeostasis or its delicate balance.

The Nervous System is divided into Two Main Divisions: Central Nervous System (CNS) and the Peripheral Nervous System (PNS)

DIVISIONS OF THE NERVOUS SYSTEM



BASIC CELLS OF THE NERVOUS SYSTEM



Structure of Neuron

NEURON

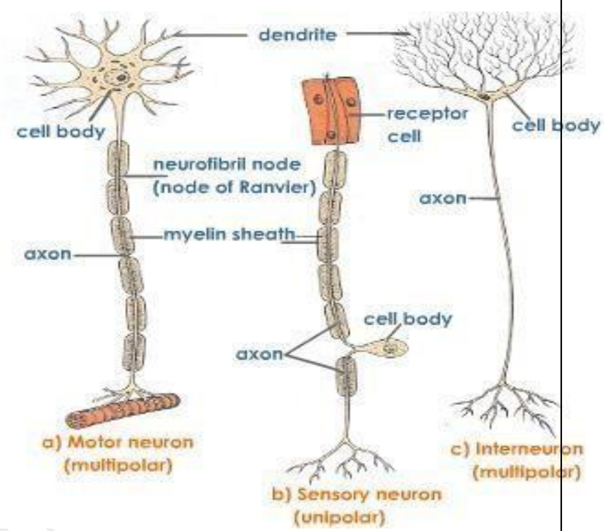
Basic functional cell of nervous system

Transmits impulses (up to 250 mph)

PARTS OF A NEURON

- **Dendrite** – receive stimulus and carries it impulses toward the cell body
- Cell Body with nucleus – nucleus & most of cytoplasm
- **Axon** – fiber which carries impulses away from cell body

- **Schwann Cells**- cells which produce myelin or fat layer in the Peripheral Nervous System
- **Myelin sheath** – dense lipid layer which insulates the axon – makes the axon look gray
- **Node of Ranvier** – gaps or nodes in the myelin sheath
- Impulses travel from dendrite to cell body to axon



<u>Three types of Neurons:</u>

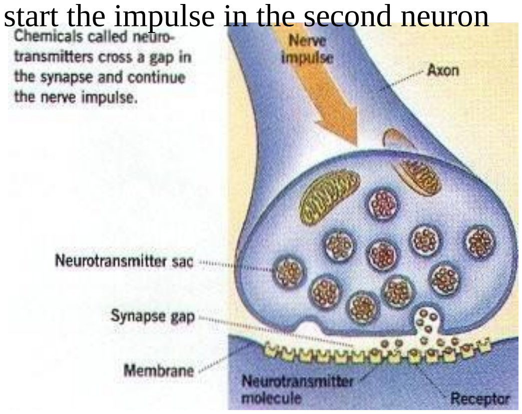
1. Sensory neurons – bring messages to CNS
2. Motor neurons - carry messages from CNS
3. Inter neurons – between sensory & motor neurons in the CNS

<u>Impulses:</u>

- A stimulus is a change in the environment with sufficient strength to initiate a response.
- Excitability is the ability of a neuron to respond to the stimulus and convert it into a nerve impulse
- All of Nothing Rule – The stimulus is either strong enough to start and impulse or nothing happens
- Impulses are always the same strength along a given neuron and they are self-propagation – once it starts it continues to the end of the neuron in only one direction- from dendrite to cell body to axon
- The nerve impulse causes a movement of ions across the cell membrane of the nerve cell.

<u>Synapse:</u>

- Synapse - small gap or space between the axon of one neuron and the dendrite of another - the neurons do not actually tough at the synapse
- It is junction between neurons which uses neurotransmitters to start the impulse in the second neuron or an effectors (muscle or gland)
- The synapse insures one-way transmission of impulses



<u>Neurotransmitters:</u>

- Neurotransmitters – Chemicals in the junction which allow

Impulses to be started in the second neuron

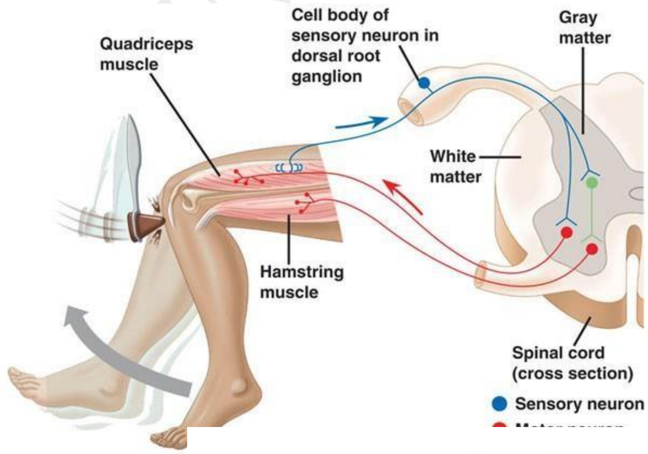
<u>Reflex Arc</u>

A reflex or reflex action is an involuntary and nearly instantaneous movement in responses to a stimulus. A reflex is made possible by neural pathways called reflex arcs which can act on an impulse before that impulse reaches the brain.

Components of a Reflex Arc

1. Receptor - reacts to a stimulus
2. Afferent pathway (sensory neuron) - conducts impulses to the CNS
3. Interneuron - consists of one or more synapses in the CNS (most are in the spine)
4. Efferent pathway (motor neuron) conducts impulses from CNS to effectors.
5. Effectors - muscle fibers (as in the Hamstring muscle) or glands responds by contracting or secreting a product.

Spinal reflexes - initiated and completed at the spinal cord level. Occur without the involvement of higher brain centers.



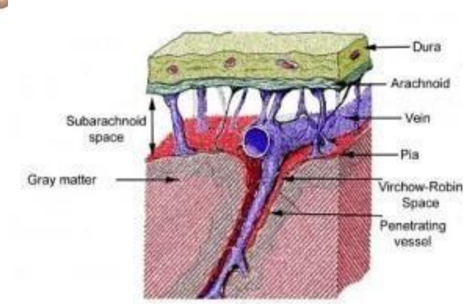
CENTRAL NERVOUS SYSTEM

1. **BRAIN**

- Brain stem – medulla, Pons, midbrain
- Diencephalon – thalamus & hypothalamus
- Cerebellum
- Cerebrum

2. **SPINE**

- Spinal Cord



Meninges:

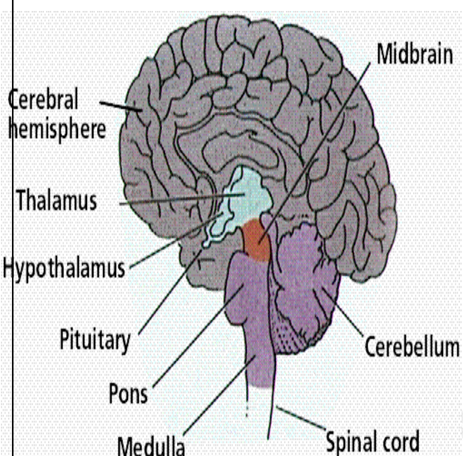
Meninges are the three coverings around the brain & spine and help cushion, protect, and nourish the brain and spinal cord.

- Dura mater is the most outer layer, very tough
- Arachnoids mater is the middle layer and adheres to the Dura mater and has web like attachments to the innermost layer, the pia mater
- Pia mater is very thin, transparent, but tough, and covers the entire brain,
Following it into all its crevices (sulci) and spinal cord

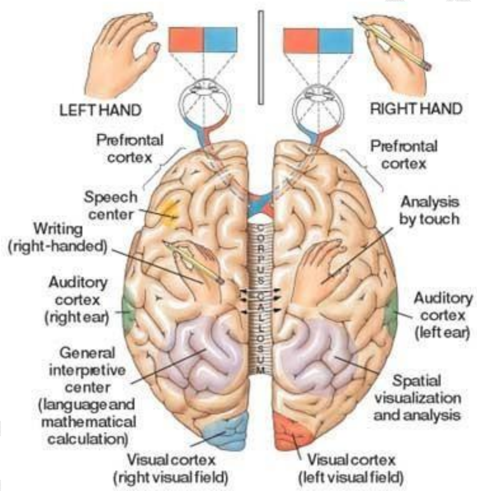
- ❖ Cerebrospinal fluid, which buffers, nourishes, and detoxifies the brain and spinal cord, flows through the subarachnoid space, between the arachnoids mater and the pia mater

Regions of the Brain

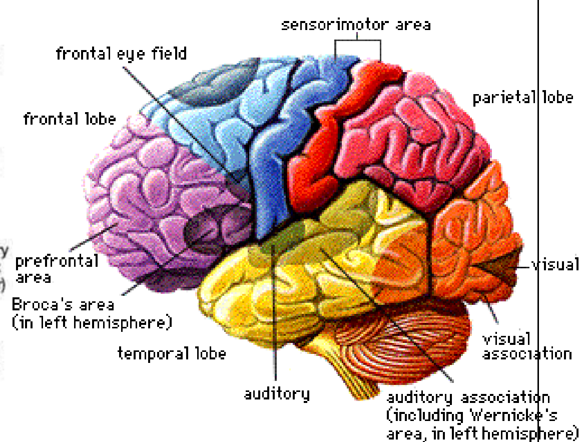
- **Cerebellum** – coordination of movement and aspects of motor learning
- **Cerebrum** – conscious activity including perception, emotion, thought, and planning
- **Thalamus** – Brain's switchboard – filters and then relays information to various brain regions
- **Medulla** – vital reflexes as heart beat and respiration
- **Brainstem** – medulla, Pons, and midbrain (involuntary responses) and relays information from spine to upper brain
- **Hypothalamus**– involved in regulating activities internal organs, monitoring information from the autonomic nervous system, controlling the pituitary gland and its hormones, and regulating sleep and appetite.



Structure of Brain



Structure of Cerebrum



Lobes of Cerebrum

Cerebrum:

- Is the largest portion of the brain encompasses about two-thirds of the brain mass -
- It consists of two hemispheres divided by a fissure – corpus callosum
- It includes the cerebral cortex, the medullary body, and basal ganglia
- cerebral cortex is the layer of the brain often referred to as gray matter because it has cell bodies and synapses but no myelin
  - The cortex (thin layer of tissue) is gray because nerves in this area lack the insulation or white fatty myelin sheath that makes most other parts of the brain appear to be white.

- The cortex covers the outer portion (1.5mm to 5mm) of the cerebrum and cerebellum
- The cortex consists of folded bulges called gyri that create deep furrows or fissures called sulci
- The folds in the brain add to its surface area which increases the amount of gray matter and the quantity of information that can be processed

- Medullary body – is the white matter of the cerebrum and consists of myelinated axons
  - Commisural fibers – conduct impulses between the hemispheres and form corpus callosum
  - Projection fibers – conduct impulse in and out of the cerebral hemispheres
  - Association fibers – conduct impulses within the hemispheres
- Basal ganglia – masses of gray matter in each hemisphere which are involved in the control of voluntary muscle movements

Lobes of the Cerebrum

1. Frontal – motor area involved in movement and in planning & coordinating behavior
2. Parietal – sensory processing, attention, and language
3. Temporal – auditory perception, speech, and complex visual perceptions
4. Occipital – visual center – plays a role in processing visual information

Special regions

- ✓ Broca’s area – located in the frontal lobe – important in the production of speech
- ✓ Wernicke’s area – comprehension of language and the production of meaningful speech
- ✓ Limbic System – a group of brain structures (aamygdala, hippocampus, septum, basal ganglia, and others) that help regulate the expression of emotions and emotional memory

Brain Waves

- Brain waves are rhythmic fluctuation of electric potential

Between parts of the brain as seen on an electroencephalogram (EEG).

To measure brain waves electrodes are placed onto

The scalp using the EEG.

There are four types of brainwaves:

i. Beta
ii. Alpha
iii. Theta
iv. Delta

PERIPHERAL NERVOUS SYSTEM

Cranial nerves

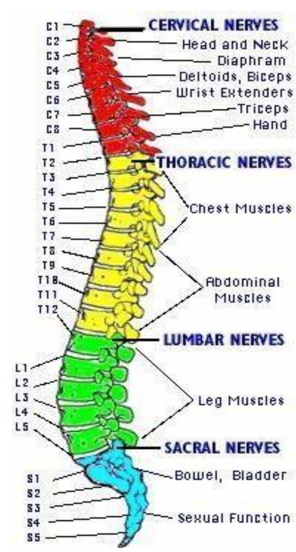
- 12 pair
- Attached to undersurface of brain

Spinal nerves

- 31 pair
- Attached to spinal cord

<u>Somatic Nervous System (voluntary)</u>

- Relays information from skin, sense organs & skeletal muscles to CNS
- Brings responses back to skeletal muscles for voluntary responses



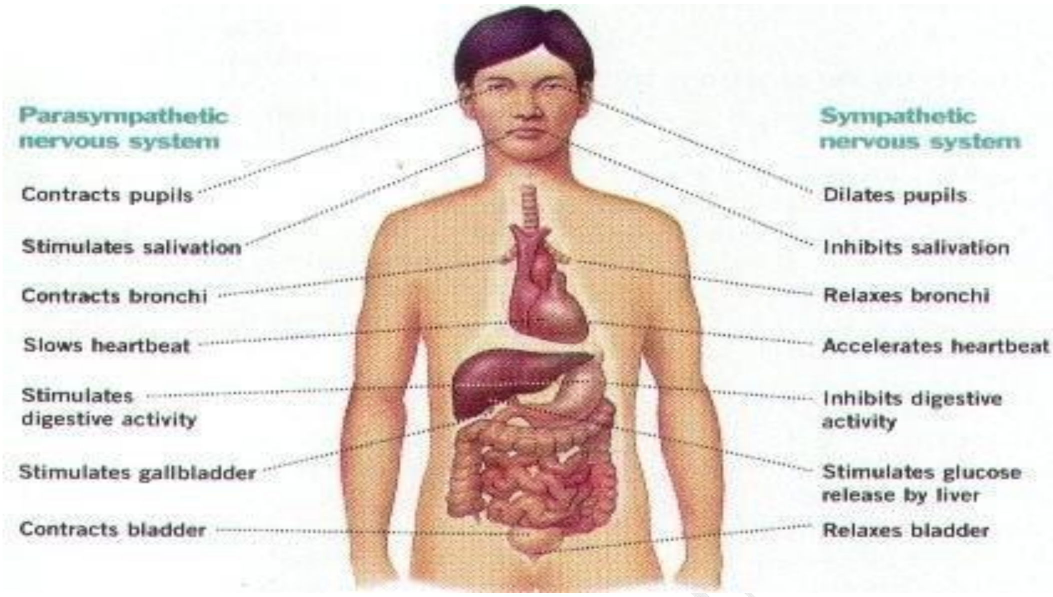
<u>Autonomic Nervous System (involuntary)</u>

- Regulates bodies involuntary responses
- Relays information to internal organs

Two divisions

1. **Sympathetic nervous system** – in times of stress
   - Emergency response
   - Fight or flight
2. **Parasympathetic nervous system** – when body is at rest or with normal functions

- Normal everyday conditions



- **Major Sense Organs**

- Sensation and perception
- Vision – Eye
- Hearing – Ear
- Taste – Taste receptors (new)
- Smell – Olfactory system
- Skin – Hot, cold, pressure, pain

DISORDERS OF THE NERVOUS SYSTEM – SYMPTOMS, PREVENTION, TREATMENT

- ❖ **Epilepsy** - common and diverse set of chronic neurological disorders characterized by seizures.
- ❖ **Seizures** - the physical findings or changes in behavior that occur after an episode of abnormal electrical activity in the brain and are caused by abnormal electrical discharges in the brain
- ❖ **Alzheimer's disease** - a degenerative disease of the brain that causes dementia, which is a gradual loss of memory, judgment, and ability to function. - the most common form of

dementia- affects an estimated 1 in 10 people over age 65

- **Multiple Sclerosis** - an autoimmune disease that affects the brain and spinal cord (central nervous system) - body's immune system eats away at the protective myelin sheath that covers the axons of the neurons and interferes with the communication - MS can affect vision, sensation, coordination, movement, and bladder and bowel control.
- **Parkinson's disease** - disorder of the brain that leads to shaking (tremors) and difficulty with walking, movement, and coordination. People with Parkinson's disease have low brain dopamine concentrations.
- **Shingles (herpes zoster)** - painful, blistering skin rash due to the varicella-zoster virus, the virus that causes chickenpox – the virus remains inactive (becomes dormant) in certain nerves in the body. Shingles occurs after the virus becomes active again
- **Cerebral Palsy** - group of disorders that can involve brain and nervous system functions such as movement, learning, hearing, seeing, and thinking resulting from damage to certain parts of the developing brain
- **Glaucoma** - a group of eye conditions that lead to damage to the optic nerve due to increased pressure in the eye - the eye's drainage system becomes clogged so the intraocular fluid cannot drain and as the fluid builds up, it causes pressure to build within the eye. High pressure damages the sensitive optic nerve.
- **Pink eye (Conjunctivitis)** – infection of the conjunctiva of the eye

Effects of Drugs on the Nervous System

- **Alcohol** - central nervous system depressant – cell membranes are highly permeable to alcohol so once in the bloodstream it can diffuse into almost all body tissues. It is absorbed in the stomach so it gets into the blood stream quickly and slows down function of the nervous system
- **Caffeine** - acts as a central nervous system stimulant - caffeine suppresses melatonin for up to 10 hours and also promotes adrenalin. Melatonin is strongly associated with quality sleep, while adrenalin is the neurotransmitter associated with alertness.
- **Nicotine** - small doses of nicotine have a stimulating action on the central nervous system – it is highly addictive nicotine's effects on the brain cause an increased release of neurotransmitters associated with pleasure. The brain quickly adjusts to repeated nicotine consumption by decreasing the amount of neurotransmitters released. The effect of this

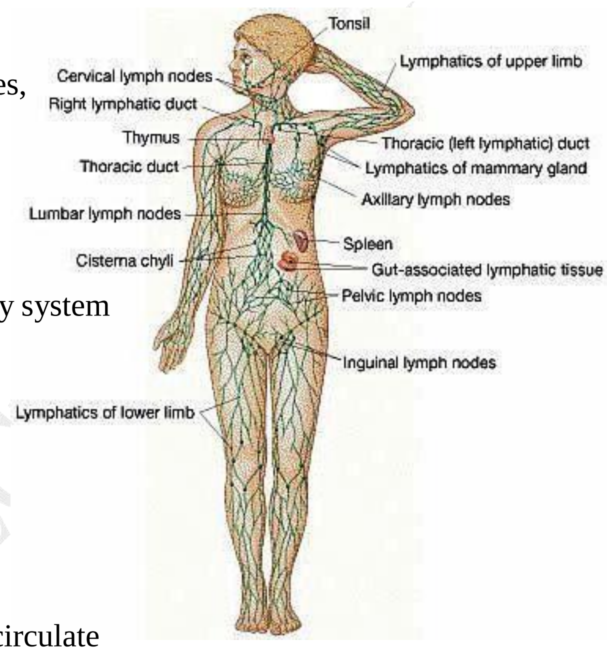
increased tolerance is that the smoker must continue to use nicotine in order to avoid the feelings of discomfort associated with withdrawal from the drug. Irritability and anxiety often ensue during nicotine withdrawal.

- **Marijuana** - THC, the main active ingredient in marijuana, binds to membranes of nerve cells in the central nervous system that have protein receptors. After binding to nerve cells, THC initiates a chemical reaction that produces the various effects of marijuana use. One of the effects is suppression of memory and learning centers (called the hippocampus) in the brain.

LYMPHATIC SYSTEM- LYMPH NODE

INTRODUCTION

- Lymphatic system is a network of tissues, organs and vessels that help to maintain the body's fluid balance & protect it from pathogens
- Lymphatic organs- Lymphatic vessels, Lymph nodes, Spleen, Thymus and Tonsils
- Without it neither the circulatory system nor The immune system would function.
- It can be thought of as an accessory to the circulatory system
- It helps the circulatory system to do its job
- The two systems are directly connected together
- It consists of fluid derived from Plasma =lymph and White blood cells (esp. Lymphocytes and Macrophages (Monocytes))
- The lymph travels in only one direction - it doesn't circulate



GENERAL FUNCTIONS OF LYMPHATIC SYSTEM

1. ***Returns Fluid from Tissues to Blood*** -85% of fluids that leak out of blood returns to blood via blood capillaries ~15% returns via lymph capillaries- in 24 hrs lymphatic return fluid equivalent to entire blood volume - if lymphatic system becomes blocked Edema
2. ***Returns Large Molecules to Blood*** -25-50% of blood Proteins leak out of capillaries each day
    - they cannot get back into capillaries
    - instead lymphatic capillaries pick them up and return them to the blood
    - if lymphatic are blocked blood protein decreases leading to fluid
    - Imbalances in body
3. ***Absorb and Transport Fats*** - Special lymphatic capillaries (Lacteals) in villi of small intestine absorb all lipids and fat soluble vitamins from digested food bypasses liver much goes straight to adipose tissues

4. ***Hemopoiesis*** - some WBC's (lymphocytes & Monocytes) are made in lymphatic tissues (not Bone marrow) main supply of lymphocytes

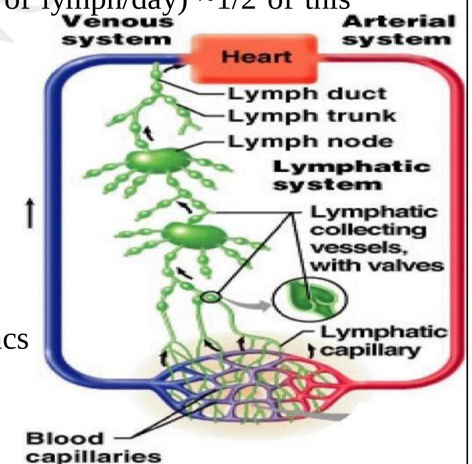
5. ***Body Defense/Immunity*** - lymphoid tissue is an important component of the Immune System (forms a diffuse surveillance defense system in all body tissues and organs)

- The major role of WBC's is in body defense. lymphatic system screens body fluids and removes pathogens and damaged cell

LYMPH

- Lymph is a clear watery fluid that resembles blood plasma but: has fewer proteins its composition varies depending on organs that it drains
- The lymphatic system handles 125 ml/hr (2500-2800 ml of lymph/day) ~1/2 of this from the liverand small intestine alone

LYMPHATIC VESSELS (LYMPHATICS)



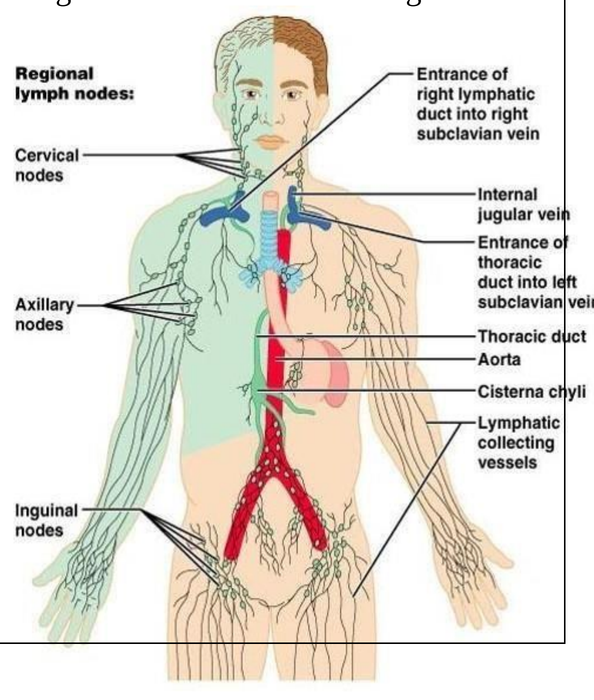
1. **Lymphatic Capillaries** originate in tissues as tiny blind ended sacs

- Lie side by side with blood capillaries
- Single layer of endothelial cells like blood capillaries
- But much more permeable to solvents, and large solutes and whole cells

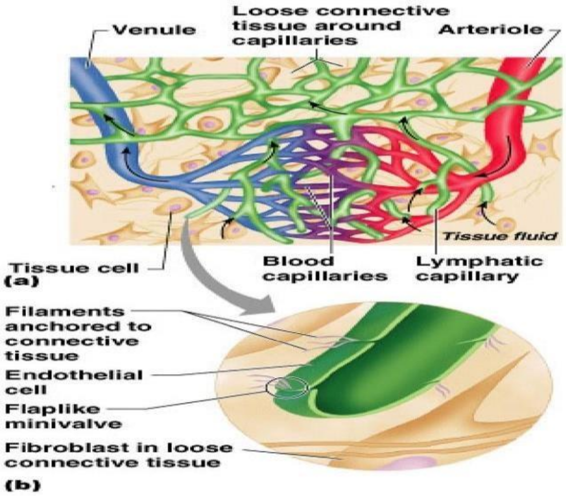
Lymphatic System

2. **Lymphatic Vessels** - these small lymphatic capillaries merge with others to form larger lymphatic vessels - they resemble veins in structure:

- Three layers – but much thinner
- 1-way valves – but many more (every few mm or so)
- Also has lymph nodes at intervals along its course



- As they converge they become larger and larger



Lymphatic Capillaries and Vessels

3. **Lymphatic Ducts-** these lymphatic trunks merge together to form two major Lymphatic Ducts

Equivalent to major vessels of circulatory system but more like veins than arteries

Two major Lymphatic Ducts:

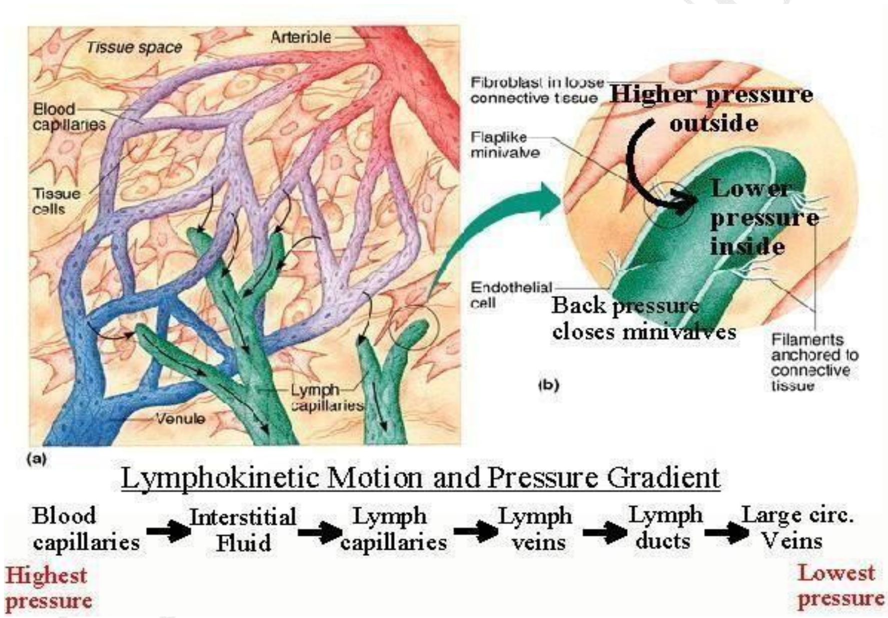
- ✓ **Right Lymphatic Duct :** very short drains upper right quadrant of body drains into right subclavian vein at jct with jugular V
- ✓ **Thoracic Duct :** much larger and longer drains the rest of body (3/4ths): all of body below diaphragm and left arm and left side of head, neck and thorax begins just below the diaphragm, anterior to vertebral column lumbar trunks and intestinal trunk join to form sac like cysterna chyli drains into left subclavian vein

FLOW OF LYMPH:

- Fluid pressure in lymphatic system is very low, as in veins
- Vessels contract rhythmically direction of flow is maintained by 1-way valves
- Also body movements and pulsing of arteries help to move lymph along
- Many vessels are wrapped in connective tissue with arteries: the pulsing of the arteries also helps move lymph along

LYMPH CIRCULATION

- Lymph vessels are thin walled, valved structures that carry lymph
- Lymph is not under pressure and is propelled in a passive fashion
- Fluid that leaks from the vascular system is returned to general circulation via lymphatic vessels.
- Lymph vessels act as a reservoir for plasma and other substances including cells that leaked from the vascular system
- The lymphatic system provides a one-way route for movement of interstitial fluid to the cardiovascular system.
- Lymph returns the excess fluid filtered from the blood vessel capillaries, as well as the protein that leaks out of the blood vessel capillaries.
- Lymph flow is driven mainly by contraction of smooth muscle in the lymphatic vessels but also by the skeletal-muscle pump and the respiratory pump.



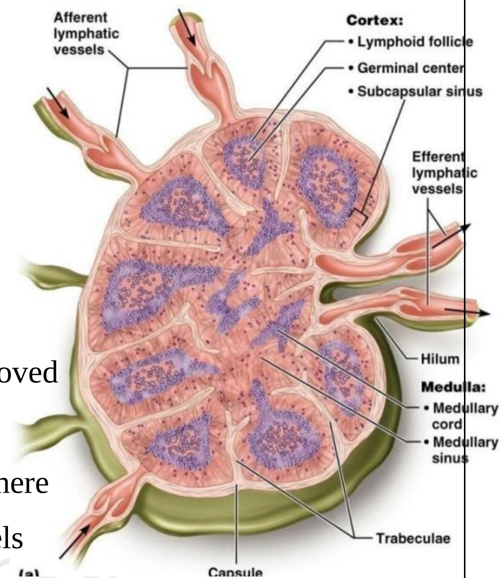
LYMPH CIRCULATION

Interstitial fluid → *Lymph* → Lymph capillary → Afferent lymph vessel → Lymph node → Efferent lymph vessel → Lymph trunk → Lymph duct {Right lymphatic duct and Thoracic duct (left side)} → Subclavian vein (right and left) → *Blood* → Interstitial fluid

LYMPH NODES

- also called Lymph Glands

- oval, vary in size from pinhead to lima bean
- most numerous of the lymphatic organs (100’s)



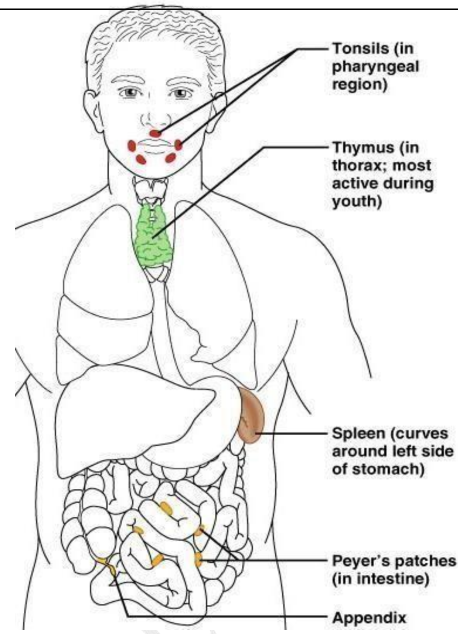
Functions of lymph nodes:

- ***Cleanse lymph*** - as lymph flows through sinuses of Node it slows down and microorganisms and foreign matter are removed
- ***Alert immune system*** to pathogens
- ***Important in Hemopoiesis*** - lymphocytes and Monocytes are made here
- Lymph moves into nodes by way of several afferent lymphatic vessels
- Moves through sinus channels lined with phagocytic white blood cells
- Exits via 1-3 efferent lymph vessels
- The WBC’s in each node remove ~99% of impurities as lymph passes from node to node virtually all impurities are normally removed
- Lymph nodes are widespread in body but most occur in groups or clusters:
- ✓ e.g. sub mental & sub maxillary lymph nodes floor of mouth; drain nose, lips teeth
- ✓ e.g. cervical lymph nodes neck drain neck and head
- ✓ e.g. axillary lymph nodes armpit (axilla) and upper chest drains arm and upper thorax including breasts
- Breasts contains 2 sets of lymphatic : (NOT mammary glands) those that drain the skin over breast excluding the areola and nipple those that originate in and drain deeper portions of breast and skin of areola and nipple
- Numerous connections join the lymphatic systems of the breast with: the other breast axillary nodes (85% of lymph from breast enters them)
- Abdominal nodes
- ✓ e.g. Inguinal lymph nodes in groin area drain legs and genitals

MAJOR ACCESSORY LYMPHATIC ORGANS

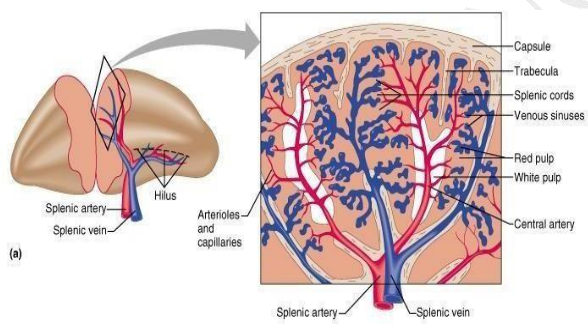
- **Spleen – largest**
- **Thymus**

- **Tonsils**
- **Peyers's patches**
- **Appendix**



SPLEEN

- largest of the lymphatic organs
- located below diaphragm in left hypochondriac region
- ovoid in shape
- inside is a network of interlacing fibers: red pulp packed With RBC's white pulp crowded with lymphocytes, Monocytes and Neutrophils

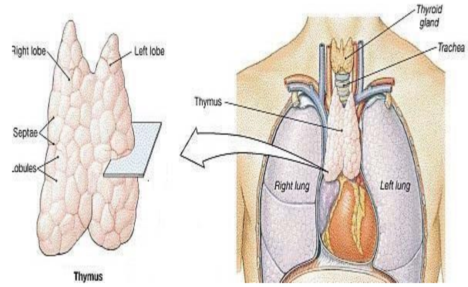


Structure of Spleen

- **Performs several functions:**
- defense helps screen blood and removes pathogens and bacteria
- Hemopoiesis Monocytes and lymphocytes are made here (before birth, RBC's also made here)
- erythrocyte and platelet destruction
- Spleen is ―erythrocyte graveyard‖ iron is salvaged from RBC's 4. blood reservoir able to store blood (~350ml) can constrict and pump blood into circulatory system if hemorrhaging = self transfusion (can squirt 200 ml into blood in <1minute) also, helps stabilize blood volume by transferring excess plasma from blood to lymphatic system

THYMUS

- s single unpaired organ in Mediastinum and neck region
- plays vital role in initial set up of body's immune system source of lymphocytes before birth which circulate to spleen, nodes and vessels soon after birth it secretes a hormone that causes lymphocytes to develop into plasma cells



Structure of Thymus

- primary function is in early life
- once this job is done it degenerates seems to complete It's essential job by end of childhood
- largest when young, esp. puberty
- then gets smaller and is replaced with fat
- Secretes thymosin and thymopoietin which causes T lymphocytes to become Immunocompetent
- Lacks B cells (no follicles)
- Atrophies with age: prominent in newborns, stops growth by adolescence, degenerates by old age

MALT (MUCOSA ASSOCIATED LYMPHATIC TISSUE) INCLUDES

- Tonsils
- Payer's Patches in intestines
- Appendix
- Small bronchiolar follicles

MALT is positioned to:

- Destroy bacteria that breach the mucosal membrane from outside
- Develop ―memory‖ lymphocytes for long term immunity

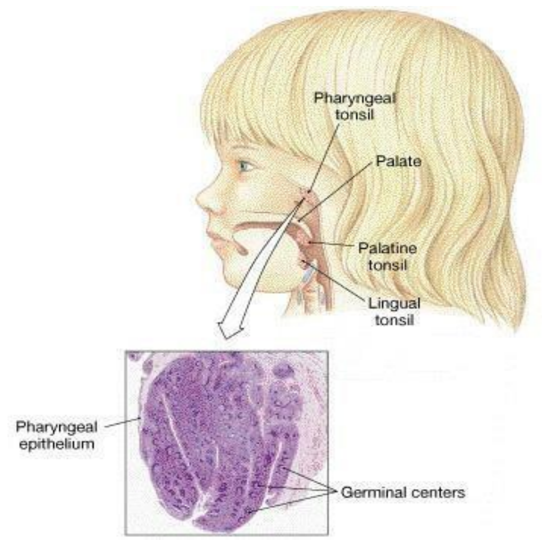
TONSILS

- Masses of lymphoid tissue embedded in mucous membranes of pharynx
- Covered by epithelium, with deep pits(=crypts)
- Crypts often contain food debris, bacteria, dead WBC's etc

Three main sets of tonsils:

- **pharyngeal tonsils** (=adenoids) on wall of pharynx behind nasal cavity
- **palatine tonsils** at post margin of oral cavity largest and most often infected = tonsillitis usually Streptococcus today usually treated with antibiotics
- **lingual tonsils** on each side of root of tongue
- Not encapsulated

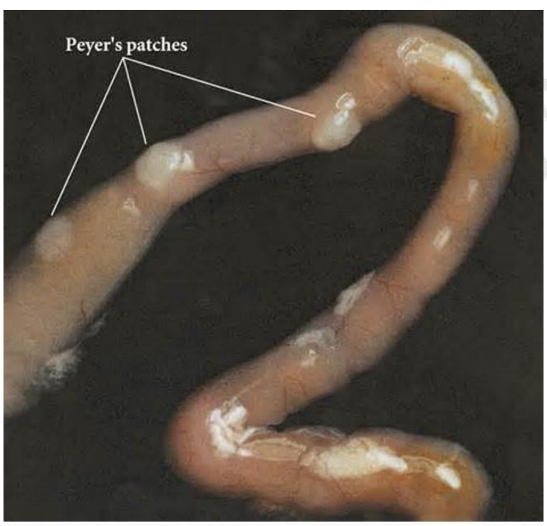
- blind pouches – crypts-bacteria can enter & induced immune response



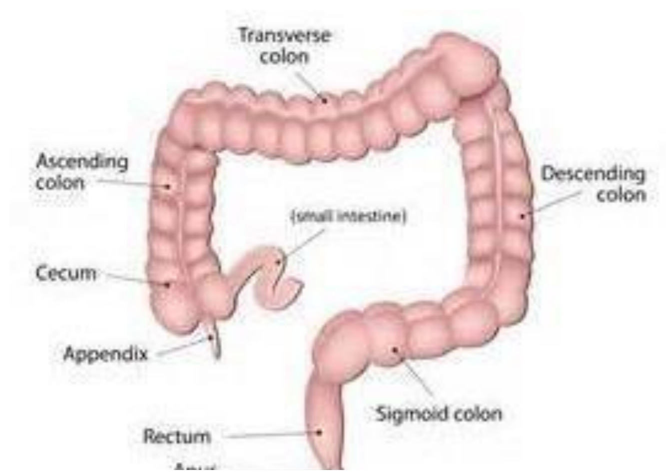
TONSILS

PEYER'S PATCHES

- Small masses of lymphatic tissue found throughout ileum region of small intestine
- Roughly egg-shaped lymphatic tissue nodules that are similar to lymph nodes in structure



Payer's Patches



Appendix

- analyze and respond to pathogenic microbes in the ileum

APPENDIX

- The location of the appendix is close to the junction of the large intestine and the small intestine
- Most researchers agree that it has a minor role in immune function – store good bacteria
- Blockage of the appendix can lead to **Appendicitis**, a type of inflammation that is painful and

potentially deadly- if it bursts it releases dangerous bacteria into the abdominal cavity

- Treated by surgical removal of the appendix

DISORDERS OF THE LYMPHATIC SYSTEM

- ***Edema*** - any disruption of lymphatic flow can lead to edema - excessive accumulation of interstitial fluid- results from injury, inflammation, surgery, or parasitic infections as Elephantitis
- ***Metastatic Cancers*** - metastasis is when cancer cells break free of original tumor and travel to other sites in the body-
- lymph nodes are common sites of metastatic cancer
- since lymphatic capillaries are so permeable, cancer cells can easily enter and travel in the lymph
- tend to lodge in 1st node they enter and enlarge and destroy the node = lymphoma
- once lymphoma is established cells travel from their to other nodes
- ***Hodgkin Disease*** - lymph node malignancy early symptoms: enlarged, painful nodes, esp. in neck;-fever, anorexia, weight loss, night sweats, severe itching often progresses to neighboring lymph nodes
- ***Non-Hodgkin Lymphoma*** - lymphoma similar to above but more common more widespread distribution in body with higher mortality rate
- ***Ruptured Spleen*** one of most common consequences of blows to left thoracic or abdominal wall it bleeds profusely if damaged, may cause fatal hemorrhaging removal of spleen usually not serious since functions are shared with liver and bone marrow

Elephantitis

- A tropical disease caused by lymphatic obstruction.
- Victim is bitten by a mosquito infected with a roundworm known as a filarial worm.
- The resulting edema leads to fibrosis and elephant-like thickening of the skin.

CARDIOVASCULAR SYSTEM

INTRODUCTION

Cardiology – Study of heart and heart diseases

Alternative names- circulatory system or vascular system

Movement of the body fluid from one part to another part is carried out by circulatory system, which is described by William Harvey.

Function:

- It is transport of O_2 , CO_2, Excretory products, Nutrients,
- Regulate body temperature and prevent our body from pathogens

TYPE OF CIRCULATORY SYSTEM

1. Open circulatory system

Open circulatory systems are where internal organs and body tissues are surrounded by circulatory fluid. (Absence of blood capillaries)

2. Closed circulatory system

In closed circulatory system is a circulatory system where blood is contained within vessels. (Presence of blood capillaries)

COMPONENTS OF THE CARDIOVASCULAR SYSTEM

- Consists of the heart plus all the blood vessels
- Transports blood to all parts of the body in two 'circulations': **Pulmonary (lungs) & Systemic (the rest of the body)**
- responsible for the flow of blood, nutrients, oxygen and other gases, and hormones to and from cells
- about 2,000 gallons (7,572 liters) of blood travel daily through about 60,000 miles (96,560

kilometers) of blood vessels

- average adult has 5 to 6 quarts (4.7 to 5.6 liters) of blood, which is made up of Plasma, Red blood cells, White blood cells and Platelets
- In addition to blood, it moves lymph, which is a clear fluid that helps rid the body of unwanted material.

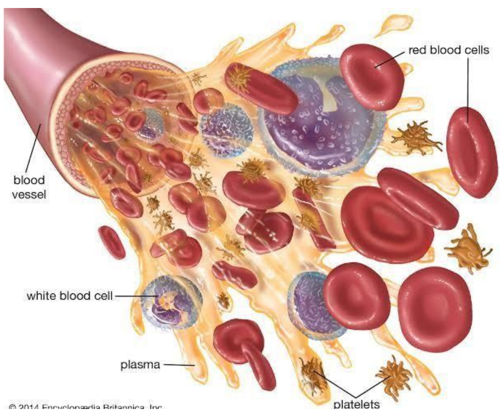


Figure 1: Components of Blood vessels

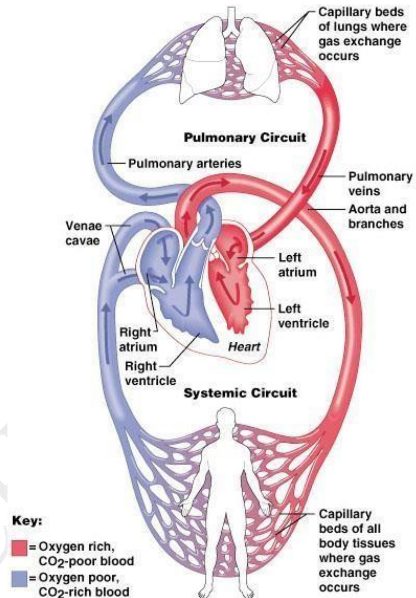
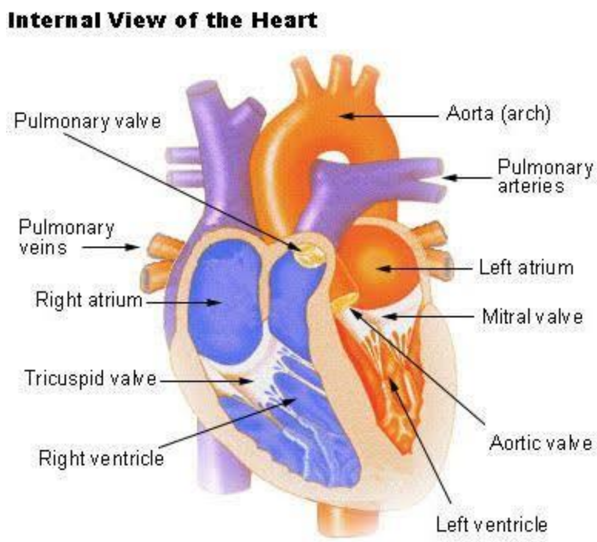
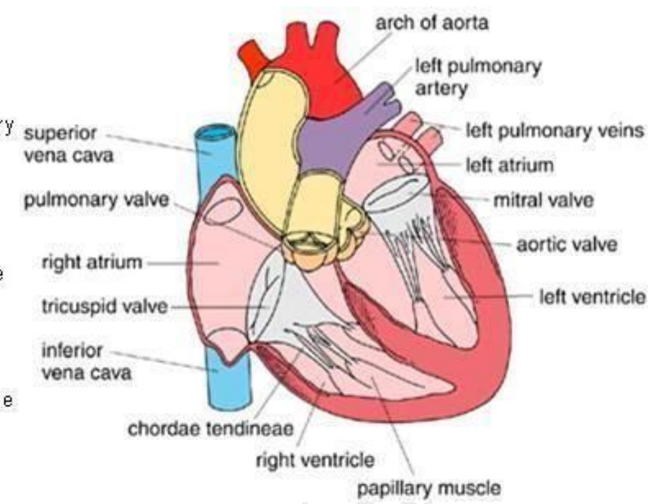


Figure 2: Type of circulation

ANATOMY OF THE HEART

- The heart is a muscular organ a little larger than your fist weighing between 7 and 15 ounces (200 to 425 grams).
- It pumps blood through the blood vessels by repeated, rhythmic contractions. The average heart beats 100,000 times per day pumping about 2,000 gallons (7,571 liters) of blood.
- The average human heart beating at 72 BPM (beats per minute), will beat approximately 2.5 billion times during a lifetime of 66 years.
- The heart is usually situated in the middle of the thorax with the largest part of the heart slightly offset to the left underneath the breastbone or sternum and is surrounded by the lungs.
- The sac enclosing the heart is known as the pericardium.
- The right side of the heart is the pulmonary circuit pump.
- Pumps blood through the lungs, where CO_2 is unloaded and O_2 is picked up.
- The left side of the heart is the systemic circuit pump.
- Pumps blood to the tissues, delivering O_2 and nutrients and picking up CO_2 andwastes.





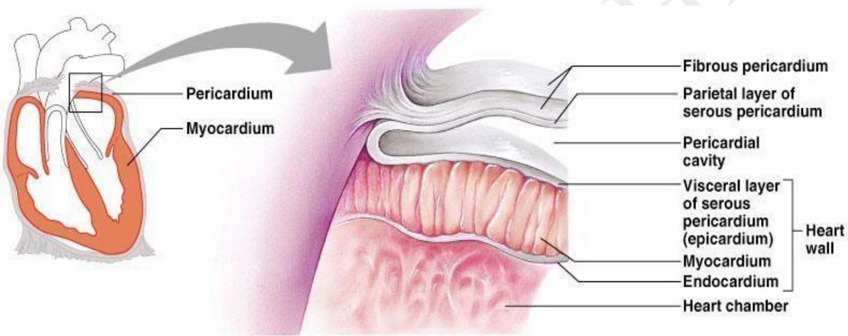
- **Right Atrium:** It collects deoxygenated blood returning from the body (through the venacava) and then forces it into the right ventricle through the tricuspid valve.
- **Left Atrium:** It collects oxygenated blood returning from the lungs and then forces it into the left ventricle through the mitral valve.
- The **Atrioventricular (AV) valves** (**Mitral & Tricuspid Valves**) prevent flow from the ventricles back into the atria.
- **Right Ventricle:** It collects deoxygenated blood from the right atrium and then forces it into the lungs through the pulmonary valve.
- **Left Ventricle:** It is the largest and the strongest chamber in the heart. It pushes blood through the aortic valve and into the body.
- The **pulmonary and aortic valves** prevent back flow from the pulmonary trunk into theright ventricle and from the aorta into the left ventricle.
- **Cardiac muscle cells** are joined by gap junctions that permit action potentials to be conducted from cell to cell.
- The **myocardium** also contains specialized muscle cells that constitute the conducting system of the heart, initiating the cardiac action potentials and speeding their spread through the heart.
- **Aorta:** It is the largest artery and carries oxygenated blood from the heart to the rest of the body.
- **Superior Vena Cava:** Deoxygenated blood from the upper parts of the body returns to

theheart through the superior vena cava.

- **Inferior Vena Cava:** Deoxygenated blood from the lower parts of the body returns to theheart through the inferior vena cava.
- **Pulmonary Veins:** They carry oxygenated blood from the lungs back to the heart.
- **Pulmonary Arteries:** They carry blood from the heart to the lungs to pick up oxygen.

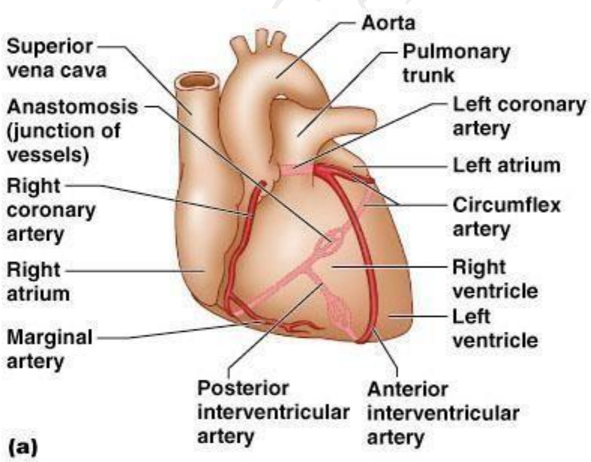
Pericardial Layers of the Heart Wall

- **Epicardium** – visceral layer of the serous pericardium
- **Myocardium** – cardiac muscle layer forming the bulk of the heart
- **Fibrous skeleton of the heart** – crisscrossing, interlacing layer of connective tissue
- **Endocardium** – endothelial layer of the inner myocardial surface

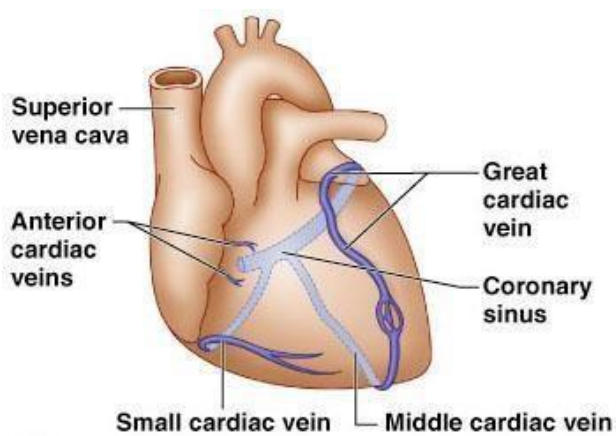


Layers of Heart Wall

CORONARY CIRCULATION

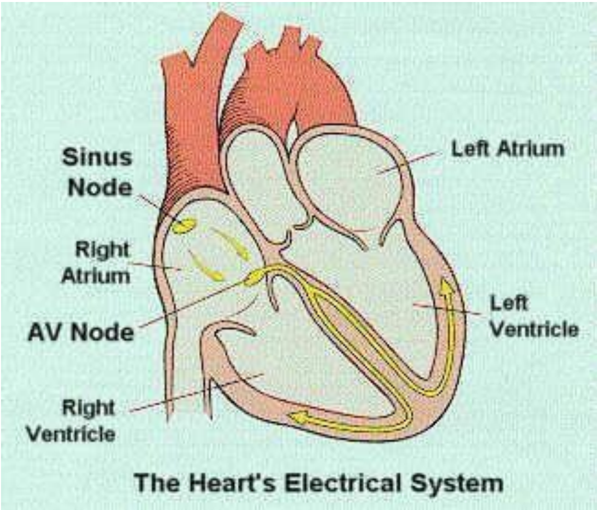


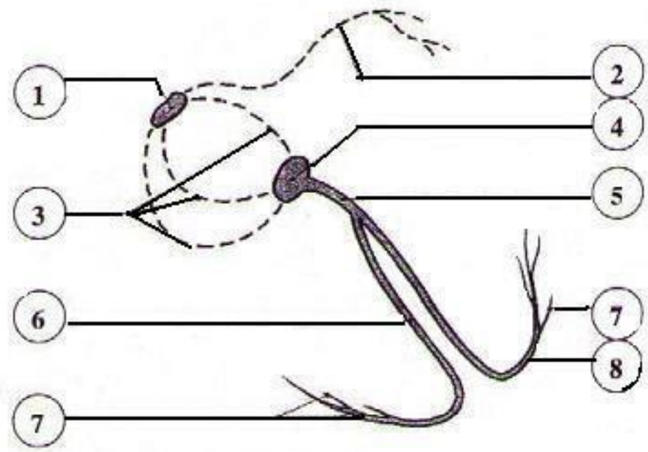
Arterial Supply



Venous Supply

Electrical System of the Heart





1. Sinoatrial Node (SA Node)-Pacemaker of the heart
2. Intra-Atrial Pathway-carries electricity through atria
3. Internodal Pathway-carries electricity through atria
4. Atriaventricular Node (AV Node)-Back up pacemaker. Slows conduction
5. Bundle of His-last part of conduction in atria
6. Right Bundle Branch-carry electricity through R. Ventricle
7. Purkinje Fibers-distribute electrical energy to the myocardium
8. Left Bundle Branch-carries electricity through L. Ventricle

Heartbeat Coordination

1. Cardiac muscle cells must undergo action potentials for contraction to occur.

- The rapid depolarization of the action potential in Atrial and ventricular cells (other than those in the conducting system) is due mainly to a positive feedback increase in sodium permeability.
- Following the initial rapid depolarization, the membrane remains depolarized (the plateau phase) almost the entire duration of the contraction because of prolonged entry of calcium into the cell through slow plasma-membrane channels.

2. The SA node generates the current that leads to depolarization of all other cardiac muscle cells.

- The SA node manifests a pacemaker potential, which brings its membrane potential to threshold and initiates an action potential.

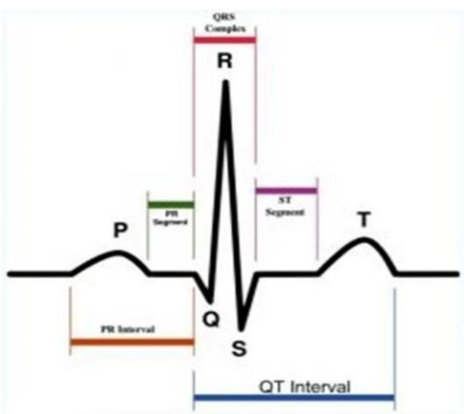
- The impulse spreads from the SA node throughout both atria and to the AV node, where a small delay occurs. The impulse then passes in turn into the bundle of His, right and left bundle branches, Purkinje fibers, and non-conducting-system ventricular fibers.

3. Calcium, mainly released from the sarcoplasmic reticulum (SR), functions as the excitation-contraction coupler in cardiac muscle, as in skeletal muscle, by combining with troponin.

- The major signal for calcium release from the SR is calcium entering through voltage-gated calcium channels in the plasma membrane during the action potential.
- The amount of calcium released does not usually saturate all troponin binding sites, and so the number of active cross bridges can be increased if cytosolic calcium is increased still further.

4. Cardiac muscle cannot undergo summation of contractions because it has a very long refractory period.

<u>ELECTROCARDIOGRAM (ECG OR EKG)</u> = record of spread of electrical activity through the heart

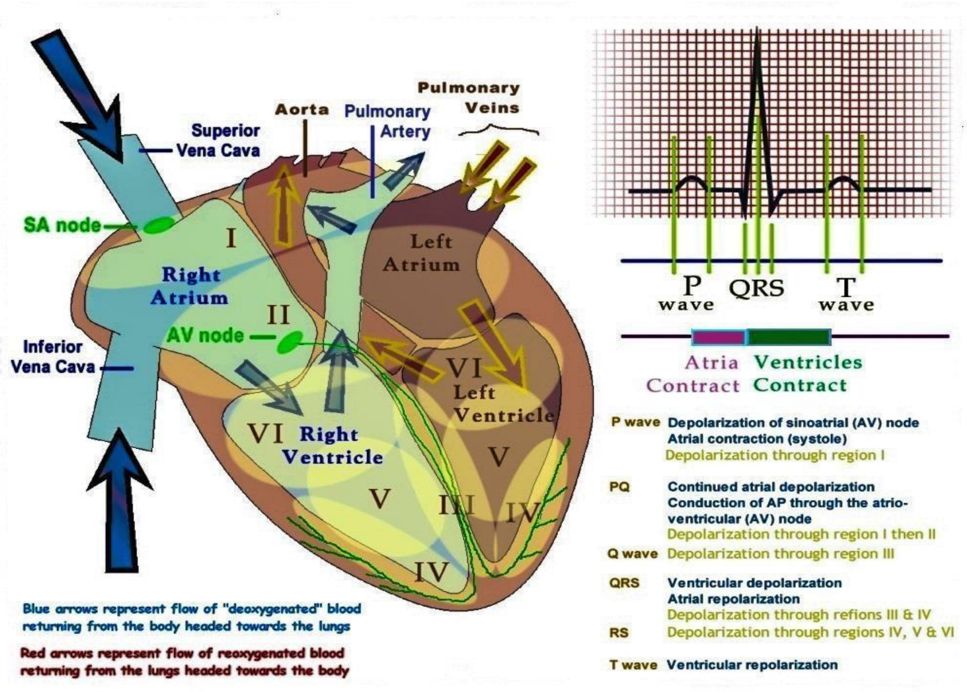


P wave = caused by Atrial depolarization (contraction)

QRS complex = caused by ventricular depolarization (contraction) and Atrial relaxation

T wave = caused by ventricular repolarization (relaxation)

ECG = useful in diagnosing abnormal heart rates, arrhythmias, & damage of heart muscle



Mechanical Events of the Cardiac Cycle

❖ The cardiac cycle is divided into **systole** (ventricular contraction) and **diastole** (ventricular relaxation).

- At the onset of **systole**, ventricular pressure rapidly exceeds atrial pressure, and the AV valves close. The aortic and pulmonary valves are not yet open, however, and so no ejection occurs during this isovolumetric ventricular contraction.
- When ventricular pressures exceed aortic and pulmonary trunk pressures, the aortic and pulmonary valves open, and ventricular ejection of blood occurs
- When the ventricles relax at the beginning of diastole, the ventricular pressures fall significantly below those in the aorta and pulmonary trunk, and the aortic and pulmonary valves close. Because AV valves are also still closed, no change in ventricular volume occurs during this isovolumetric ventricular relaxation.
- When ventricular pressures fall below the pressures in the right and the left atria, the AV valves open, and the ventricular filling phase of diastole begins.
- Filling occurs very rapidly at first so that atrial contraction, which occurs at the very end of diastole, usually adds only a small amount of additional blood to the ventricles.

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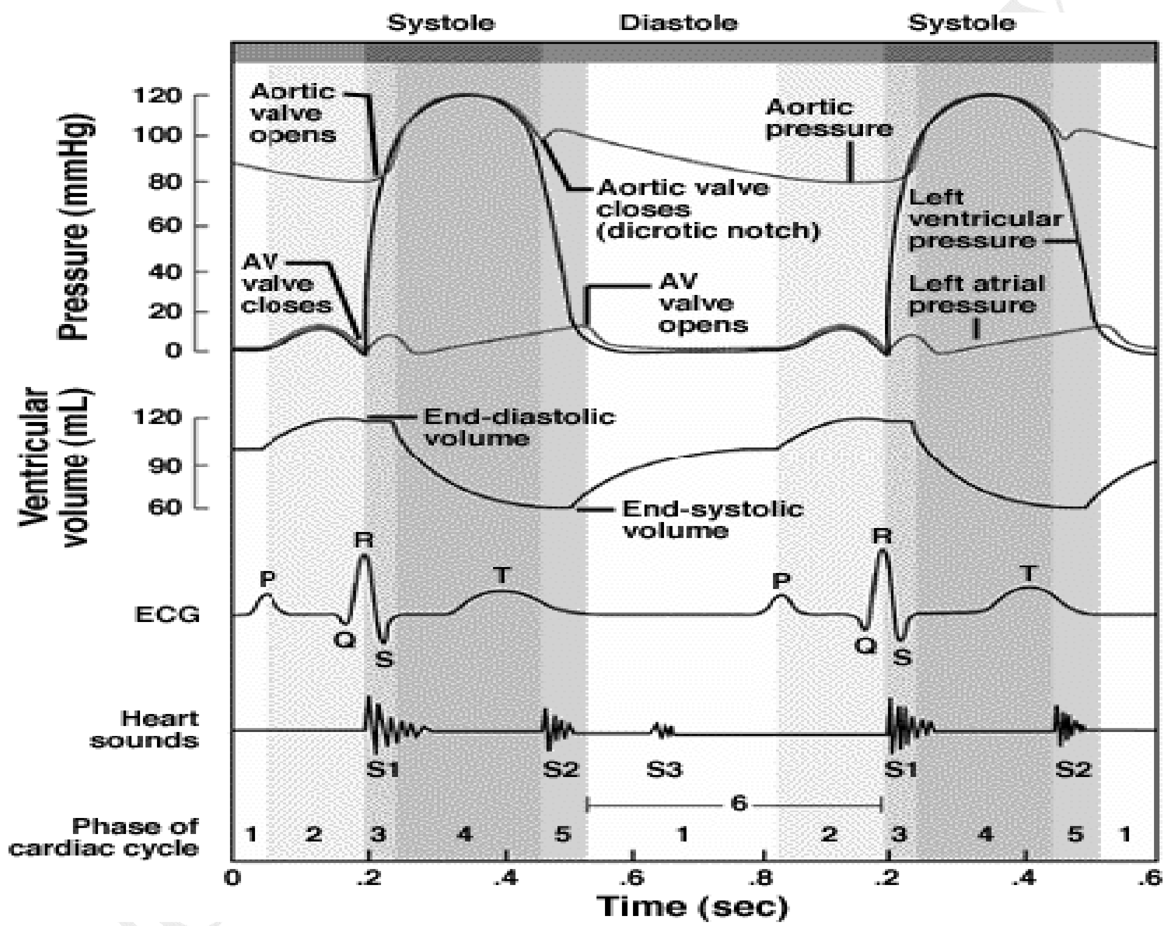
❖ The amount of blood in the ventricles just before systole is the end diastolic volume. The volume remaining after ejection is the end-systolic volume, and the volume ejected is the stroke volume.

- ❖ Pressure changes in the systemic and pulmonary circulations have similar patterns but the pulmonary pressures are much lower.
- ❖ The first heart sound is due to the closing of the AV valves, and the second to the closing of the aortic and pulmonary valves.



The Cardiac Output

- ➢ The cardiac output is the volume of blood pumped by each ventricle and equals the product of heart rate and stroke volume.

1. Heart rate is increased by stimulation of the sympathetic nerves to the heart and by epinephrine; it is decreased by stimulation of the parasympathetic nerves to the heart.
2. Stroke volume is increased by an increase in end-diastolic volume (the Frank-Starling mechanism) and by an increase in contractility due to sympathetic-nerve stimulation or to epinephrine.

Inherent rates for each of the three pacemaker sites Sinus Node 60 to 100 beats per minute

AV Junction 40 to 60 beats per minute

Ventricles 20 to 40 beats per minute

Relevant Formulas

Stroke volume (SV) **= milliliters of blood pumped per beat**

Heart rate (HR) **= number of beats per minute**

Cardiac output (CO) **= heart rate times stroke volume**

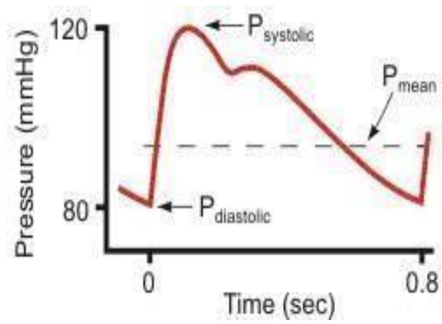
CO = HR x SV

Pulse pressure (PP) **= the difference between systolic pressure (SP) and diastolic pressure (DP)**

PP = SP – DP

Mean Arterial Pressure (MAP) (2 equations):

Formula 1: MAP = diastolic pressure + 1/3 pulse pressure Formula 2: MAP = 2/3 diastolic pressure + 1/3 systolic pressure



- Mean arterial pressure, the primary regulated variable in The cardiovascular system equals the product of cardiac output and total peripheral resistance.

The factors that determine cardiac output and total peripheral resistance are complex and include venous pressure, inspiration, stroke volume, and nervous activity.

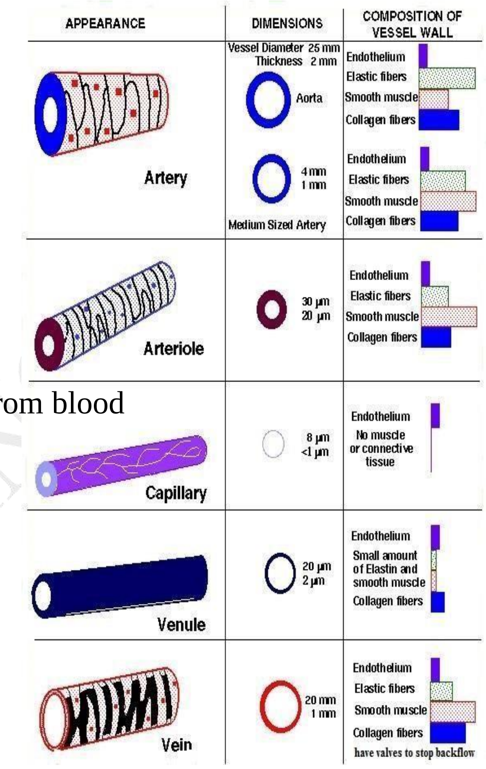
BLOOD

Functions: Transportation, oxygen & carbon dioxide**,** nutrients**,** waste products (metabolic wastes, excessive water, & ions)

Regulation - hormones & heat (to regulate body temperature)

Protection - clotting mechanism protects against blood loss & leucocytes provide immunity against infection.

Blood types – A, B, O alleles - A and B genes are co-dominant and both dominant over the O gene which is recessive



THE VASCULAR SYSTEM

BLOOD VESSELS

Arteries – largest vessels – carry blood from the heart.

Arterioles- smaller version of arteries, carry blood to the capillaries

Capillaries – smallest vessels, one cell thick, transfer materials to and from blood

Venules – small version of veins, carry blood from capillaries to veins

Veins – carry blood back to heart, have valves to stop backflow

ARTERIES

- The arteries function as low-resistance conduits and as pressure reservoirs for maintaining blood flow to the tissues during ventricular relaxation.
- The difference between maximal arterial pressure (systolic pressure) and minimal arterial pressure (diastolic pressure) during a cardiac cycle is the pulse pressure.
- Mean arterial pressure can be estimated as diastolic pressure plus one-third pulse pressure.

ARTERIOLES

- Arterioles, the dominant site of resistance to flow in the vascular system, play major roles in determining mean arterial pressure and in distributing flows to the various organs and tissues.
- Arteriolar resistance is determined by local factors and by reflex neural and hormonal input.
  - Local factors that change with the degree of metabolic activity cause the arteriolar vasodilation and increased flow of active hyperemia.
  - Flow auto regulation, a change in resistance that maintains flow constant in the face of a change in arterial blood pressure, is due to local metabolic factors and to arteriolar myogenic responses to stretch.

- The sympathetic nerves are the only innervation of most arterioles and cause vasoconstriction via alpha-adrenergic receptors. In certain cases noncholinergic, non-adrenergic neurons that release nitric oxide or other noncholinergic vasodilators also innervate blood vessels.
- Epinephrine causes vasoconstriction or vasodilation, depending on the proportion of alpha- and beta-adrenergic receptors in the organ.
- Angiotensin II and vasopressin cause vasoconstriction.
- Some chemical inputs act by stimulating endothelial cells to release vasodilator or vasoconstrictor paracrine agents, which then act on adjacent smooth muscle. These paracrine agents include the vasodilators nitric oxide (endothelium-derived relaxing factor) and prostacyclin, and the vasoconstrictor endothelin-1.

- Arteriolar control in specific organs varies considerably, including influences from metabolic factors, physical forces, auto regulation, and sympathetic nerves.

VEINS

- Veins serve as low-resistance conduits for venous return.
- Veins are very compliant and contain most of the blood in the vascular system.
- Their diameters are reflexively altered by sympathetically-mediated vasoconstriction so as to maintain venous pressure and venous return.
- The skeletal-muscle pump and respiratory pump increase venous pressure locally and enhance venous return. Venous valves permit the pressure to produce only flow toward the heart.

VENUOLES

- Venules are small blood vessels that collect spent blood from capillary beds and transport it to the larger veins for transport back to the heart.
- Apart from their small size and narrow interior lumens, venules are structurally similar to veins, and several venules often merge together to form a vein.

CAPILLARIES

- Capillaries are the site of exchange of nutrients and waste products between bloodand tissues.
- Blood flows through the capillaries more slowly than in any other part of the vascular system because of the huge cross-sectional area of the capillaries.
- Capillary blood flow is determined by the resistance of the arterioles supplying the capillaries and by the number of open precapillary sphincters.

- Diffusion is the mechanism by which nutrients and metabolic end-products exchange between capillary plasma and interstitial fluid.
    - Lipid-soluble substances move across the entire endothelial wall, whereas ions and polar molecules move through water-filled intercellular clefts or fused-vesicle channels.
    - Plasma proteins move across most capillaries only very slowly, either by diffusion through water-filled channels or by vesicle transport.
    - The diffusion gradient for a substance across capillaries arises as a result of cell utilization production of the substance. Increased metabolism increases the diffusion gradient and increases the rate of diffusion.
- Bulk flow of protein-free plasma or interstitial fluid across capillaries determines the distribution of extracellular fluid between these two fluid compartments.
    - Filtration from plasma to interstitial fluid is favored by the hydrostatic pressure difference between the capillary and the interstitial fluid. Absorption from interstitial fluid to plasma is favored by the plasma protein concentration difference between the plasma and the interstitial fluid.
    - Filtration and absorption do not change the concentrations of crystalloids in the plasma and interstitial fluid because these substances move together with water.
    - There is normally a small excess of filtration over absorption.

DISORDERS OF THE VASCULAR SYSTEM

- **Arteriosclerosis -** a general term describing any hardening (and loss of elasticity) of medium or large arteries
- **Atherosclerosis-**Common form of arteriosclerosis-cholesterol, lipid, and calcium deposits in the walls of the arteries
- **High Cholesterol-**elevated level of cholesterol. Can cause deposits on walls of blood vessels Increases risk of Coronary Heart Disease
- **high blood pressure –** hypertension
- **Stroke-**Sudden loss of neurological function caused by vascular injury to the brain
- **Myocardial Infarction-**loss of living heart muscle as a result of coronary occlusion
- **Congestive Heart Failure -** the heart's function as a pump is inadequate to deliver oxygen rich blood to the body due to weakend heart muscle, stiffening of heart muscle

Or deceases that demand oxygen beyond the capacity of the heart to deliver oxygen-rich blood. It is treated with medications like ACE inhibitors, beta blockers, and diuretics as well as lifestyle changes. Surgery may also be used.

- **Bradycardia –** slowness of heart rate, usually fewer than 60 beats per minute in resting adults. Treatments vary based on the underlying cause of the condition. They may include medications, pacemaker, surgery, or even in severe cases a heart transplant
- **Tachycardia –** rapid resting heart rate, more than 100 beats per minute. Treatment varies based on underlying causes may include lifestyle changes, medications to slow heart, surgery for pacemaker or defibrillator

RESPIRATORY SYSTEM

INTRODUCTION

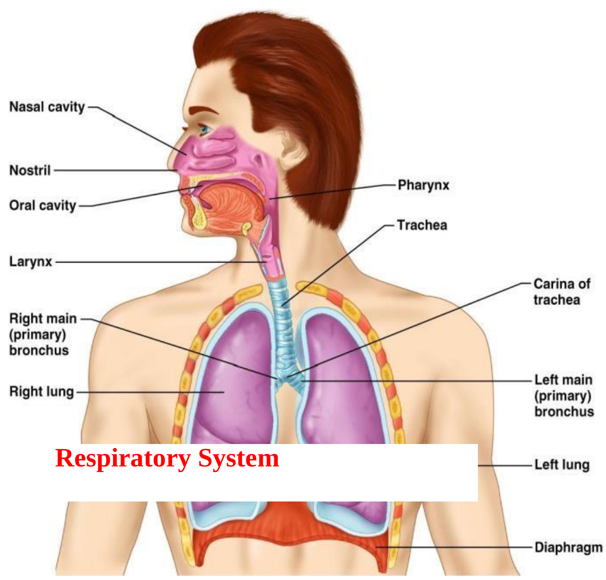
The respiratory system is a biological system consisting of specific organs and structures used for gas exchanges in animals and plants.

FUNCTIONS OF THE RESPIRATORY SYSTEM

- To allow gases from the environment to enter the bronchial tree through inspiration by expanding the thoracic volume.
- To allow gas Exchange to occur at the respiratory membrane, so that oxygen diffuses into the blood while carbon dioxide diffuses into the bronchial tree.
- To permit gases in the lungs to be eliminated through expiration by decreasing the thoracic volume.

GENERAL ANATOMY OF THE RESPIRATORY SYSTEM

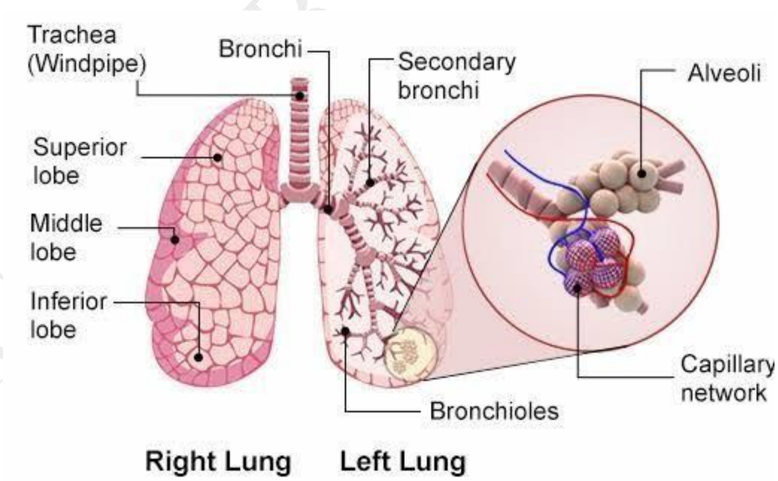
Consists of a tube that divides into small branching tubes in the lungs: External nares → nasal cavity → nasaopharynx → laryngopharynx → larynx → trachea → primary bronchi → lungs (secondary bronchi → tertiary bronchi → bronchioles → alveolar sacs → alveoli).



Respiratory System

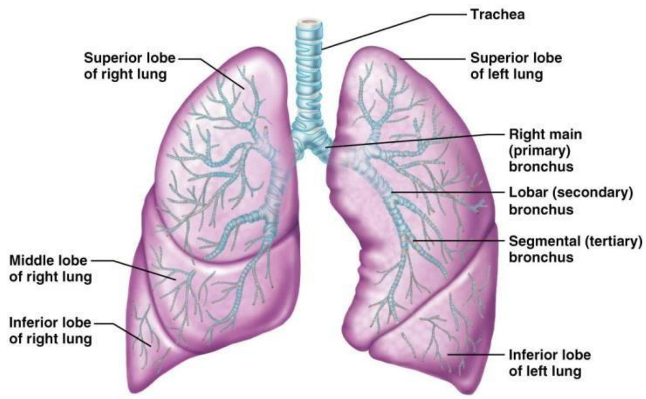
LUNGS

- Cone – shaped organs located in the thoracic cavity.
- Pair of spongy, air filled organs located on either side of the chest
- Right lung is made up of 3 lobes (620 gm)
- Left lung is made up of 2 lobes (560 gm)
- Thoracic cavity is lined with a body membrane called **parietal pleura**, while the surface of lungs is covered with **visceral pleura**.
- The thin space between the two pleural membranes is called **pleural cavity** which is filled with a clear fluid called **plural fluid** to minimize friction between the tissues and to provide **surface tension** in the pleural cavity. [Water molecules in the pleural fluid allow the two pleural membranes to adhere toone another, to prevent collapsing of the lungs].
- A chemical substance called **surfactant** secreted by the lungs also facilitates the surface tension.

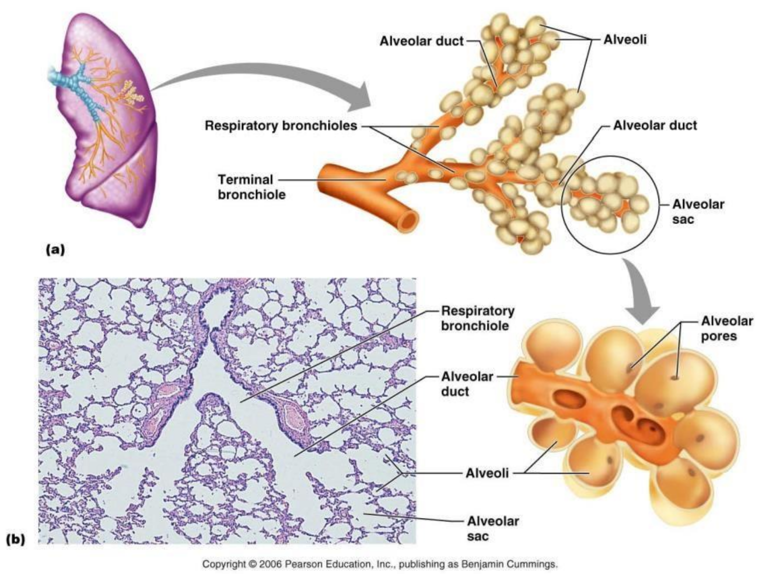


Structure of Lung

The respiratory Tract – Bronchial Tree



The Respiratory Tract



- The histology along the respiratory tract changes – from the trachea to the tertiary bronchi, the tract is lined with **ciliated pseudo stratified columnar epithelium**, **smooth muscle** and **cartilage rings**; the bronchioles are lined with **cuboidal epithelium**; and from the alveolar ducts to the alveoli, the tract is lined with **simple squamous epithelium**.

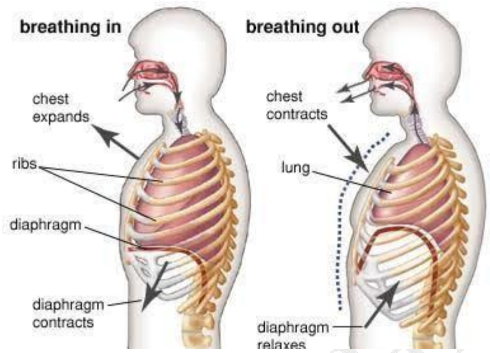
- Inferior to the lungs is a sheet of skeletal muscle under involuntary control, called **diaphragm**, to facilitatethe control of thoracic volume.

The Bronchial tree

- Tree – like branching tubes extended from the trachea. Only the primary bronchi are external to the lungs, while the rest of the bronchial tree is embedded in lung tissues.
- Diameters of the tubes from primary bronchi to tertiary bronchi are large, so that support with

cartilage rings is necessary.

- Diameter at the bronchioles is down to 1 mm where the tubes do not need cartilage rings for support. This structure is composed of cuboidal cells where diffusion is also not possible.
- From the alveolar duct to the alveoli, the lining tissue becomes simple squamous epithelium where gas exchange is possible. Since there is a much larger surface area at the alveoli, almost all gas exchange occurs at the alveoli [300 million alveoli provide a total surface area similar to a tennis court!]



Mechanism of Respiratory System

Inspiration (Inhalation)

- An active process where nerve impulses from medulla oblongata cause the contraction of diaphragm and external intercostals muscles.
- As these muscles contract, thoracic volume increases which decreases the pressure within the lung (intraalveolar pressure)
- When intraalveolar pressure falls below the atmospheric pressure (758 mmHg versus 760 mmHg, respectively), gases move from the environment into lungs.

Expiration (exhalation)

- A passive process where elastic tissues of thelungs and diaphragm recoil to their original position.
- As the diaphragm and external intercostals muscles relax and recoil, a thoracic volume decrease which raises the intra alveolar pressure.
- When intraalveolar pressure is risen above the atmospheric pressure (762 mmHg versus 760 mmHg, respectively), gases move from the lungs into the

Pulmonary Ventilation - Inspiration

- Pulmonary ventilation is the mechanism by which air is exchanged between the atmosphere and the alveoli.
- Air is exchanged due to the expansion and contraction of the lungs.
- Contraction of the diaphragm pulls down, enlarging the intra pleural cavity.
- Elevation of the ribs also expands the intrapleural cavity.
- These factors decrease the intrapleural cavity pressure: thus, air flows into the lungs (inspiration).

Pulmonary ventilation - Expiration

- During expiration the diaphragm relaxes, the ribs arepulled down.
- This increases the intrapleural cavitypressure.
- This results in the movement of air out of the lungs.
- Normal quiet breathing is accomplished entirely bythe movement of the diaphragm.
- In the "normal sized" person, about 6 liters of gas perminute move in and out of the lungs.
- Ventilation can increase up to almost 100 liters perminute during maximal exercise.

Lung Capacities

- Lung capacities (air volumes contained in the lungs) can be measured by a **Spirometer**, and provide invaluable information regarding the normal function of the respiratorysystem.

1. Tidal volume (TV)

- Amount of air moving in and out of the lungs during normal breathing.
- Average value is about 500 ml.

2. Inspiratory reserve volume (IRV)

- Amount of air that can be inhaled after normal inspiration.
- Average value is about 3,000 ml.
- Can be calculated by: IRV = IC – TV where IC represents inspiratory capacity.

3. Expiratory reserve volume (ERV)

- Amount of air that can be exhaled after normal expiration. Average value is about 1,100 ml.

4. inspiratory capacity (IC)

- Total amount of air that can be inhaled.
- Average value is about 4,000 ml. can be calculated by: IC = VC
  – ERV where VC represents vital capacity.

5. Vital capacity (VC)

- Total amount of air that can be exhaled. Average value is about 5,000 ml. Can be calculated by: VC = TV + IRV +ERV.

- Can also be determined by predicted VC values on a chart based on a person's age and height.

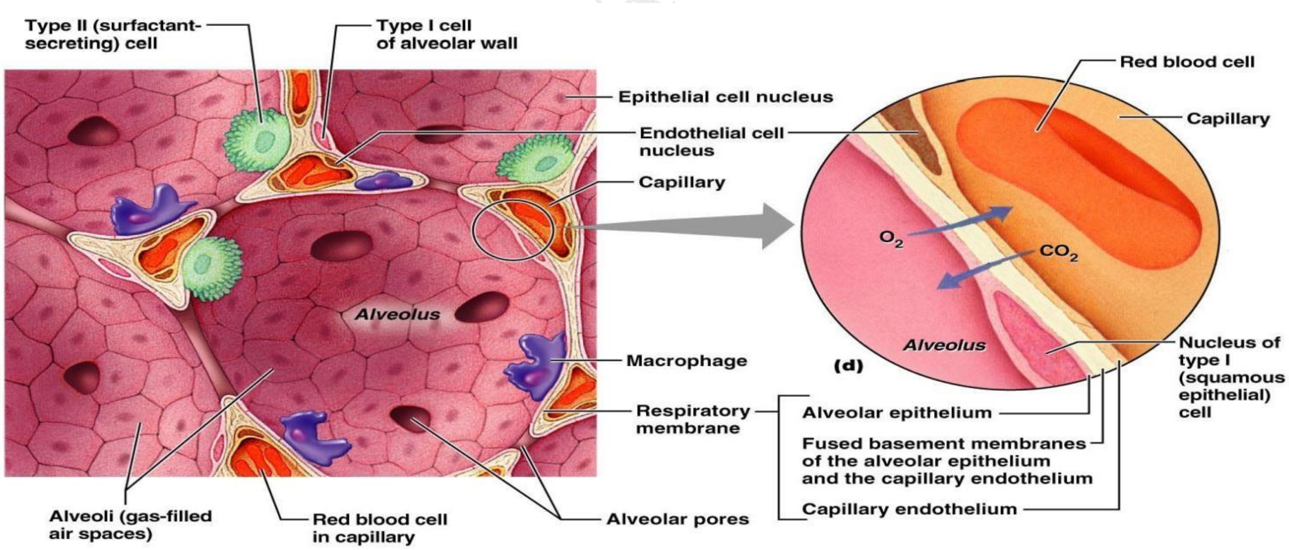
6. Residual volume (RV)

- Amount of air that is always left in the lungs after expiration. Average value is about 1,200 ml.
- Total lung capacity (TLC)
- Total amount of air that the lungs contain, including residual volume. Average value is about 6,000 ml. Can be calculated by: TLC =VC + RV.

7. **Anatomic dead space** refers to the amount of air remain in the bronchial tree that is not involved in gas exchange, due toobstruction of air flow or damage in the bronchial tree
8. **Alveolar dead space** refers to the amount of air in the alveolar ducts or alveolar sacs that is not involved in gas exchange, due to poor blood flow or unusually long diffusion distances in gas exchange.
9. **Physiologic dead space** refers to the total amount of air in the lungs that is not involved in gas exchange (i.e. anatomic dead space + alveolar dead space).

Gas Exchange

- Respiratory membrane is formed by the walls of alveoli and capillaries where they are both made of simple squamous epithelium, thin enough to allow diffusion of gases called gas exchange to occur.



EXTERNAL & INTERNAL RESPIRATION

External Respiration: occurs in the lungs to oxygenate the blood and remove CO_2 from the deoxygenated blood. O_2 diffuses from the alveoli into capillaries, while CO_2 diffuses from the capillaries into alveoli.

Internal respiration (tissue respiration) occurs in the body tissues to provide O_2 to tissue cells and remove CO_2 from the cells. O_2 is critical in the release of energy molecules (i.e. ATP) a process called cellular respiration, while CO_2 is a byproduct of metabolism which can become harmful to tissue cells in large quantities.

O_2 diffuses from the capillaries into tissue cells, while CO_2 diffuses from tissue cells into capillaries.

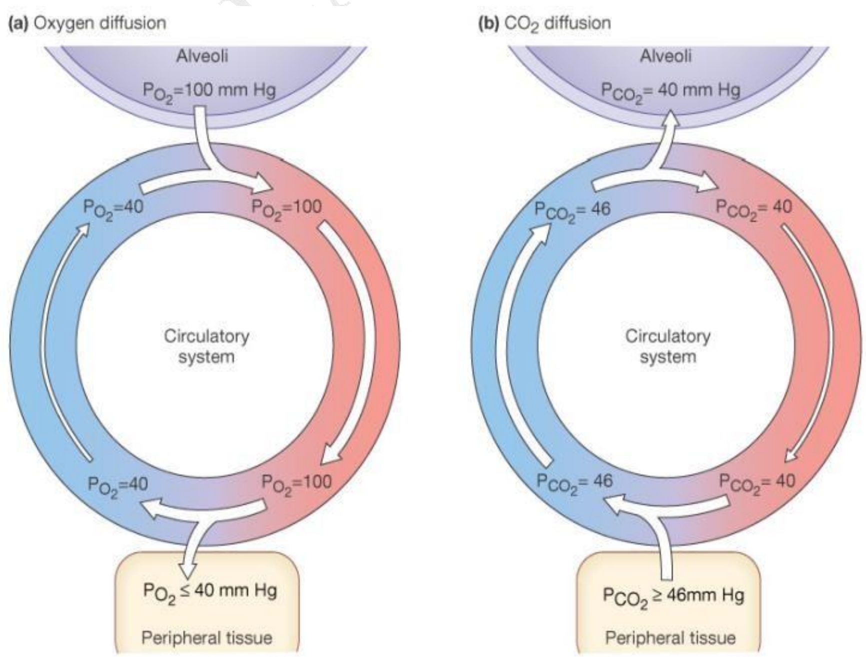
Alveolar Gas exchange

Gas exchanges between the air and the blood occur within the alveoli.

1. The alveoli are tiny sacs clustered at the distal ends of alveolar ducts.
2. The respiratory membrane consists of the alveolar and capillary walls. Gas exchange takes place through thesewalls.
3. Diffusion through the respiratory membrane.

O_2 diffuses from the alveolar air into the blood; Co_2 diffuses from the blood into the alveolar air.

Gas Exchange at the Alveoli & Cells



DISEASES IN RESPIRATORY SYSTEM

1. **Anoxia**: absence or a deficiency of O_2 withintissues.
2. **Asphyxia:** deficiency of O_2 and excess of Co_2 in the blood and tissues.
3. **Atelectasis:** collapse of a lung or some portion of it.
4. **Bronchitis:** inflammation of the bronchial lining.
5. **Cheyne – strokes – respiration:** irregular breathing pattern of a series of shallow breaths that increases in depth and rate, followed by breaths that decrease in depth and rate.
6. **Dyspnea:** difficulty in breathing.
7. **Hyperoxia:** excess oxygenation of the blood.
8. **Hyperpnea:** increase in the depth and rate of breathing.
9. **Hypoxia:** diminished availability of O_2 in thetissues.
10. **Pneumothorax:** entrance of air into the space between the pleural membranes, followed by collapse of the lung.
11. **Tachypnea:** rapid, shallow breathing.
12. **Asthma:** the dyspnea, wheezing and other symptoms of asthma are produced by obstruction of air flow through the bronchioles that occur in episodes or "attacks" (obstruction is due to inflammation).
13. **Lung cancer:** 1/3 of cancer death in the U.S. – smoking is the leading cause.
14. **Tuberculosis:** the bacteria that cause TB are spread when an infected person coughs or sneezes.

DIGESTIVE SYSTEM

INTRODUCTION

The digestive system consistsof the digestive tract, a tube extending from the mouth to the anus, and its associated accessory organs, primarily glands, which secrete fluids into the digestive tract. The digestive tract is also called the alimentary tract, or alimentary canal.

FUNCTIONS OF THE DIGESTIVE SYSTEM

- Ingestion – the oral cavity allows food to enter the digestive tract and have mastication (chewing) occurs, and theresulting food bolus is swallowed.

- Digestion

- **Mechanical digestion** – muscular movement of the digestive tract (mainly in the oral cavity and stomach) physically break down food into smaller particles.

- **chemical digestion** – hydrolysis reactions aided by enzymes (mainly in the stomach and small intestine) chemically break down food particles into nutrient molecules , small enough to be absorbed

- Secretion – enzymes and digestive fluids secreted by the digestive tract and its accessory organs facilitate chemical digestion.

- Absorption – passage of the end – products (nutrients) of chemical digestion from the digestive tract into blood or lymph for distribution to tissue cells.

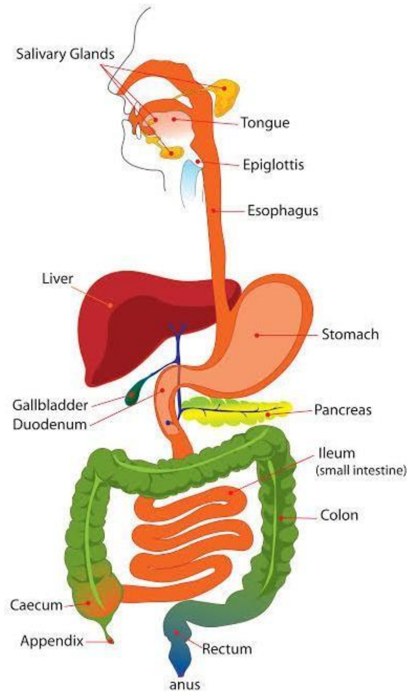
- Elimination – undigested material will be released through the rectum and anus by defecation.

ORGANIZATION OF THE DIGESTIVE SYSTEM

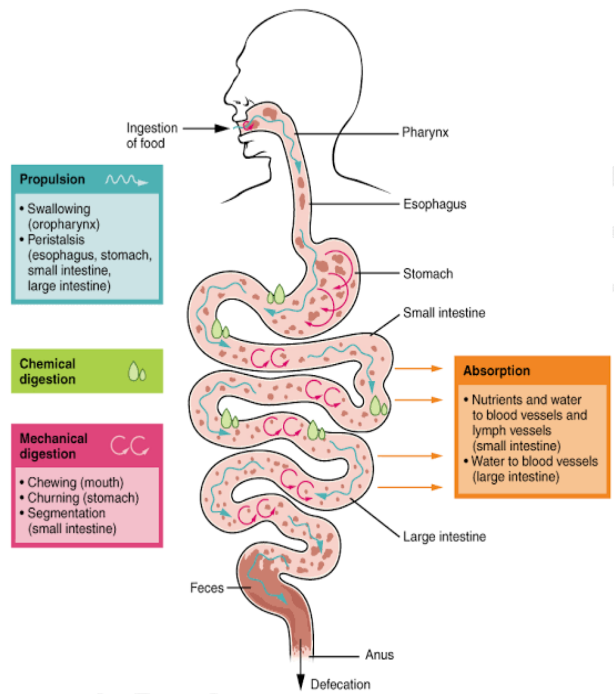
- Organs of the digestive system are divided into 2 main groups: the **gastrointestinal tract (GI tract)** and **accessory structures.**

- GI tract is a continuous tube extending through the ventral cavity from the mouth to the anus – it consists of the mouth, oral cavity, pharynx, esophagus, stomach, small intestine, large intestine, rectum, and anus.

- Accessory structures include the teeth, tongue (in oral cavity), salivary glands, liver, gallbladder, and pancreas.



Digestive system



Process of digestion

MOUTH & ORAL CAVITY:

- Food enters the GI tract by ingestion.

- Food is broken down by mechanical digestion, using mastication.

- One chemical digestive process occurs where **amylase** enzyme in saliva breaks down polysaccharide into disaccharides.

- The **tongue,** made of skeletal muscle, manipulates the food during mastication. It also contains taste buds to detect taste sensations (intrinsic).

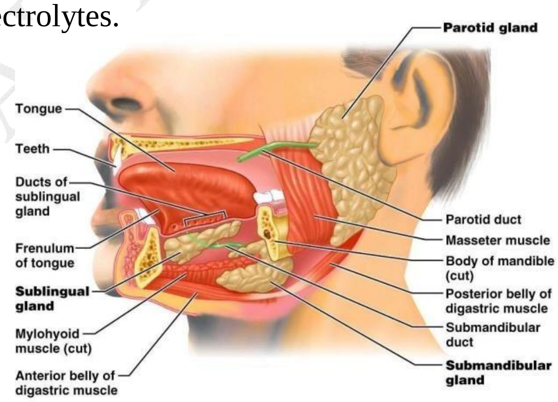
- Food particles are mixed with saliva during mastication, resulting in a moist lump called **bolus** for easier passage into or pharynx.

TEETH

- Adapted for **mechanical digestion** (mastication) in the oral cavity.
- 20 deciduous or primary teeth before the age of 6.
- By age 7, 32 permanent or secondary teeth are developed & are divided into 4 types: **incisors** (for cutting), **Canines** (for tearing), **Premolars** (for crushing), and **Molars** (for grinding). These teeth follow the human dental formula of 2-1-2-3.

SALIVARY GLAND

- 3 pairs of salivary glands called **parotid, submandibular,** and **sublingual** gland secrete most of the saliva in the oral cavity, using salivary ducts.
- Saliva helps moisten the food during mastication, dissolve the food in forming the bolus, and help cleanse the teeth.
- Saliva consists of 99.5% water, the remaining 0.5% is dissolved substances including **amylase** enzyme (for chemically digesting carbohydrate), bicarbonate ion (HCO_3^-; maintains pH of saliva at 6.5-7.5), and many electrolytes.



STOMACH

- A pouch-like organ primarily designed for food storage (for 2-4 hours), some mechanical and chemical digestion also occur.
- Contains two sphincters at both ends to regulate food movement

– **cardiac sphincter** near the esophagus ,and **pyloric sphincter**

- Near the small intestine.

- Divided into 4 regions: **cardiac stomach** (or cardiac), **fundic stomach** (or funded), **body of stomach,** and **pyloric stomach** (or Pylorus).

- Contain thick folds called **rugae** at its layer, for providing larger surface area for expansion, secretion, digestion, and some absorption.

Gastric Gland:

Chief cells: secrete pepsinogen (an inactive enzyme).

-**Parietal cells:** secrete hydrochloric and (HCl) and "intrinsic factor" (which helps absorption of vitamin B_{12} in theintestines).

- **Mucous cells:** secrete mucus and alkaline substances to help neutralize HCl in the gastric juice.

-**G cells:** secrete a hormone called gastrin , which stimulates the parietal cells and overall gastric secretion.

Chemical digestion & absorption in the stomach:

- Carbohydrate digestion is continued with **gastric amylase,** resulting in disaccharides.

- Protein digestion begins with **pepsin** (activation of pepsinogen by HCl), resulting in peptides (small chains of protein).

- Lipid digestion begins with **gastric lipases** which can only break down certain lipids such as butterfat, resulting in fatty acids.

Absorption in the stomach is limited, where only small and fat- soluble substances can be absorbed—water, alcohol, aspirin, and certain drugs.

The result of all these mixing, chemical digestion, secretion, and absorption is a yellowish paste called **chyme,** which will be passed on to the small intestine

Regulation of Gastric Secretion:

Regulation of gastric secretion and activities is by both nervous and hormonal mechanisms – food moving along the oral cavity and esophagus stimulates the **parasympathetic nerves** to activate the secretion in gastric glands, the **gastric hormone** from G cells in turn stimulates the gastric glands for more activities ("positive feedback").

On the other hand, when food is emptying from the stomach, **sympathetic nerves** inhibit the gastric glands and gastric, and a hormone called **intestinal gastrin** (released by small intestine) inhibits other gastric activities.

The above regulations occur in 3 overlapping phases:

Cephalic Phase, **Gastric Phase,** & Intestinal Phase.

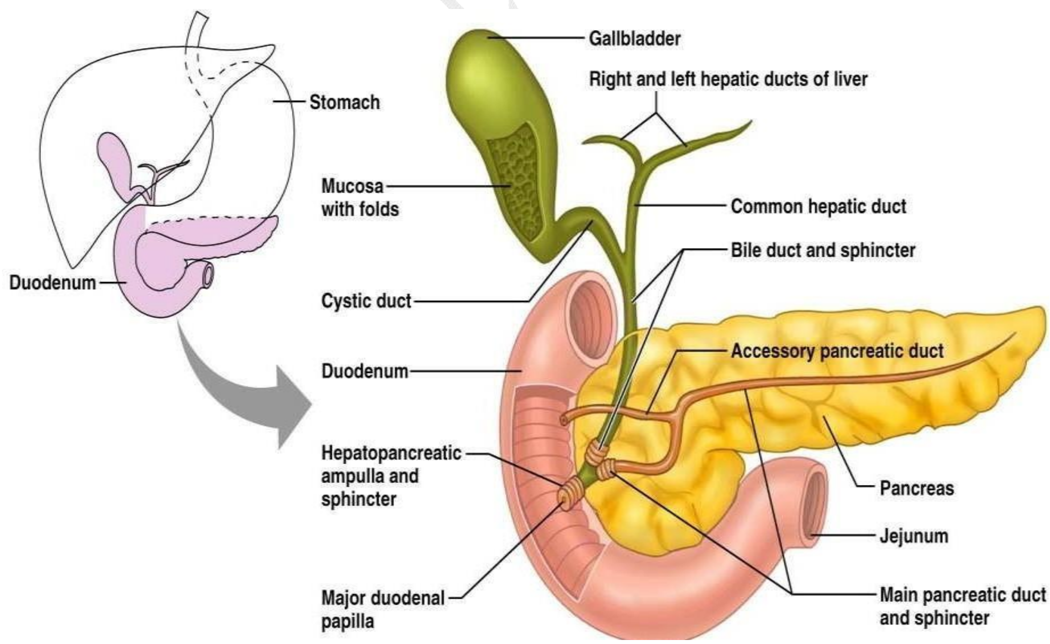
PANCREASE

Pancreas: most pancreatic enzymes are produced as inactivate molecules, or zymogens, so that the risk of self – digestion within the pancreas is minimized.

More than 98% of the pancreas mass is devoted to its exocrine function: the secretion of pancreatic juice by the pancreatic acini and their ductile cells. Ductile cells produce **Sodium bicarbonate** which helps neutralize the acidic gastric contents.

Acinar cells of the exocrine pancreas produce a variety of **digestive enzymes** to break down food substances into smaller absorbable molecules.

Only 2% of pancreas mass is devoted to the islets of langerham, which produce **insulin** and **glucagon,** hormones that regulate blood sugar and carbohydrate metabolism (they have opposite effects).



Major pancreatic Enzymes:

-**pancreatic amylase:** digest polysaccharides into disaccharides

- **Pancreatic lipases** digest triglycerides into fatty acids.

- **Pancreatic nucleases** digest nucleic acids into nucleotides.

-**Pancreatic proteinases** (all secreted in their inactive forms) digest peptides into amino acids:

Trypsinogen is activated by enterokinase (secreted by duodenum) into **trypsin,** which in turn activates the other 3 enzymes – **chymo- Trypsinogen** becomes **chymotrypisn, proaminopeptidase** becomes **amino peptidase**, **and procarboxypeptidase** becomes **carboxypeptidase**.

Pancreatic Secretion:

1. The parasympathetic nervous system increases pancreatic secretion

2. Two duodenual hormones also influence pancreatic secretion: Secretin and Cholecystokinin.

3. Food entering the small intestine stimulates the secretion of both hormones.

4. Secretin stimulates the secretion of pancreatic electrolyte – rich fluid, while CCK enhances the enzymatic secretions of the pancreas.

Regulation of pancreatic Juice:

1. Acidic chyme enters duodenum.

2. Secretin is released into blood stream from intestinal mucosa.

3. Secretin stimulates pancreas.

4. Pancreas secretes pancreatic juice.

5. Pancreatic juice, high in bicarbonate ions, neutralizes acidic chyme.

Functions of the Liver:

Important in carbohydrate metabolism where hepatic cells conduct **glycogenesis** (converting glucose into glycogen), and **glycogenolysis** (breaking glycogen down to glucose).

Also is critical in lipid metabolism where hepatic cells produce **bile** (for fat emulsification), oxidize fatty acids, synthesize various forms of lipids, and convert glucose to fatty acids (**lipogenesis**).

Other functions of the liver include:

- Storage of glycogen, iron, and vitamins A, D, B_{12}.

-Contains phagocytes to destroy damaged erythrocytes and foreign substances, using Phagocytosis.

-Detoxifies harmful substances in the blood.

-Serves as a blood reservoir (contains 7% of blood volume).

GALL BLADDER

A small sac located on the inferior, visceral surface of the liver.

Stores and concentrates bile secreted by the liver.

Regulation of Bile Release:

1. **Chyme** with fat enters small intestine.

2. Cells of intestinal mucosa secrete the hormone **Cholecystokinin**

(CCK) into the blood stream.

3. **CCK** stimulates muscular layer of gallbladder wall to contract.

4. **Bile** passes down the cystic duct and common bile duct to duodenum.

5. Hepatopancreatic sphincter relaxes and **bile** enters duodenum.

SMALL INTESTINE:

A long tube, with a small diameter (about 1 inch), extending from pyloric sphincter to the ileocecal valve.

Divided into Duodenum, Jejunum, and ileum.

1. Secretions of small intestine:

a. Intestinal glands secrete a watery fluid that lack digestive enzymes but provides a vehicle for moving chyme to villi

.Intestinal enzymes include: **maltase** digests maltose into glucose. **Sucrose** digests sucrose into glucose and fructose. **Lactase** digests sucrose into glucose and glucose. **Peptidases** digest peptides into amino acids. **Lipases** digest triglycerides into fatty acids and glycerol. **Nucleases** digest nucleotides into nitrogenous bases.

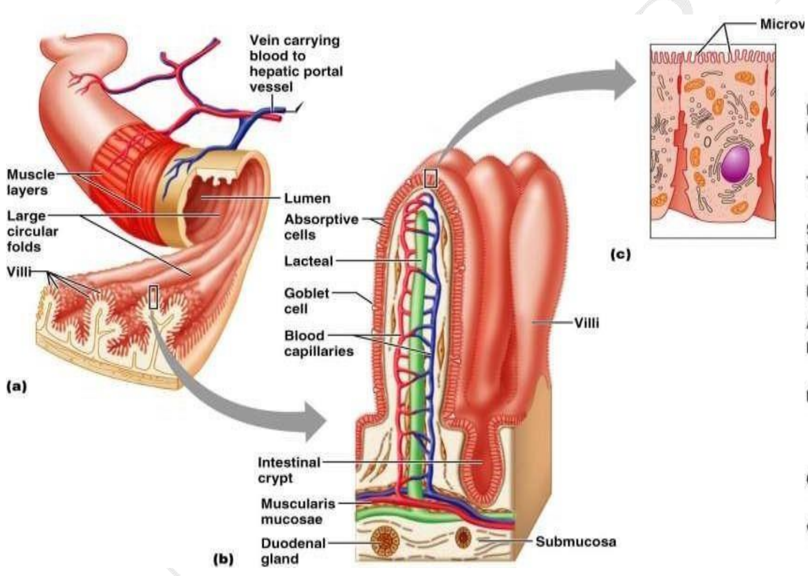
Enterokinase converts Trypsinogen into trypsin.

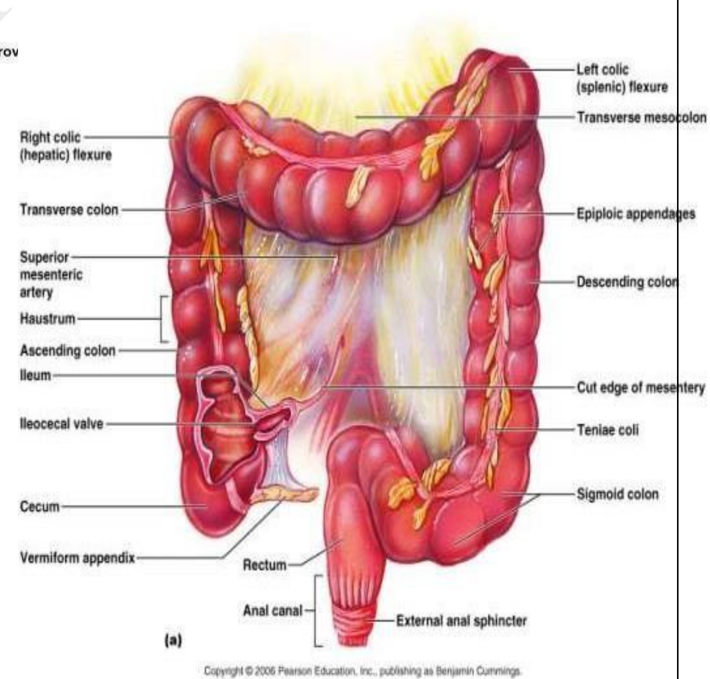
b. Digestive enzymes embedded in the surfaces of microvillus split molecules of sugars, proteins and fats.

c. Regulation of small intestine secretions: secretion is stimulated by gastric juice, chyme, and reflex stimulated by distension of the small intestinal wall.

. Each villus contains blood capillaries to absorb water, glucose, amino acids, vitamins, minerals, and short-chain fatty acids, and also contains lymphatic capillaries called **lacteals** to absorb long – chain fatty acids in the forms of **micelles.**

e. Water is absorbed by osmosis, fatty acids are absorbed by diffusion (since they are fat-soluble), and most other nutrients (glucose, amino acids, & minerals) are absorbed by active transport.





Large intestine

The last segment of the GI tract, with a large diameter (2-3 inches), is extending from the ileocecal valve to the anus.

Divided into **cecum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum, anal canal** and **anus.**

The large intestine has little or no digestive function, although it secretes mucus. Its mucosa has no villa or microvillus, but contains numerous **goblet cells** for secreting mucus to aid in the formation of feces and maintain an alkaline condition.

Mechanical stimulation and parasympathetic impulses control the rate of mucus secretion.

The large intestine only absorbs **water**, electrolytes and some vitamins.

Many **bacteria** inhabit the large intestine, where they break down certain indigestible substances and synthesize certain vitamins.

Feces are formed and stored in the large intestine. **Defecation** involves a reflex mechanism aided by voluntary contraction of the diaphragm, abdominal muscles, and the external anal sphincter

Major Hormones of the Digestive Tract:

1. Gastrin: (Gastric & intestinal): released by Gastric cells, in response to the presence of food. Causes Gastric glands to increase their secretory activity.

2. Somatostatin: (Gastric inhibitory peptides - GIP): Inhibits secretion of acid by parietal cells.

3. Cholecystokinin: released by intestinal wall cells, in response to the presence of proteins and fats in the small intestine. It causes gastric glands to decrease their secretory activity and inhibits gastric motility; stimulation of pancreas to secrete digestive enzyme; stimulates gall – bladder to contract and release bile.

4. Secretin: released by cells in the duodenal wall, in response to acidic chyme entering the small intestine.

Major Digestive Enzyme:

Salivary enzyme: Begins carbohydrates digestion by breaking down starch and glycogen to disaccharides

Gastric enzymes: Pepsin, from gastric glands – Begins protein digestion. Lipase, from Gastric glands – Begins fat digestion.

Pancreatic enzymes: Amylase, from pancreas – breaks down starch and glycogen into disaccharides. Lipase, from pancreas – breaks down fats into fatty acids and glycerol.

Proteolytic enzymes:

Trypsin, Chymotrypisn, and Carboxypeptidase from pancreas breaks down peptides into amino acids. Nucleases, from pancreas- breaks down nucleic acids into nucleotides.

Intestinal Enzymes: Peptidase, from mucosal cells, breaks down peptides into amino acids. Sucrase, maltase, and lactase, from mucosal cells, breaks down disaccharides into monosaccharides. Lipase, from mucosal cells, breaks down fats into fatty acid and glycerol. Enterokinase, from mucosal cells, (breaks down) converts Trypsinogen into trypsin.

CLINICAL TERMS

Achalasia: failure of the smooth muscle to relax at some junction in the digestive tube.

Cholecystitis: Inflammation of the gallbladder.

Chloelithiasis: stones in the gallbladder.

Cholestasis: Blockage in bile flow from the gallbladder.

Cirrhosis: liver cells degenerate and the surrounding connective tissue thicken.

Diverticulitis: Inflammation of small pouches that sometimes form in the lining and wall of the colon.

Dysentery: Intestinal infection.

Dyspepsia: Indigestion

Dysphasia: Difficulty in swallowing

Enteritis: Inflammation of the intestine

EXCRETORY SYSTEM

INTRODUCTION

- Cells are generating many unwanted things like nitrogen waste. Everything filter and eliminated through excretory organ is called excretion
- As blood travels through the tissues, it picks up waste produced by the body's cells. Your blood is like a train that comes to town to drop off supplies and take away garbage.
- If the waste is not removed, body can actually be poisoned.
- Function: Collects and removes or excretes excess water, H_2O, urea, CO_2, and other wastes from our blood that are produced by cells.

BODY PARTS THAT EXCRETE WASTE

- Excretory System (kidneys) – filter out excess water, metabolic waste, waste products from your blood, salt and chemicals as urine.
- Respiratory System (lungs) – filter out carbon dioxide, CO_2, from the blood.
- Integumentary System (skin) – excretes salt and organic substances as sweat, which contains some trace chemical wastes, including urea.
- Digestive System – indigested food leaves through large intestine.

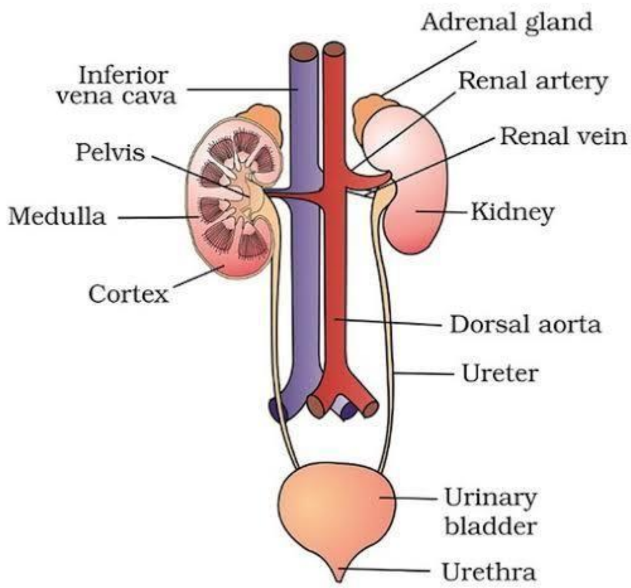
THE EXCRETORY SYSTEM

Two wastes that your body must eliminate are excess water and urea. Urea, which contains nitrogen and is, formed when, cells breakdown proteins for energy. The structures of the excretory system that eliminate urea, water, and other wastes include the kidneys, Ureter, urinary bladder, and urethra

Functions

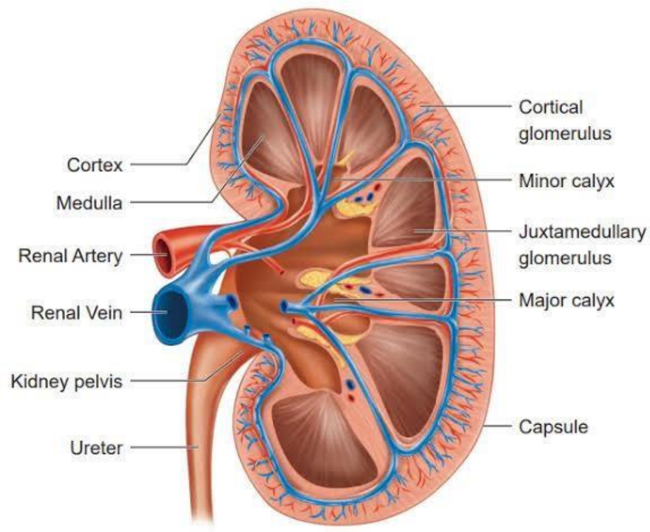
- Removes wastes from blood
- Removes harmful substances from blood
- Regulates body fluids
- Maintains homeostasis

PARTS OF EXCRETORY SYSTEM



KIDNEY

- Function -filter wastes and excess water from the blood.
- The champion of filters.
- Filters about 2,000 L of blood each day.
- Importance –control the amount of water in body, tell body when to make new red blood cells, take harmful chemicals from blood
- Other Info –located in back under ribs You have 2 kidneys, but can live with 1.
- The wastes are eliminated in urine, a watery fluid that contains urea and other waste.
- The main organs of the urinary system
- Bean-shaped organs in your abdomen that filter blood and remove waste.
- The wastewater, or urine, that has been filtered out of the blood moves into the ureters, tubes that connect the kidneys to the bladder.
- The bladder is a muscular sac that holds urine until it exits the body through the urethra.



Structure of Kidney

URETER

Function -tubes that take urine from the kidney to the urinary bladder.

Importance –after the waste is filtered from blood, it must go to the bladder for storage Other Info –each kidney has its own Ureter

URINARY BLADDER

Function: a sack like muscular organ that stores urine/liquid waste

Importance: Holds urine until you go to the bathroom

Other Info: when full, a message is sent to your brain telling you to go to the bathroom. It can hold 0.5 liters of urine

Muscular sac in the pelvis

Urine is made in the kidneys and travels down two tubes called Ureter to the bladder

Urine exits the bladder into the urethra, which carries out of the body

URETHRA

Function- small tube that carries urine out of the body.

Importance – connects the bladder to the outside of the body, how urine leave body

Other Info – about 6mm wide

FILTRATION OF WASTE

Each of your kidneys contains about a million Nephrons, tiny microscopic filtering factories that remove wastes from blood and produce urine. The nephrons filter wastes in stages. First, both wastes and needed materials, such as glucose, are filtered out of the blood. Then, much of the needed material is returned to the blood, and the wastes are eliminated from the body.

FORMATION OF URINE

Anti diuretic Hormone when you get thirsty, other parts of your body react to the water shortage, too. A hormone called anti-diuretic hormone, or ADH, is released. ADH signals the kidneys to take water from the nephrons. The nephrons return the water to the bloodstream. Thus, the kidneys make less urine. When your blood has too much water, small amounts of ADH are released. The kidneys react by allowing more water to stay in the nephrons and leave the body as urine.

Diuretics Some beverages contain caffeine, which is a diuretic. Diuretics cause the kidneys to make more urine, which decreases the amount of water in the blood. When you drink a beverage that contains water and caffeine, the caffeine increases fluid loss. So, your body gets to use less of the water from the caffeinated beverage than from a glass of water.

Filtering out Wastes during the first stage of waste removal, blood enters the kidneys. Here, the blood flows through smaller and smaller arteries. Eventually it reaches a cluster of capillaries in a Nephron. The capillaries are surrounded by a thin walled, hollow capsule that is connected to a tube. In the capillary cluster, urea, glucose, and some water move out of the blood and into the capsule. Blood cells and most protein molecules do not move into the capsule. Instead, they remain in the capillaries. Formation of Urine forms from the filtered material in the capsule. This material flows through the long, twisting tube. As the liquid moves through the tube, many of the substances are returned to the blood. Normally, all the glucose, most of the water, and small amounts of other materials pass back into the blood in the capillaries that surround the tube. In contrast, urea and other wastes remain in the tube.

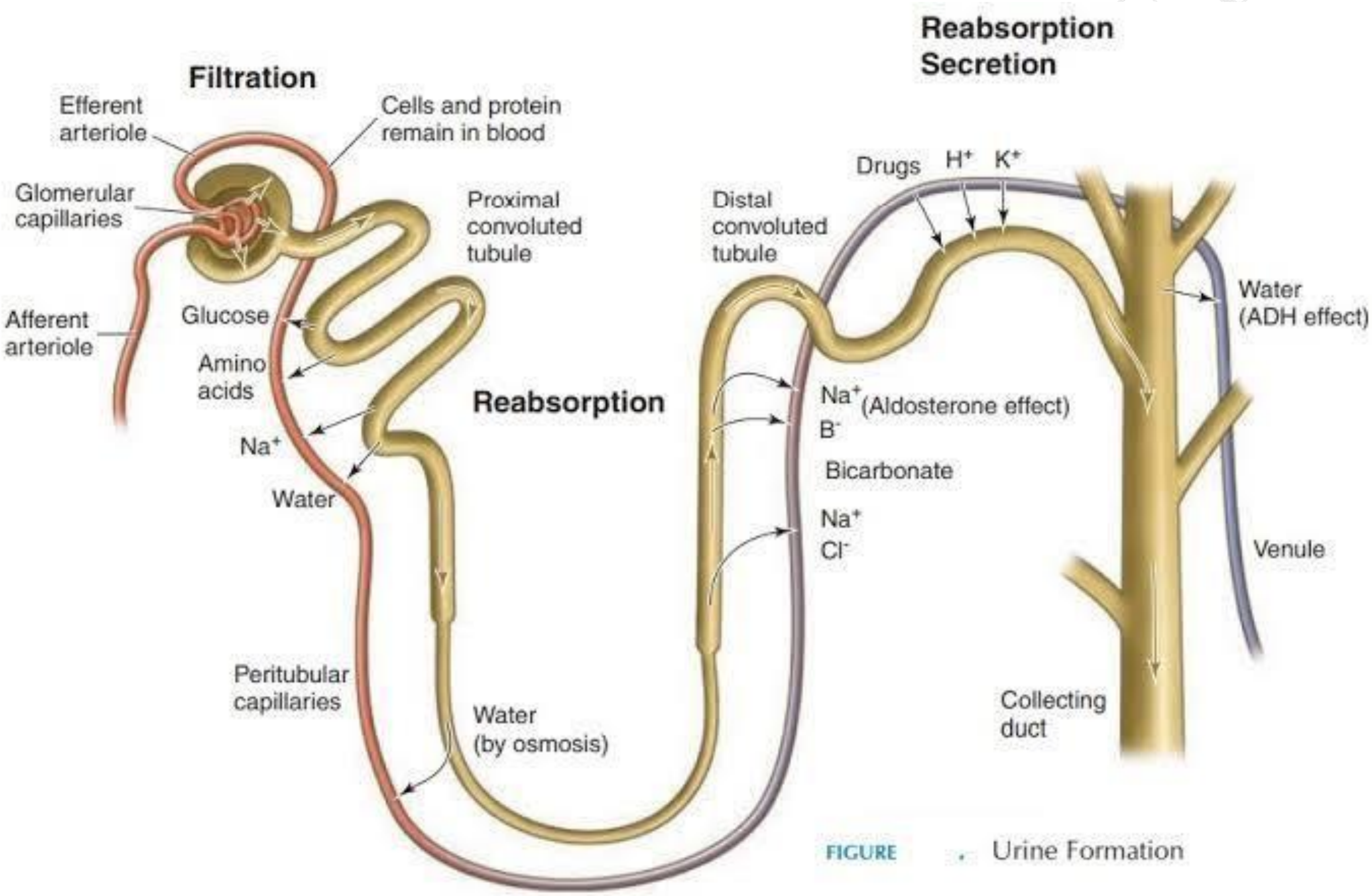
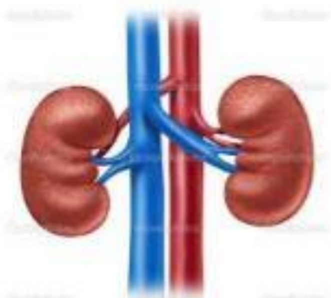
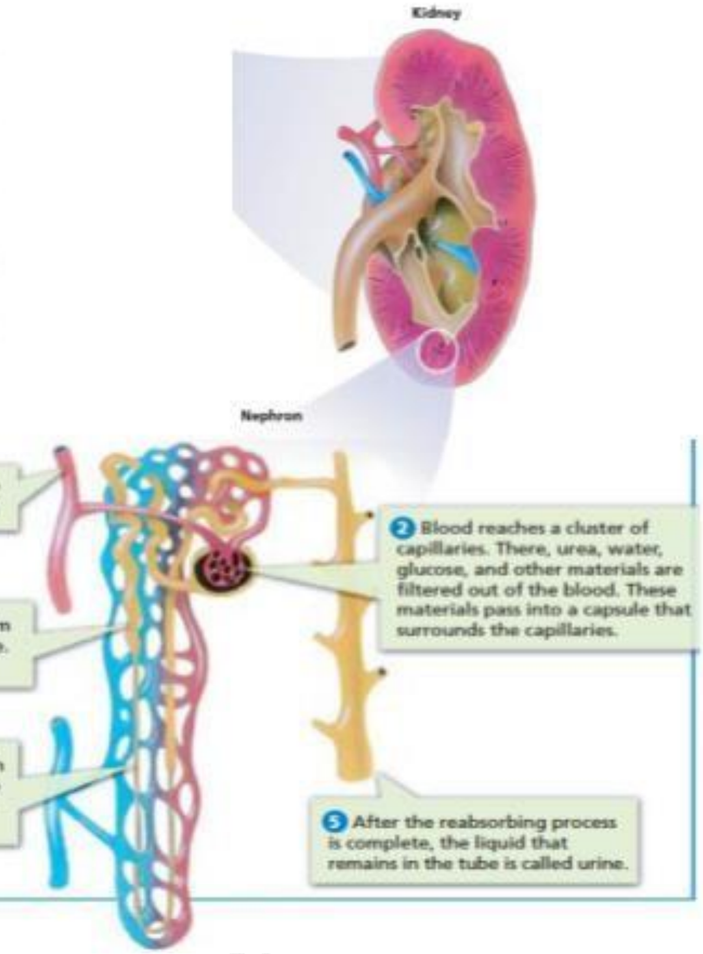
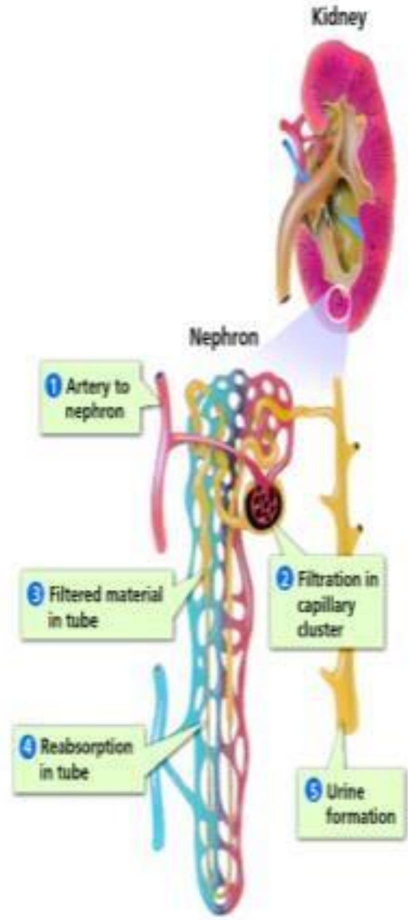


FIGURE . Urine Formation

Filtration of Waste







DISEASES OF URINARY SYSTEM

A chemical analysis of urine can be useful in detecting some medical problems. Normally, urine contains almost no glucose or protein. If glucose is present in urine, it may indicate that a person has diabetes, a condition in which body cells cannot absorb enough glucose from the blood. Protein in urine can be a sign that the kidneys are not functioning properly.

Bacterial infections can get into the bladder and Ureter from the urethra. Infections in the kidney can permanently damage nephrons, and cause the kidney to not work properly. Infections should be treated early, before they spread to the kidneys. Infections in the kidneys can permanently damage the nephrons.

When waste is not removed (Kidney Stones) Wastes can build up and act as poison, it causes ankles and feet to swell because of the extra water. Fluid can build up around the heart, causing it to work harder to move blood to the lungs. Unbalance of salts can cause kidney damage, along with infections in bladder that can spread to kidneys. Blockages in ureters or urethra due to kidney stones. These stones cause pain and some pass naturally while other must be removed.

Polycystic kidney disease (PKD) causes many fluid filled cysts to grow in the kidneys. PKD cysts can make the kidneys much larger, but at the same time, the cysts replace the normal parts of the kidney. This causes the kidneys to not work as well or even to stop working. After many years with PKD the kidney s stop working, and dialysis or kidney transplants are needed. In the United States, about 600,000 people have PKD.

Kidney Failure occurs when one or both kidneys no longer work. You can survive with only one kidney, but when both kidneys don’t work, you need dialysis, when a machine cleans your blood for you. Like healthy kidneys, dialysis keeps your body in balance.

Dialysis: removes waste, salt and extra water to prevent them from building up in the body.

Keeps a safe level of certain chemicals in your blood, such as potassium, sodium and bicarbonate. Helps to control blood pressure

REFERENCE

- https://my.clevelandclinic.org/health/body/21205-respiratory-system
- https://byjus.com/biology/human-respiratory-system/
- https://byjus.com/biology/cells/#:~:text=cells%20do%20not.-,Cell%20Structure,on%20cell%20structure%20and%20function.
- https://www.britannica.com/science/cell-biology
- https://www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article
- https://www.britannica.com/science/nervous-system
- https://byjus.com/biology/nervous-system/
- https://www.britannica.com/science/human-digestive-system
- https://byjus.com/biology/human-digestive-system/
- https://byjus.com/biology/human-excretory-system/
- https://biologydictionary.net/excretory-system/