Ministry of Higher Education and Scientific Research
Al-Furat Al-Awsat Technical University
Najaf Medical Technical Institute
Aesthetic and Laser Department
Physiology

Dr. Rabab Ali Al-Mosawi

Lecture 1&2 Cell structure

Physiology is the science that seeks to explain the physical and chemical mechanisms that are responsible for the origin, development, and progression of life.

The term "physiology," from Ancient Greek, meaning (study of nature, origins).

physiology focuses on how organisms, organ systems, individual organs, cells, and biomolecules carry out chemical and physical functions in a living system.

According to the classes of organisms, the field can **be divided** into medical physiology, animal physiology, plant physiology, cell physiology, and comparative physiology.

Cells are the structural and functional unit of all living organisms, from the unicellular organisms, like amoeba, which are the body made up of one cell to the multicellular organisms, such as human beings, whom their body made up of 50-100 trillion cells.

The cell has been known in the 6 th century by Robert Hook with the discovery of the light microscope.

A typical cell under light microscope consists of two major parts are **nucleus** and **cytoplasm.**

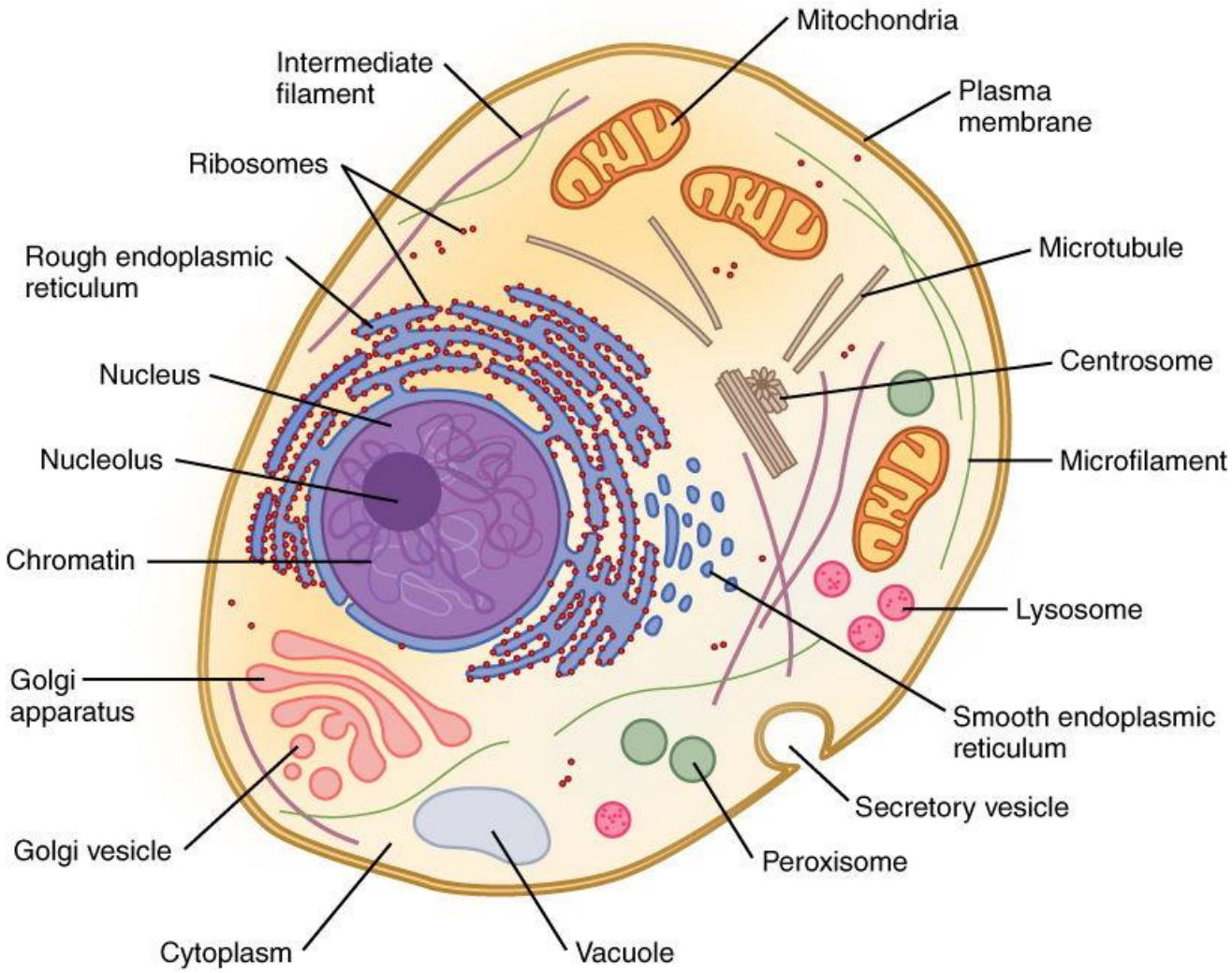
Cell Theory

A. All living things are composed of one or more cells.
B. Cells are the basic units of structure and function in an organism.
C. Cells come only from the replication of existing cells.

Main structures of the cell

1-Cell membrane

-It is a thin elastic structure, generally about 7.5 nm thick. It also generally known as plasma membrane.
- semipermeable, allowing some substances to pass through it and excluding others.
- It is composed of proteins (55%), phospholipids (25%); cholesterol (13%), other lipid (4%) and carbohydrates (3%).



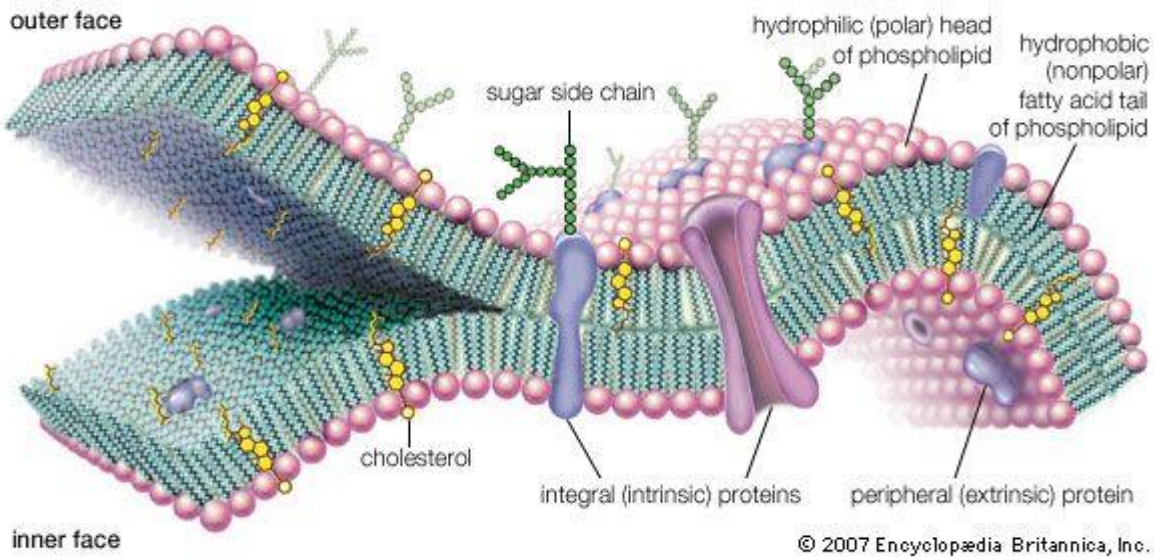
-Its basic structures are lipids that are bilayer, interspersed with large globular protein molecules.

-The head end of lipid bilayer molecule contains the phosphate portion and

is relatively soluble in water (polar hydrophilic). While the tails are

relatively insoluble (nonpolar hydrophobic).

-The lipid bilayer membrane is **highly permeable** to lipid-soluble substances such as oxygen, carbon dioxide and alcohol, but acts as **a major barrier** to water-soluble substances such as ions and glucose.



Two types of membrane proteins are present in cell membrane

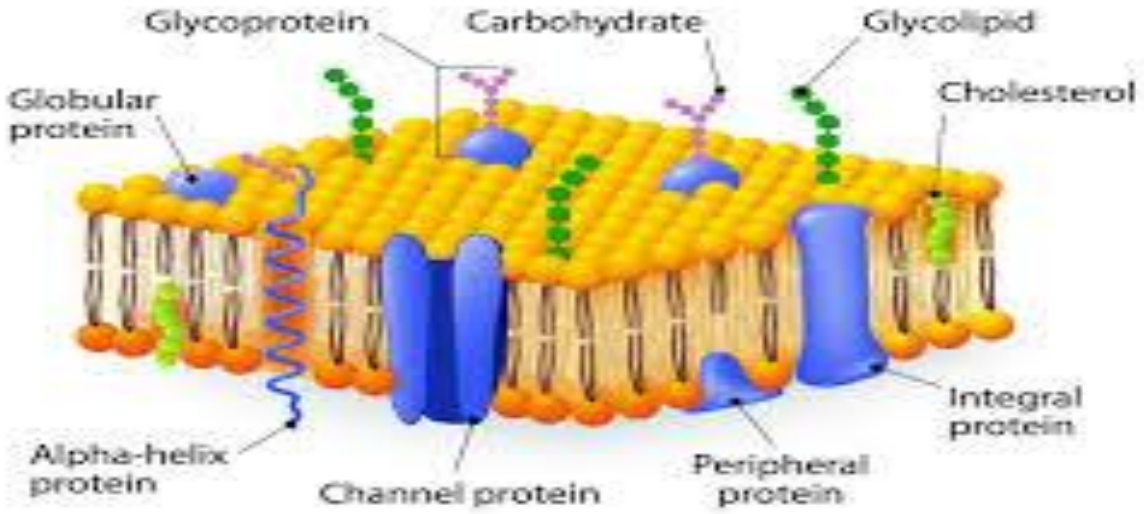
(1) The integral proteins, which protrude all the way through the membrane.

-Many of the integral proteins provide structural channels (pores), through which water-soluble substances, especially ions, can diffuse.

-Other integral proteins acts as carrier proteins for transporting substances.

(2) The peripheral proteins, which are attached to the inner surface of the membrane and do not penetrate.

-The peripheral proteins are normally attached to one of the integral proteins and usually function as enzymes that catalyze chemical reactions in the cell.



2- Nucleus

nucleus, in biology, a specialized structure found in most cells (except bacteria and blue-green algae)

Nucleus components

nuclear membrane a double layer separated nucleus from the rest of the cell by, this membrane seems to be continuous with the endoplasmic reticulum of the cell and has pores, which probably permit the entrance of large molecules.

Nucleoli are small bodies often seen within the nucleus.

Nucleoplasm The gel-like matrix in which the nuclear components are suspended

Chromosomes The cell nucleus contains nearly all of the cell's genome. Nuclear DNA is often organized into multiple chromosomes – long strands of DNA dotted with various proteins, such as histones, that protect and organize the DNA.

The nucleus functions

- The nucleus controls and regulates the activities of the cell (e.g., growth and metabolism)
- carries the genes, structures that contain the hereditary information.

3- Cytoplasm

The Cytoplasm is a gel cellular material found between the plasma membrane and the nuclear envelope of the nucleus, consists of three major components including cytosol, organelles, and cytoplasmic inclusions.

 Cytoplasm without Cell organelles are called Cytosol.

 Cytosol is the jelly-like mixture in which the other organelles are suspended, so cytosol + organelles =cytoplasm.

 The cytoplasmic inclusions are chemical substances differ in nature in different types of human cells

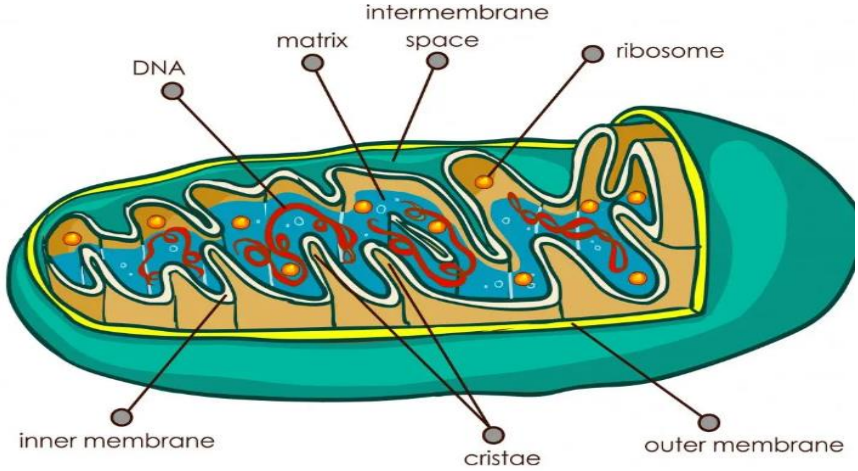
The cell organelles such as, mitochondria, endoplasmic reticulum, ribosomes, are suspended in this cytoplasm.

organelles

A-The mitochondria

- The mitochondria are often called the "powerhouses" of the cell.
- The mitochondria contain large quantities of **oxidative and other enzymes** that are responsible **for supplying energy to the cells**.
- The total number of them per cell varies from less than hundred to several thousand depending on the **amount of energy required by each cell.**
- Small molecules resulting from digestion enter the cell and reach the mitochondria, where other enzymes remove carbon dioxide and hydrogen ions in a process called **the citric acid cycle**. Then an oxidative enzyme system causes progressive oxidation of the hydrogen atoms.
- The products of the reaction of the mitochondria are **water and CO2** and the energy liberated is used by the mitochondria to synthesize another substance, **adenosine triphosphate (ATP),** a highly reactive chemical that can diffuse through the cell to release its energy whenever it is needed for performing cellular functions.

The structure of mitochondria



B-Endoplasmic reticulum (ER)

-Is a large network of tubules and vesicles, penetrates almost all parts of the cytoplasm.

-It provides an extensive surface area for manufacturing multiple substances that can be used inside the cells and released from some cells

-In rough or granular endoplasmic reticulum, granules called ribosomes are attached to the cytoplasmic side of the membrane.

-The granular ER is concerned with protein synthesis.

-In the smooth or a granular ER, the granules are absent. Smooth ER is the

site of steroid synthesis in steroid-secreting cells and the site of detoxification processes in other cells.

C-Ribosomes

-The ribosomes contain about 65% ribonucleic acid (RNA) and 35%

protein. They are the site of protein synthesis.

-**Ribosomes attached to ER** synthesize proteins in the form of hormones

and cell membrane proteins.

-While, **the free ribosomes synthesize** cytoplasmic proteins such as hemoglobin.

D-Lysosomes

-The lysosomes provide an intracellular digestive system, contain digestive

enzymes that allow lysosomes to digest intracellular substances and

structures, especially damaged cell structures, food particles and unwanted

materials, such as bacteria.

E-Golgi apparatus

-The Golgi apparatus is a collection of membrane-enclosed sacs that are stacked like dinner plates.

-One or more Golgi apparatus is present in all eukaryotic cells, usually near the nucleus. It functions in association with the ER.

-Substances entrapped in the ER vesicles are transported from the ER to the Golgi apparatus.

-These substances are then processed in the Golgi apparatus to form lysosomes, secretory vesicles or other cytoplasmic components.

F-Cytoskeleton

- maintain the structure of the cell and permit it to change its shape and move.

- made up primary of microfilaments, intermediate filaments and microtubules.

a-Microfilaments

-They are made up of actin, the protein that by its interaction with myosin

bring about contraction of muscles. It presents in all types of cells.

b-Microtubules

-The primary function of microtubules is to act as a cytoskeleton, providing rigid physical structures of cells.

-They also provide the tracks for transport of vesicles, such as secretory granules and organelles such as mitochondria from one part of the cell to another.

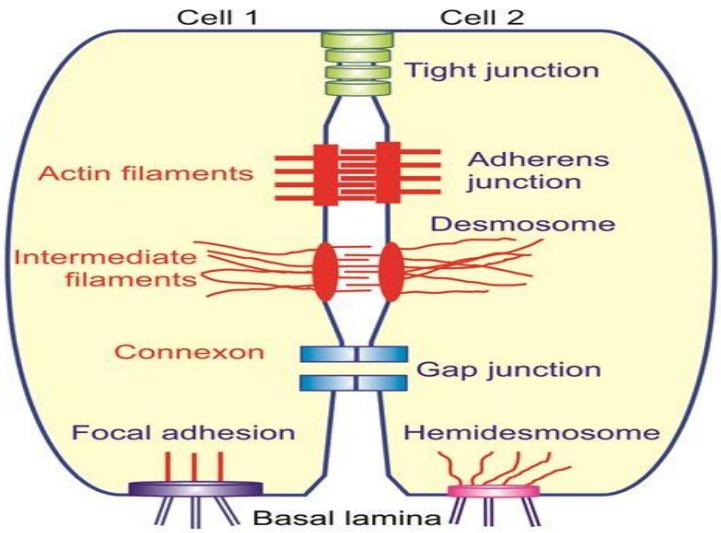
c-Intermediate filaments

-They are about 8-10 nm in diameter, some of these filament connect the nuclear membrane to the cell membrane. Participates in production of meio-gametes and meiospores through another type of cell division called meiotic cell divisions.

Intercellular connections

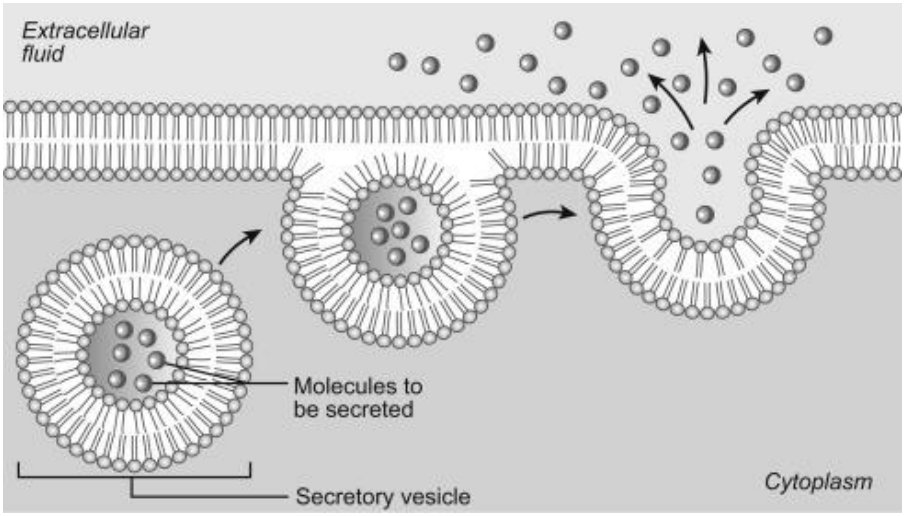
-Two types of junction's form between the cells that make up tissues:

- Junctions that attach the cells to one another and to surrounding tissues (tight junctions).
- junctions that permit transfer of ions and other molecules from one cell to another (gap junctions), which permit the passage of ions, sugars, amino acids and some of other solutes.



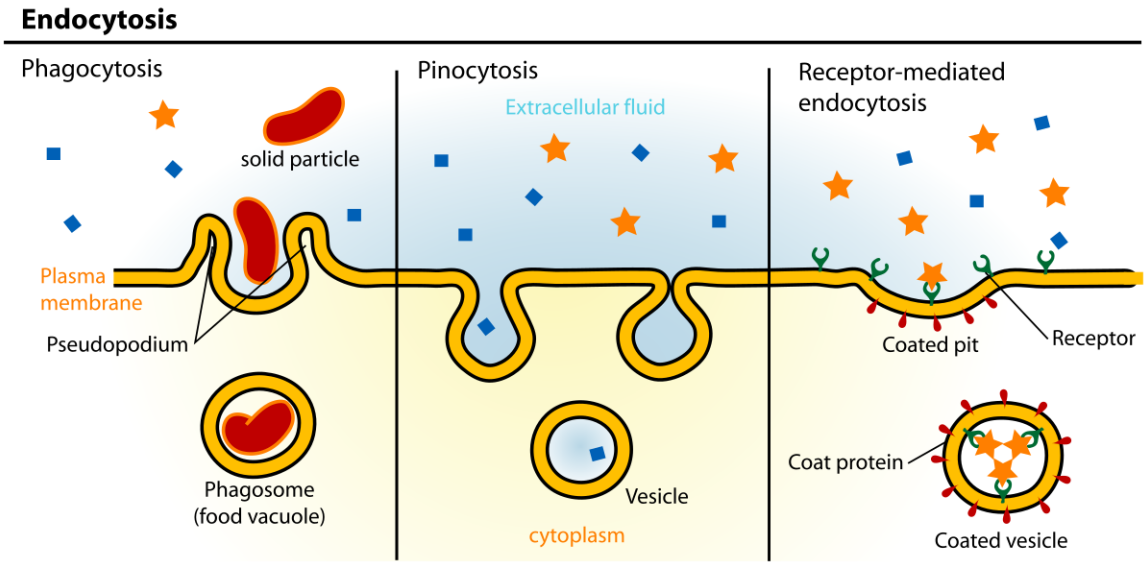
Exocytosis

-Proteins that are secreted by cells move from the ER to Golgi apparatus and then extruded into secretary granules or vesicles.
-These secretory granules and vesicles move to the cell membrane.
-Their membrane then fuses to the cell membrane and the area of fusion breaks down.
-This leaves the contents of granules or vesicles outside the cell and the cell membrane intact.



Endocytosis

-Endocytosis is the reverse of exocytosis.
-phagocytosis (cell eating) is the process by which bacteria and dead tissues are engulfed by tissue macrophages and some of the white blood cells.
-pinocytosis (cell drinking) is essentially the same process, the only difference being that the substances ingested are in soluble form.



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Lecture 3: Organization of the Nervous System, Basic Functions of Synapses, and Neurotransmitters

Nervous System One of the most complex organ system to ever evolve, the human nervous system consists of two parts, namely:

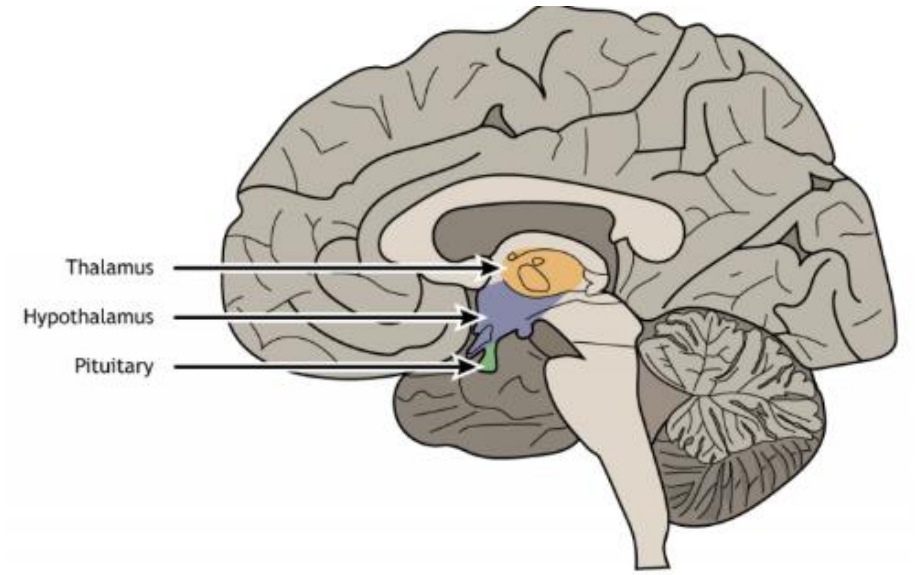
1. **Central Nervous System** (consists of the brain and spinal cord)
2. **Peripheral Nervous System** (includes all the nerves of the body)

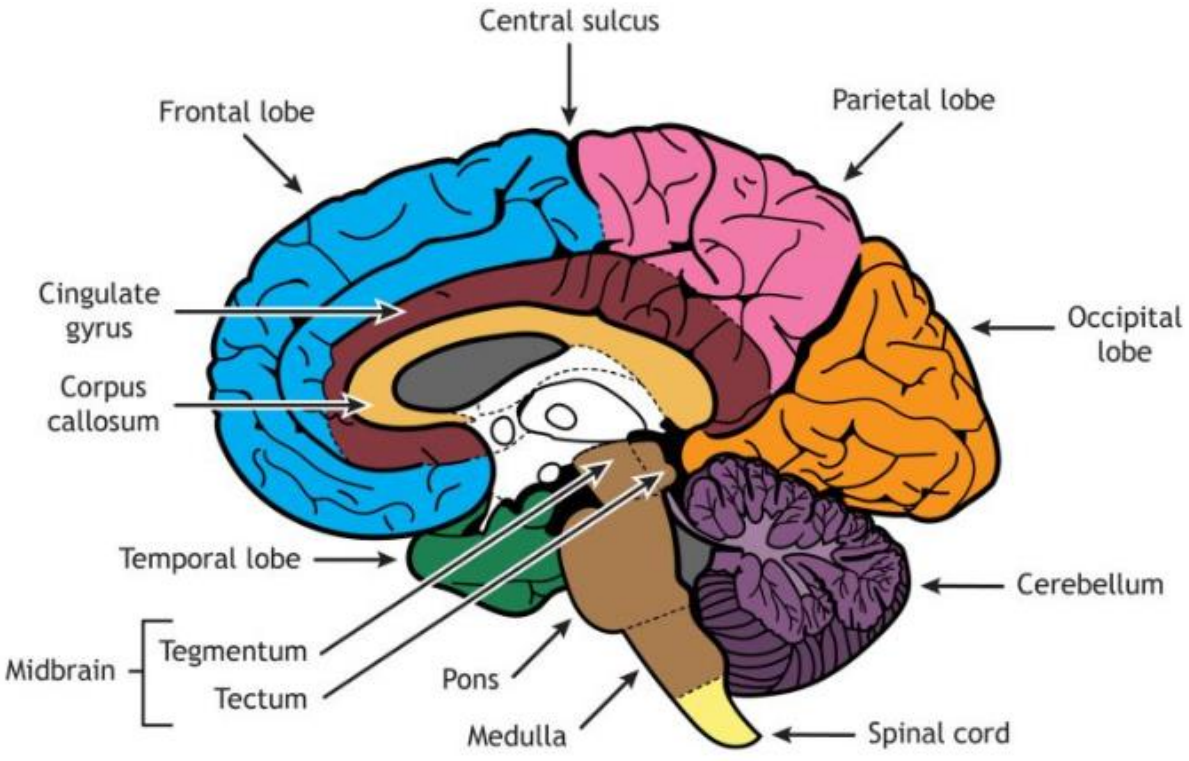
Central Nervous System (CNS) is often called the central processing unit of the body. It consists of the brain and the spinal cord.

Brain

The brain is one of the important, largest and central organ of the human nervous system. It is the control unit of the nervous system, which helps us in discovering new things, remembering and understanding, making decisions, and a lot more. It is enclosed within the skull, which provides frontal, lateral and dorsal protection. The human brain is composed of three major parts:

1. **Forebrain**: The anterior part of the brain, consists of Cerebrum, Hypothalamus and Thalamus.
2. **Midbrain**: The smaller and central part of the brainstem, consists of Tectum and Tegmentum.
3. **Hindbrain**: The central region of the brain, composed of Cerebellum, Medulla and Pons.





Spinal Cord

The spinal cord is a cylindrical bundle of nerve fibers and associated tissues enclosed within the spine (vertebral column) and connect all parts of the body to the brain. It is surrounded by membranes called meninges. The spinal cord is concerned with spinal reflex actions and the conduction of nerve impulses to and from the brain

Peripheral Nervous System

Peripheral Nervous System (PNS) is the lateral part of the nervous system that develops from the central nervous system which connects different parts of the body with the CNS. We carry out both voluntary and involuntary actions with the help of peripheral nerves.

Classification of the peripheral nervous system:

Somatic neural system (SNS): It is the neural system that controls the voluntary actions in the body by transmitting impulses from CNS to skeletal muscle cells. It consists of the somatic nerves.

Autonomic neural system (ANS): The autonomic neural system is involved in involuntary actions like regulation of physiological functions (digestion, respiration, salivation, etc.). It is a self-regulating system which conveys the impulses from the CNS to the smooth muscles and involuntary organs (heart, bladder and pupil). The autonomic neural system can be further divided into:

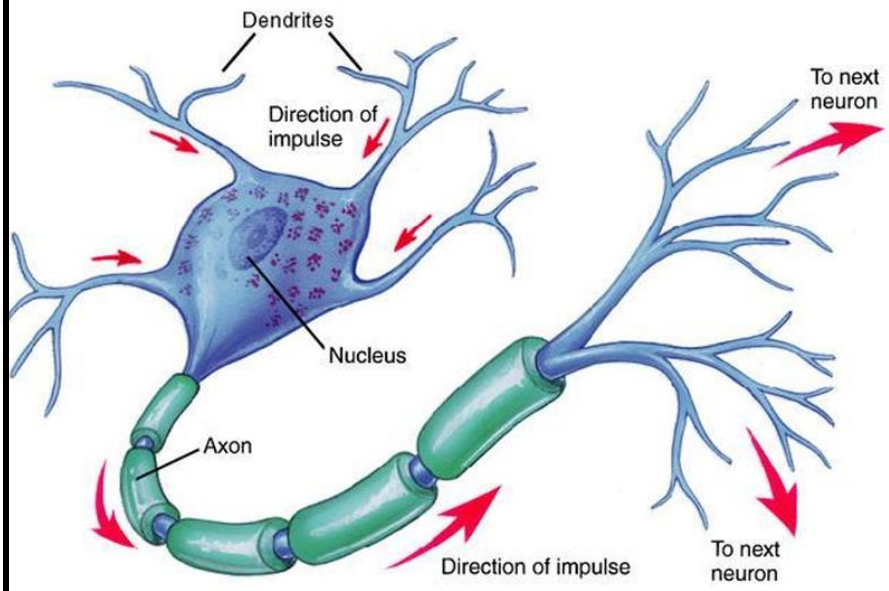
1. Sympathetic nervous system
2. Parasympathetic nervous system

The nervous system is remarkable for its ability to process millions of sensory signals each minute and coordinate the body's responses.

Neurons are sensitive to stimuli convert stimuli into nerve impulse and conduct nerve impulses.

Parts neurons:

- **Cell Body**– Largest part; contains nucleus and most of cytoplasm– Most metabolic activities occur here. It has ability to generate impulse.
- **Dendrites–** Short, branched extensions– Carry impulses from environment or other neuron toward cell body– Neurons can have several dendrites. They have ability to receive stimuli from the environment and transport them to the neuron body.
- **Axon**– Long fiber which carries impulses away from cell body– Ends in axon terminals, located a distance away from cell body– Neurons only have one axon. It has ability to transport the nerve impulses to other cells.
- **Myelin layer** Insulating membrane surrounding axon.



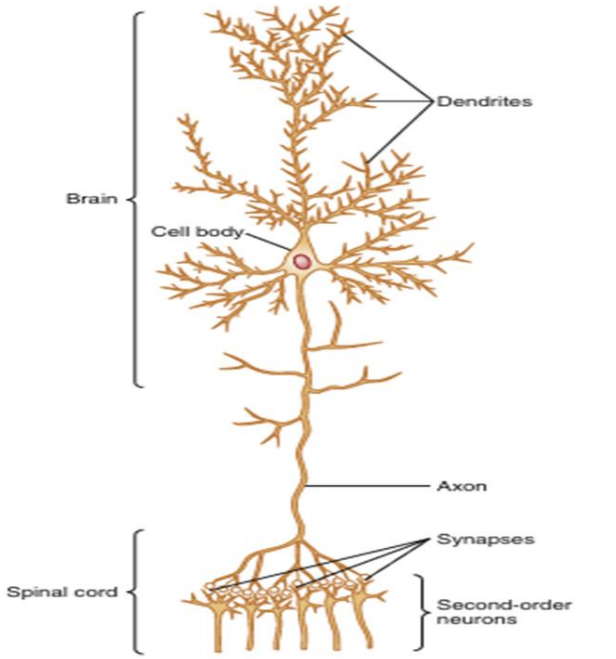


Figure 46-1. Structure of a large neuron in the brain showing its important functional parts.

Membrane Potential:

Membrane potential refers to the **voltage difference across a cell membrane**, primarily due to the distribution of ions between the inside and outside of the cell. It is essential for the functioning of **neurons and muscle cells**, as it allows the transmission of signals.

Factors Contributing to Membrane Potential:

1. **Selective Permeability**: The cell membrane allows some ions, like **potassium (K^+)**, to pass through more easily than others.

2. **Ion Concentration Gradient**: Higher concentration of **Na^+ (sodium ions)** outside the cell and **K^+ (potassium ions)** inside the cell.

3. **Sodium-Potassium Pump (Na^+/K^+ pump)**: Actively pumps **3 Na^+ out** and **2 K^+ in**, maintaining the gradient.

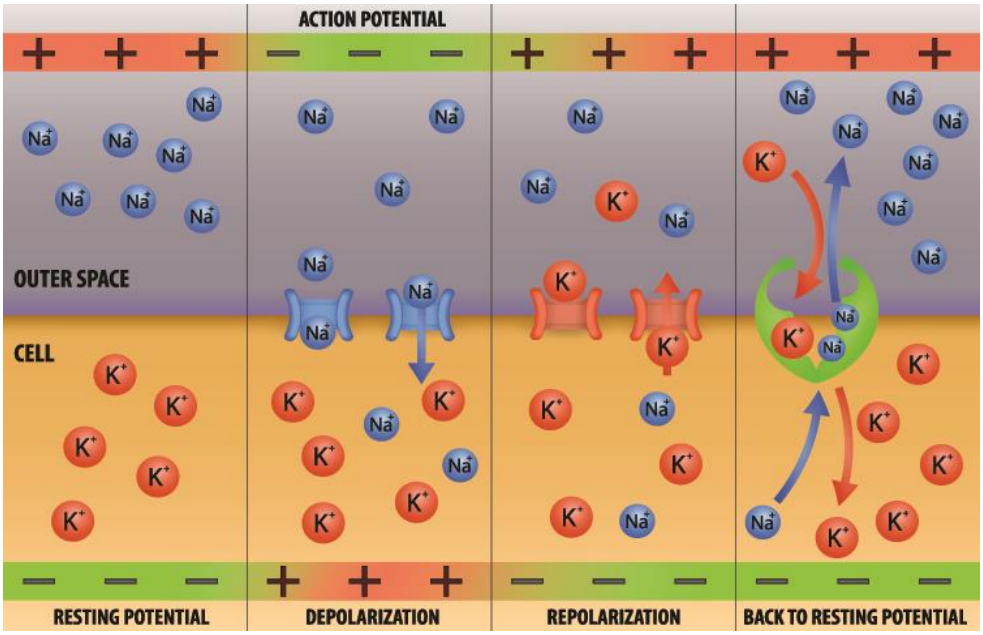
4. **Leak Channels**: Potassium leak channels allow some K^+ to move out, making the inside of the cell more negative.

Action Potential:

An **action potential** is a **rapid and temporary change in membrane potential**, which allows neurons to transmit electrical signals along the axon.

Steps of Action Potential:

1. **Resting State (-70 mV)**: Na^+ and K^+ channels are closed, and the resting potential is maintained.
2. **Depolarization (Up to +40 mV)**: When a stimulus occurs, **voltage-gated sodium channels open**, allowing Na^+ to rush in. This makes the inside of the cell more positive.
3. **Repolarization**: After reaching the peak, **sodium channels close** and **voltage-gated potassium channels open**. K^+ moves out of the cell, bringing the membrane potential back to negative.
4. **Return to Resting State**: The **sodium-potassium pump** restores the original ion balance, bringing the membrane back to resting potential.



Sensory part of the nervous system—Sensory receptors

Most activities of the nervous system are initiated by sensory experiences that excite sensory receptors, whether visual receptors in the eyes, auditory receptors in the ears, tactile receptors on the surface of the body

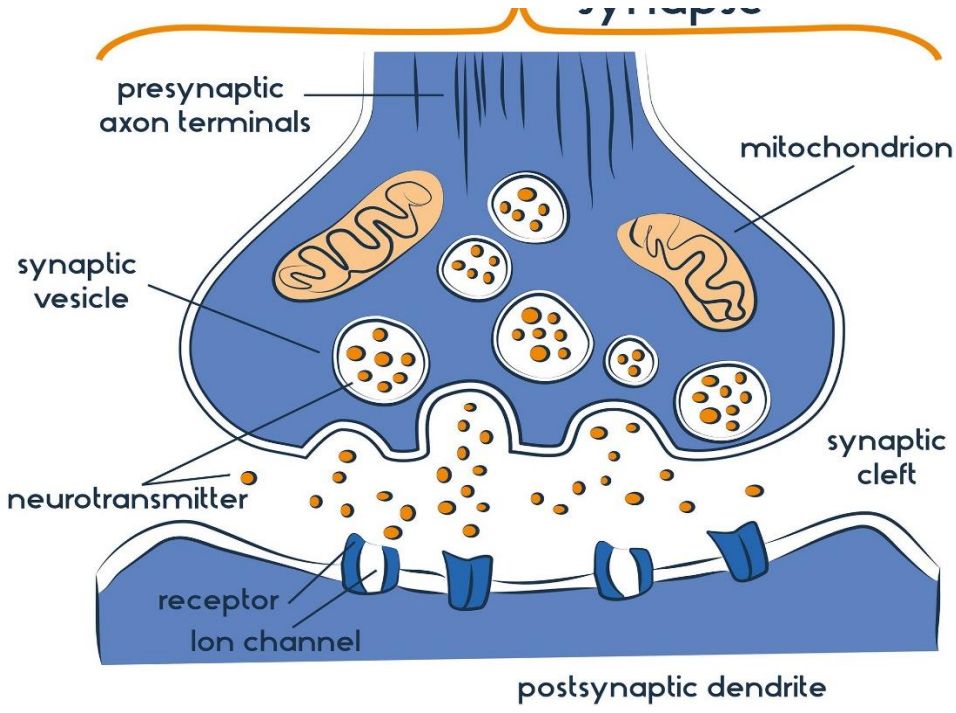
Motor part of the nervous system —Effectors

The nervous system controls body functions by controlling muscle contractions and gland secretions. These activities, called **Motor functions**, the muscles and glands, called **Effectors**, are the physical structures that carry out the tasks directed by nerve signals.

The synapse is the junction point from one neuron to the next. Information is transmitted in the central nervous system mainly in the form of nerve action potentials, called nerve impulses

Synaptic communication • Synapses are sites of functional contact between neurons or neurons and other effector cells (e.g. muscle cells). • The synapse itself is formed by:

1. **presynaptic** terminal an axon terminal that deliver the signal.
2. **postsynaptic** terminal a region on the surface of another cell where a new signal is generated
3. **synaptic cleft** a thin intercellular space.



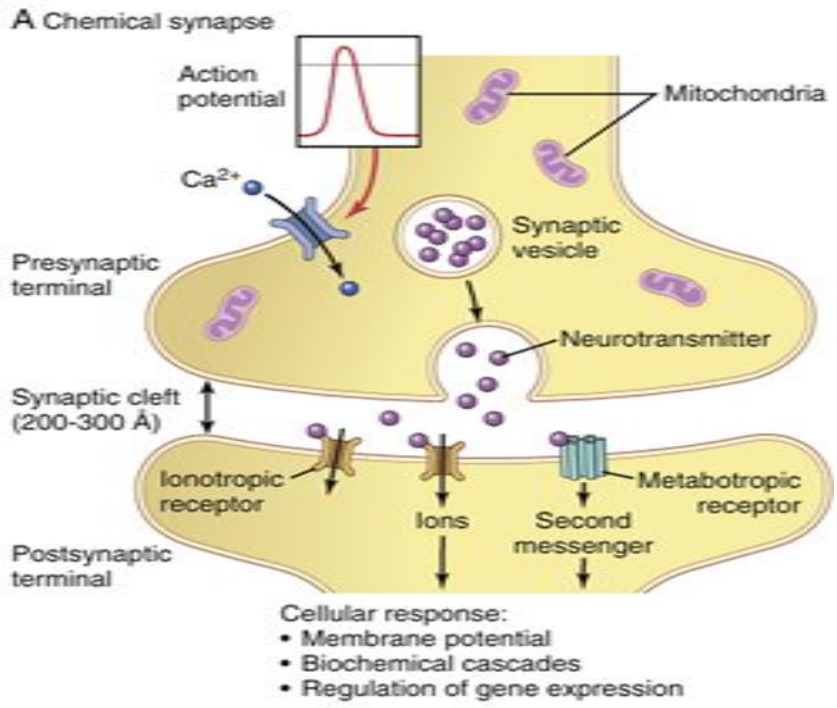
The function of the synapse is to convert an electrical signal (impulse) from the presynaptic cell into a chemical signal that act on the postsynaptic cell. Most synapses

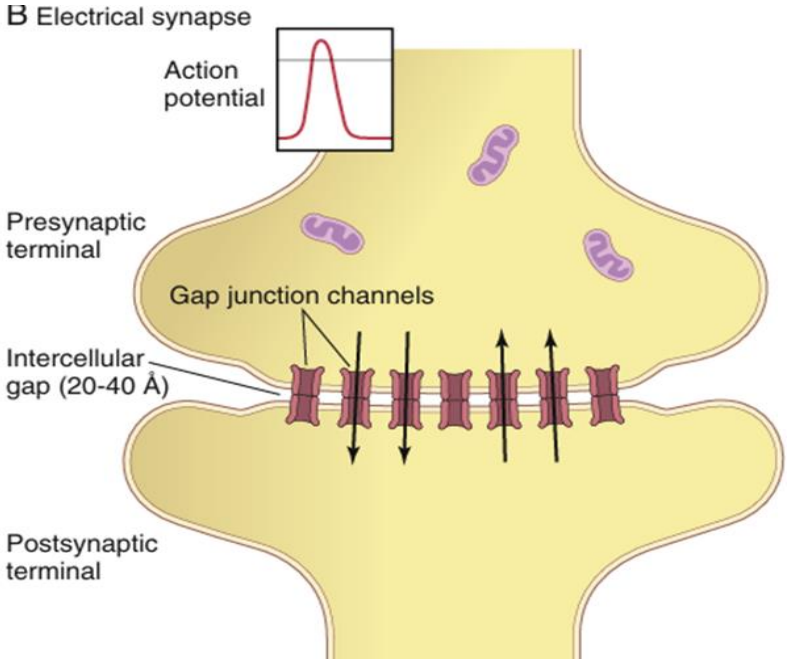
transmit information by releasing neurotransmitters during the signaling process. • **Neurotransmitters** are chemical substances present in the vesicles of presynaptic button. When a nerve impulse reaches a button of presynaptic terminal.

Types of Synapses

There are two major types of synapses (1) chemical and (2) electrical.

1. **Chemical synapses:** Most of the synapses used for signal transmission in the central nervous system of the human being are chemical synapses. In these synapses, the first neuron secretes at its nerve ending synapse a chemical substance called **a neurotransmitter**, and this transmitter in turn acts on receptor proteins in the membrane of the next neuron to excite the neuron, inhibit it, or modify its sensitivity in some other way.
2. **Electrical synapses**, the cytoplasm of adjacent cells is directly connected by clusters of ion channels called gap junctions that allow free movement of ions from the interior of one cell to the interior of the next cell **Such junctions were gap junctions that action potentials are transmitted from one smooth muscle fiber to the next in visceral smooth muscle and from one cardiac muscle cell to the next in cardiac muscle**




B Electrical synapse
Action potential
Presynaptic terminal
Gap junction channels
Intercellular gap (20-40 Å)
Postsynaptic terminal

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Lecture 4

Muscular System

- Types of Muscles

- Structure and Function

- Mechanism of Contraction Muscle

There are more than 600 muscles in our body. Muscles perform many useful functions and help us in doing everything in day to day life. Muscles are classified by three different methods based on different factors:

I. Depending upon the presence or absence of striations

II. Depending upon the control

III. Depending upon the function.

I. Depending upon the presence or absence of striations

1. Striated Muscle: Striated muscle is the muscle which has a large number of

Cross-striations (transverse lines). Skeletal muscle and cardiac muscle belong to this category.

2. Non-striated Muscle: Muscle which does not have cross-striations is called non-striated muscle. It is also called plain muscle or smooth muscle. It is found in the wall of the visceral organs.

II. Depending upon the control,

1.Voluntary Muscle: Voluntary muscle is the muscle that is controlled by the will. Skeletal muscles are the voluntary muscles. These muscles are innervated by **somatic nerves.**

2.Involuntary Muscle: The muscle that cannot be controlled by the will is called involuntary muscle. Cardiac muscle and smooth muscle are involuntary muscles. These muscles are innervated by **autonomic nerves.**

III. Depending upon the situation: the muscles are classified into three types

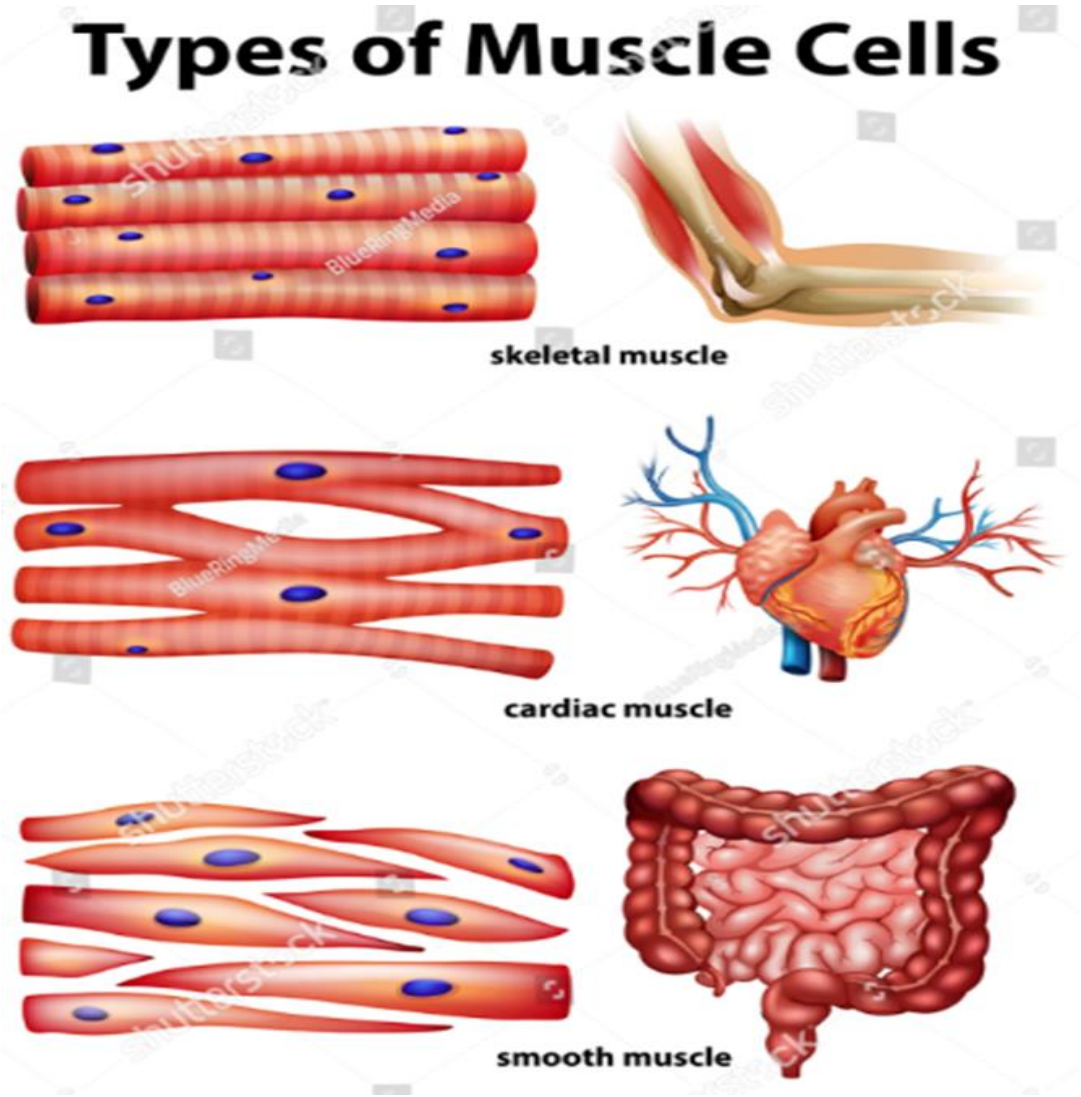
1. Skeletal Muscle: is situated in association with bones forming the skeletal system.

The skeletal muscles from 40 to 50% of body mass and are voluntary and striated.

These muscles are supplied by **somatic nerves**.

2.Cardiac muscle: forms the musculature of the heart. These muscles are striated and involuntary. Cardiac muscles are supplied by **autonomic nerve fibers.**

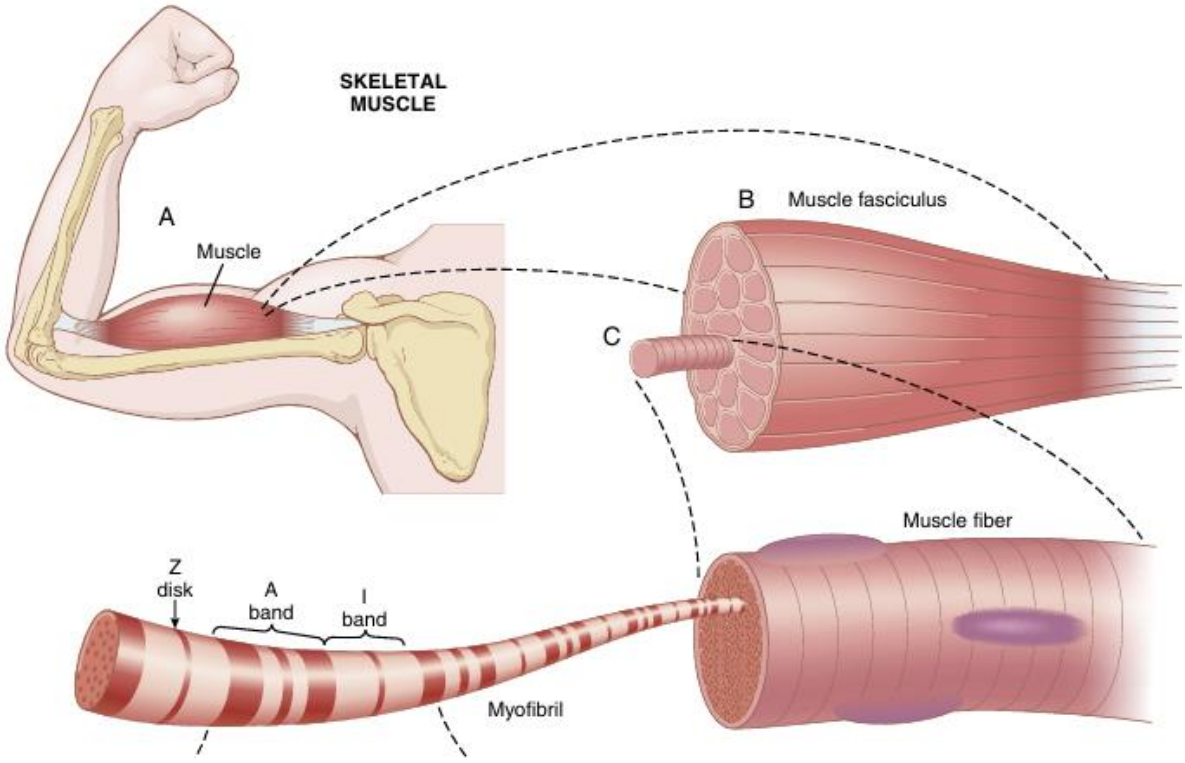
3.Smooth muscle or visceral muscle is situated in association with viscera. Smooth muscle is non-striated and involuntary. Because of the absence of cross striations, it is called smooth or plain muscle. It is supplied by **autonomic nerve fibers.**



Organization of skeletal muscle,

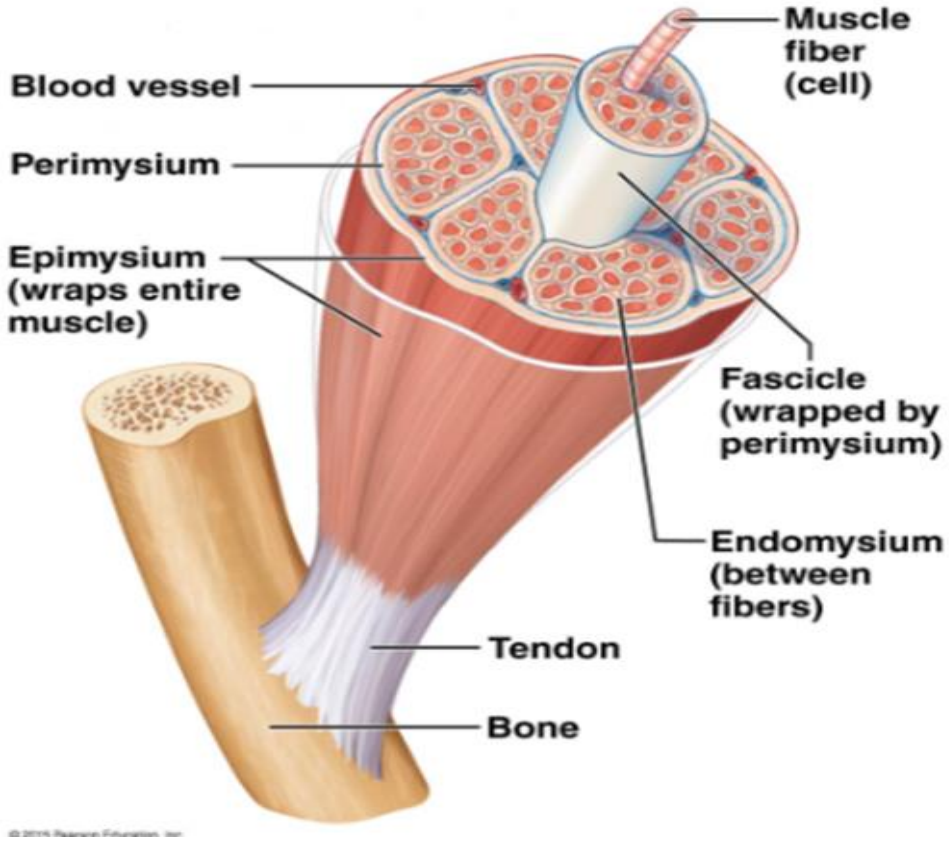
A skeletal muscle is a collection of muscle bundles or fascicles. Each fascicle is made up of a number cells or (muscle fibers). Each muscle is cell compose of hundreds to thousands of myofibrils. Myofibrils are strings of the structural unit referred to as the sarcomere.

The sarcomere is the functional unit of skeletal and cardiac muscle. The sarcomere contains the myofibrils; which are the proteins that are responsible for the contractile behavior of the muscle cell.



Structure of Skeletal Muscle

The muscle mass (or tissue) is made up of a large number of individual muscle cells or myocytes. The muscle cells are commonly called muscle fibers because these cells are long and slender in appearance. The skeletal muscle fibers are multinucleated and arranged parallel to one another with some connective tissue in between. The muscle mass is separated from the neighboring tissues by the thick fibrous tissue layer known **as fascia**. Beneath the fascia, the muscle is covered by a connective tissue **sheath called epimysium**. In the muscle, the muscle fibers are arranged in various groups called the **bundles or fasciculi**. The connective tissue sheath that covers each fasciculus is called perimysium. Each muscle fiber is covered by the connective tissue layer called **the endomysium**. Each muscle fiber is enclosed by a cell membrane called plasma membrane that lies beneath the endomysium. **Myofibrils or myofibrillae** are the special structures present only in muscle fibers. These are the fine parallel filaments present in sarcoplasm of the muscle cell.

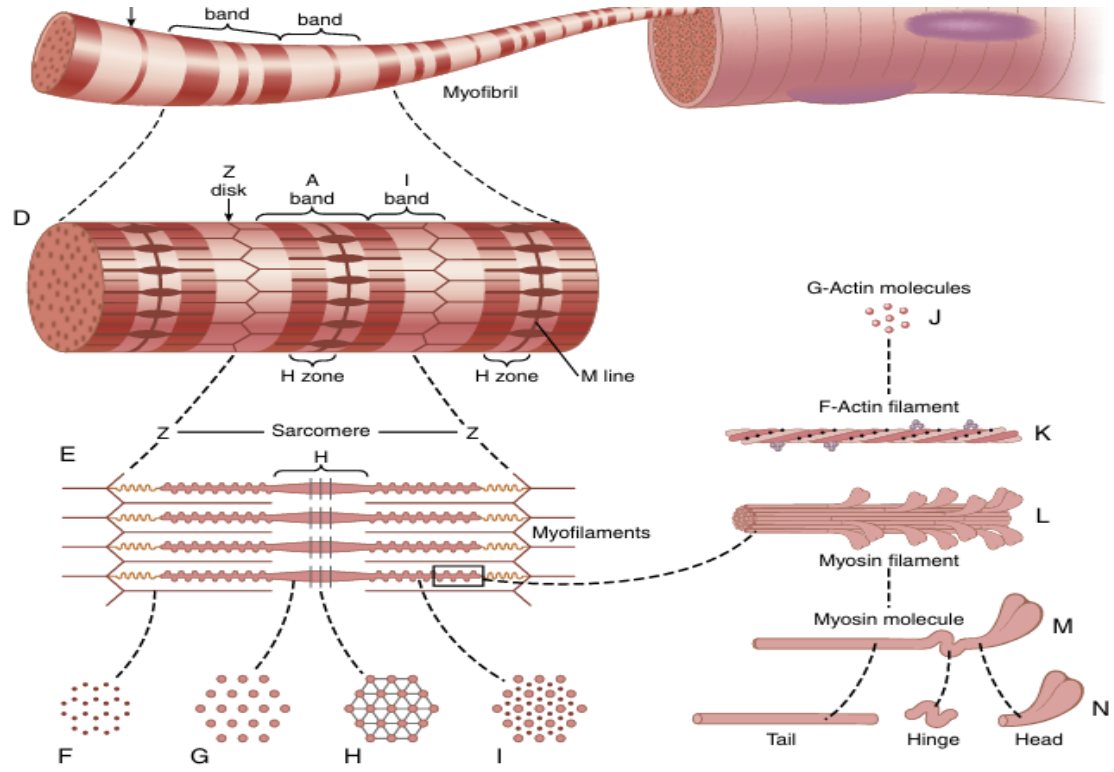


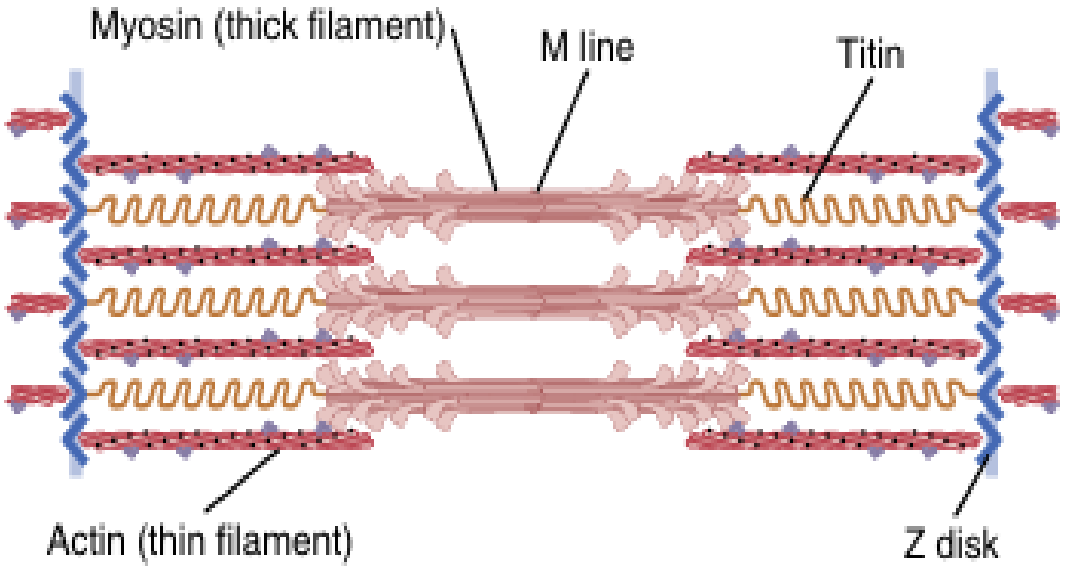
Microscopic Structure of a myofibril

Light microscopic studies show that, each myofibril consists of a number of two alternating bands. The two bands are:

1. Light band or 'I' band
2. Dark band or 'A' band.

In an intact muscle fiber, 'I' band and 'A' band of the adjacent myofibrils are placed side by side. It gives the appearance of characteristic cross striations in the muscle fiber. I band is divided into two portions by a narrow dark line called 'Z' line or 'Z' disk. The portion of myofibril in between two 'Z' lines is called sarcomere.





Sarcomere is the structural and functional unit of the skeletal muscle. The sarcomere consists of many thread like structures called myofilaments. Myofilaments are of two types:

1. **Actin filaments** are the thin filaments that extend from either side of the 'Z' lines, run across 'I' band and enter into 'A' band up to 'H' zone.

2. **Myosin filaments**. are thick filaments and are situated in 'A' band. Some lateral processes (projections) or cross bridges arise from myosin filaments. These bridges have enlarged structures called myosin heads at their tips. The myosin heads attach themselves to actin filaments. These heads pull the actin. filaments during contraction of the muscle by means of a mechanism called sliding mechanism or ratchet mechanism.

Mechanism of Contraction Muscle

1. An action potential travels along a motor nerve to its endings on muscle fibers this communication called a neuromuscular junction or myoneural junction.

2. At each ending, the nerve secretes a small amount of the neurotransmitter acetylcholine.

3. Acetylcholine acts on a local area of the muscle fiber membrane to open acetylcholine- gated cation channels through protein molecules floating in the membrane.

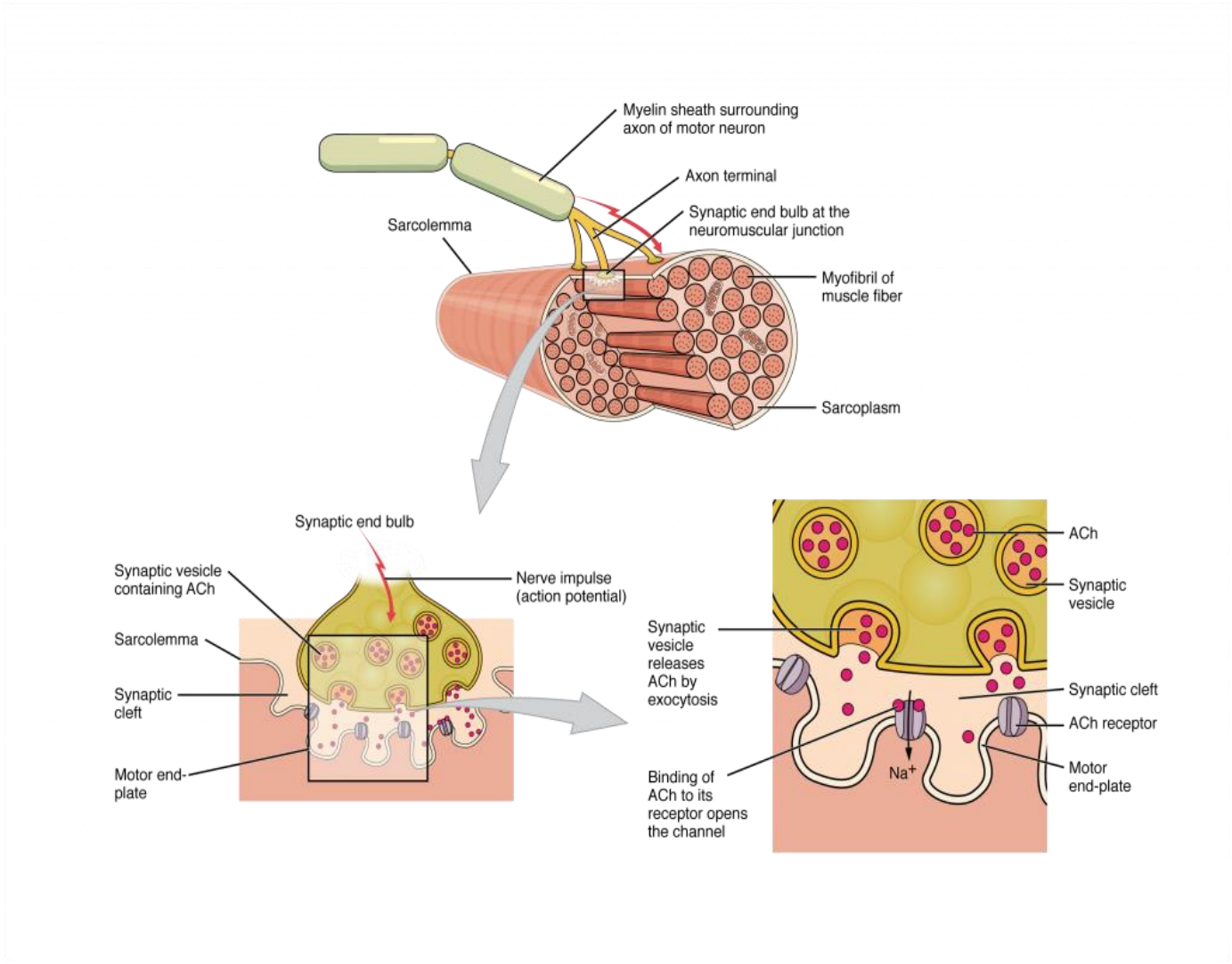
4. The opening of acetylcholine- gated channels allows large quantities of sodium ions to diffuse to the interior of the muscle fiber membrane. This action causes a local depolarization that in turn leads to the opening of voltage-gated sodium channels, which initiates an action potential at the membrane.

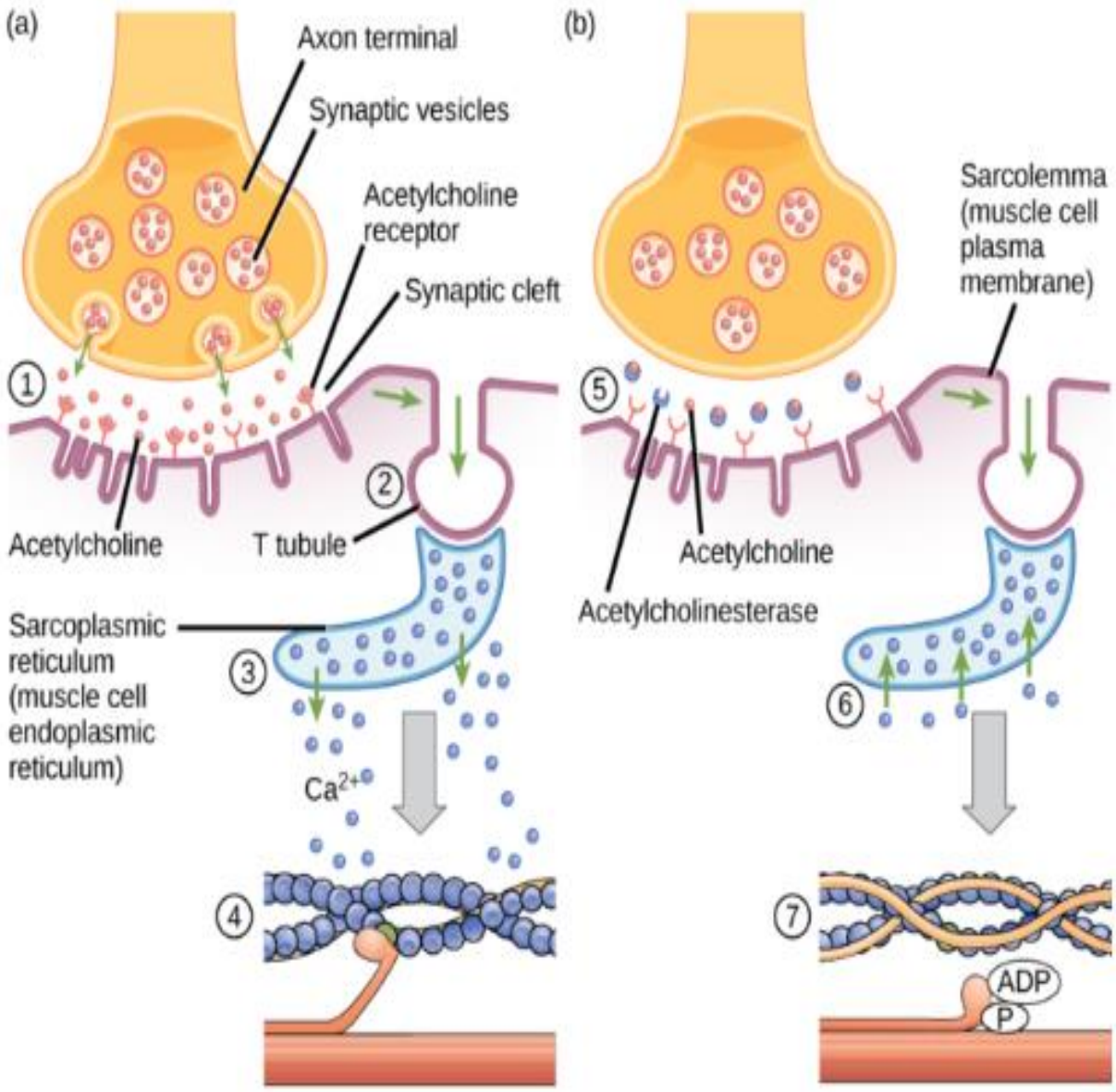
5. The action potential travels along the muscle fiber membrane in the same way that action potentials travel along nerve fiber membranes.

6. The action potential depolarizes the muscle membrane, and much of the action potential electricity flows through the center of the muscle fiber. Here it causes the **sarcoplasmic reticulum** to release large quantities **of calcium ions** that have been stored within this reticulum. The calcium ions initiate attractive forces between the actin and myosin filaments, causing them to slide alongside each other, which is the contractile process.

7. After a fraction of a second, the calcium ions are pumped back into the sarcoplasmic reticulum by a Ca2+ membrane pump and remain stored in the reticulum until a new

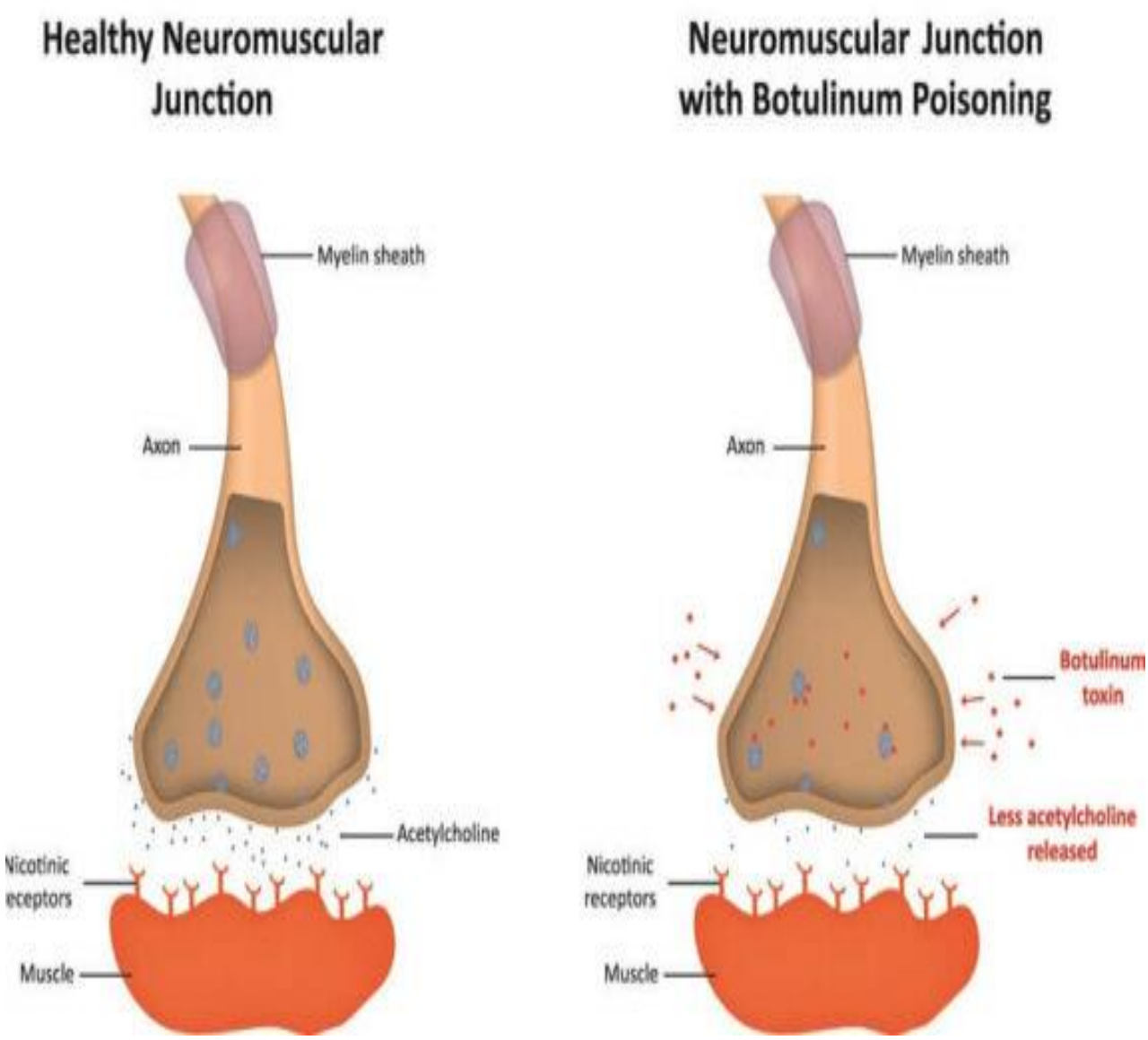
muscle action potential comes along; this removal of calcium ions from the myofibrils causes the muscle contraction to cease.





1. Acetylcholine released from the axon terminal binds to receptors on the sarcolemma.
2. An action potential is generated and travels down the T tubule.
3. Ca^{2+} is released from the sarcoplasmic reticulum in response to the change in voltage.
4. Ca^{2+} binds troponin; Cross-bridges form between actin and myosin.
5. Acetylcholinesterase removes acetylcholine from the synaptic cleft.
6. Ca^{2+} is transported back into the sarcoplasmic reticulum.
7. Tropomyosin binds active sites on actin causing the cross-bridge to detach.

Botox Mechanism of Action blocks the release of acetylcholine, the neurotransmitter that is responsible for transmitting signals from the nerve endings to the muscles. When Botox is injected into a muscle, it temporarily blocks the release of acetylcholine, which prevents the muscle from contracting. Without the signal from acetylcholine, the muscle is unable to contract, which temporarily relaxes the muscle and reduces the appearance of wrinkles and fine lines. The effect of Botox is temporary and will wear off as the body naturally metabolizes the toxin over time.



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Dr. Rabab Ali Al-Mosawi

Lecture 5&6.

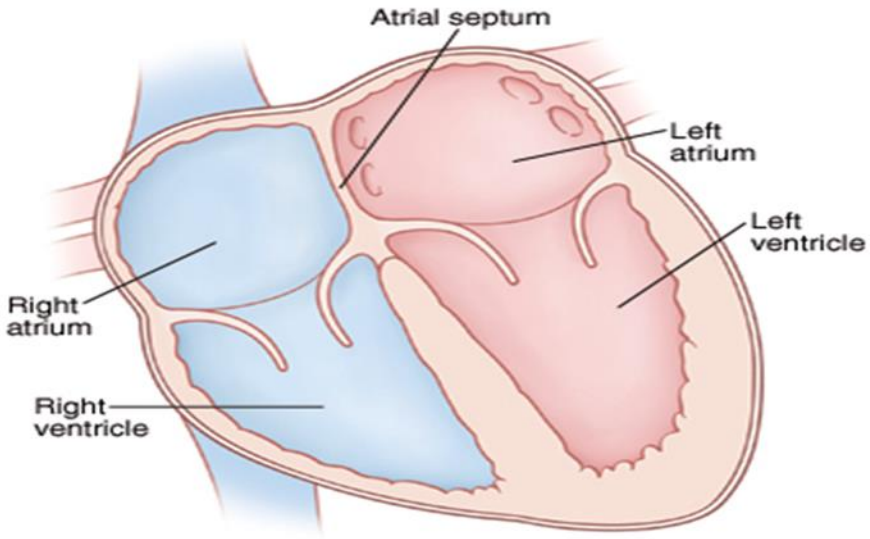
Vascular System - Circulatory System & Lymphatic system

- Circulatory System The cardiovascular system in all vertebrates, consists of the heart and blood vessels

The heart is located in the thoracic cavity in the middle mediastinum, rests on the diaphragm, between the lungs, behind and to the left of the sternum. It is a little larger than the owner's closed fist.

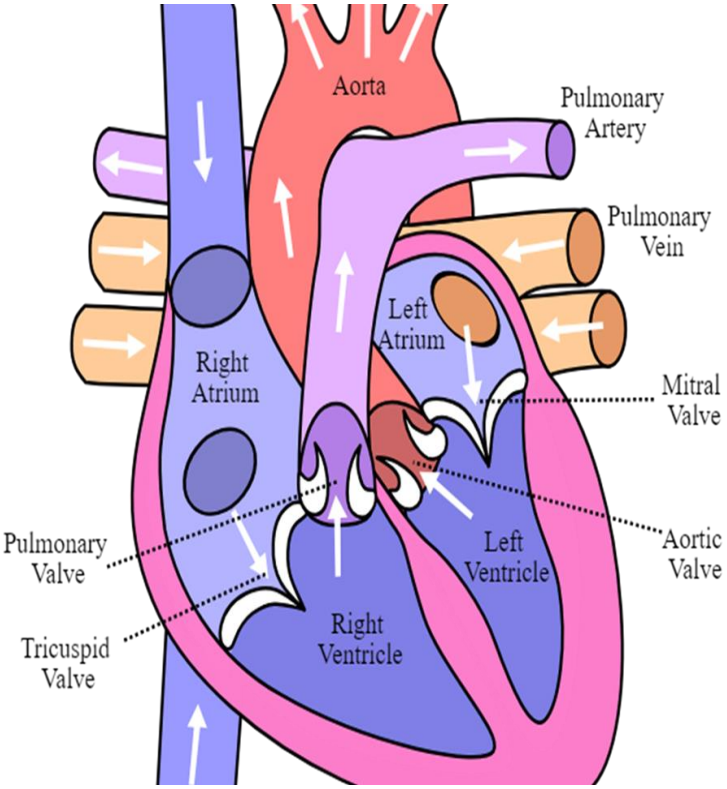
Chambers of the Heart

The heart has four chambers, two atria (right and left) and two ventricles (right and left). There are two dividing walls between the atria and ventricles; the interatrial septum and the interventricular septum. Thus, with these septa there is no mixing of blood between the two sides



Valves of Heart

Between the atria and the ventricles are two valves (the atrioventricular valves), which are attached by chordae tendineae to the papillary muscles of the ventricles:



1. The tricuspid valve: This is made up of three cusps and lies between the right atrium and the right ventricle.
2. The bicuspid (mitral) valve: This is made up of two cusps and lies between the left atrium and the left ventricle.

The purpose of the atrioventricular valves is to prevent the backward flow of blood from the ventricles into the atria

There are two semilunar valves between ventricles and great arteries

1. Aortic valve: This is made up of three cusps and lies between the aorta and the left ventricle
2. Pulmonary valve: This is made up of three cusps and lies between the pulmonary trunk(artery) and right ventricle.

The purpose of the semilunar valves is to prevent the backward flow of blood from the great arteries into the ventricles during diastole

Walls of The Heart

1. Pericardium:

The heart is surrounded by a membrane called the pericardium (peri = around). This is divided into two parts forming two sacs surrounding the heart: the fibrous pericardium and the serous pericardium, that are closely connected to each other.

a. Fibrous pericardium:

A tough layer is made up of dense fibrous tissue. The role of this layer is to

prevent the overstretching of the heart. It also provides protection to the heart and fixes it in place on the diaphragm.

b. Serous pericardium:

The serous pericardium is a thinner, more delicate, epithelial layer surrounding the heart. It consists of two layers:

• Parietal pericardium: This outer layer is fused to the fibrous pericardium.

• Visceral pericardium (also known as the epicardium): This inner layer adheres tightly to the surface of the heart.

Between the parietal and visceral pericardium is a space called the pericardial cavity contains a thin film of fluid (pericardial fluid) which reduces the friction between the membranes as the heart contracts and relaxes.

2. Myocardium:

Underlying the pericardium is the heart muscle known as the myocardium (myo = muscle). Myocardial thickness varies between the four chambers. The ventricles have thicker walls than the atria; however, the left ventricle has the thickest myocardial wall. This is because the left ventricle pumps blood great distances to different parts of the body. The myocardium makes up the majority of the bulk of the heart, which is made up of a specialized muscle that is only found within the heart.

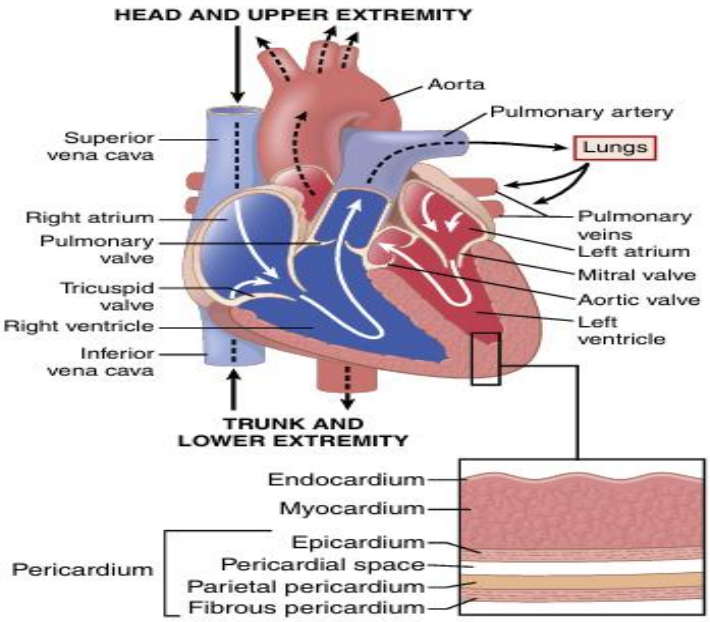
They are divided into two categories:

a) The contracting muscles: These form the majority of the myocardium which perform the mechanical work of the heart (contraction).
b) The electrical muscles: These form the remainder of the myocardium which initiate and conduct the electrical impulses to the contracting cardiac muscles. Conducting cells (Conducting cells constitute the tissues of the SA node, the atrial internodal tracts, the AV node, the bundle of His, and the Purkinje system).

Note: The atrial and ventricular types of muscle contract in much the same way as skeletal muscle, except that the duration of contraction is much longer. Why?? The

specialized excitatory and conductive fibers of the heart, however, contract feebly because they contain few contractile fibrils; instead, they exhibit automatic rhythmical electrical discharge in the form of action potentials or conduction of the action potentials through the heart, providing an excitatory system that controls the rhythmical beating of the heart.

3. Endocardium: (endo = within) is the innermost layer of the heart, made up of simple epithelium lining the inside of the heart and its valves.

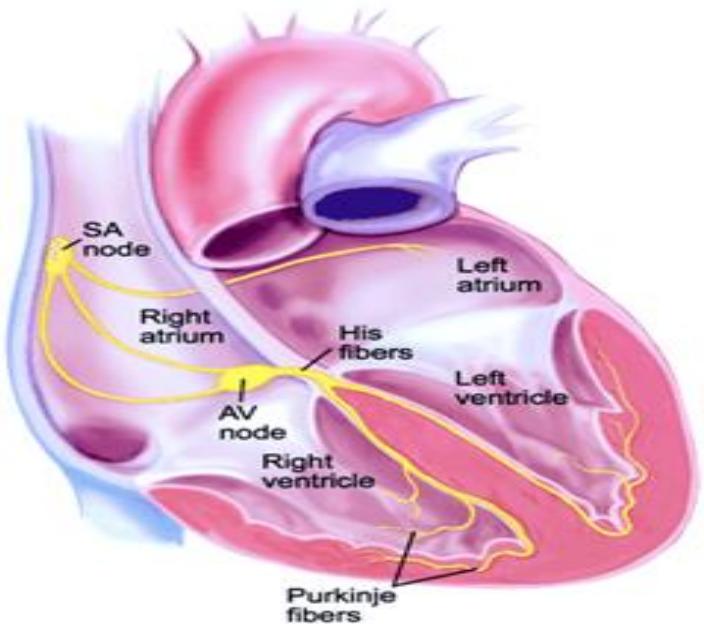


Origin and Spread of Excitation within the Heart

Character of Conducting cells

1. Specialized muscle cells
2. Do not contribute significantly to generation of force
3. They function to rapidly spread action potentials over the entire myocardium.
4. Their capacity to generate action potentials occur spontaneously. Except for the SA node, however, this capacity normally is suppressed.
5. SA node, which serves as the pacemaker
6. the pacemaker is a specialized tissue consist of modified excitatory cardiocyte that have spontaneous generation of action potential located within SA node.

Electrical Conduction System



1. SA node
2. Inter-nodal atrial pathways
3. atrioventricular node (AV) node
4. Bundle of his
5. Left & Right bundle branches
6. Purkinje fibers

1. SA node. Normally, the action potential of the heart is initiated in the SA node, there is a specific sequence and timing for the conduction of action potentials to the rest of the heart.
2. Inter-nodal atrial pathways which spreads the action potential from the SA node to the right and left atria. Simultaneously, the action potential is conducted to the AV node.
3. AV node. Conduction velocity through the AV node is considerably slower than in the other cardiac tissues.
4. Bundle of His, Purkinje system, and ventricles,

- The action potential enters the specialized conducting system of the ventricles.
- The action potential is first conducted to the bundle of His through the common bundle.
- It then invades the left and right bundle branches and then the smaller bundles of the Purkinje system.
- Conduction through the His-Purkinje system is extremely fast, and it rapidly distributes the action potential to the ventricles.

Cardiac cycles

1. Systole: meaning is Follow… contraction the both ventricles and pushing the blood from the right ventricles to the lungs and left ventricles to body.
2. Diastole: meaning is relaxation the both ventricles and filling of blood coming from the upper chamber (right and left atria).

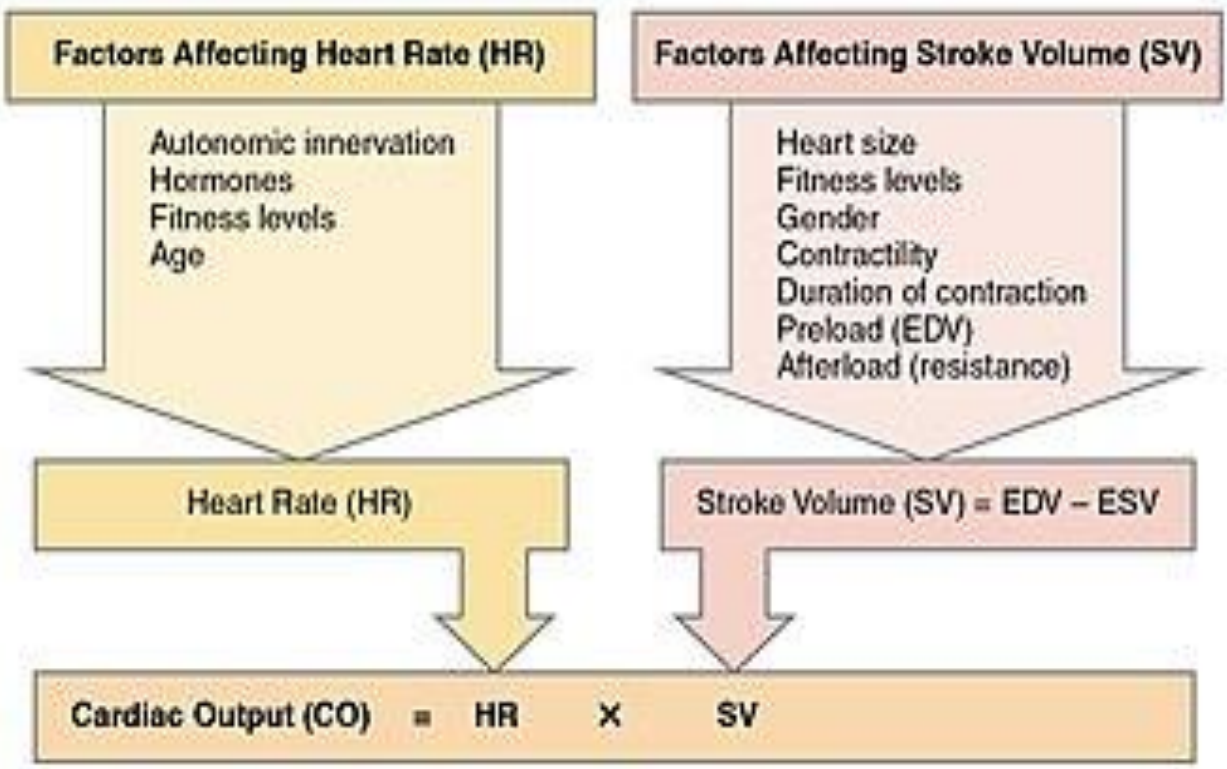
Note: during diastole all four chambers are relaxed

Cardiac Output (CO)

- ✓ Cardiac output is the amount of blood pumped from each ventricle per minute. Usually, it refers to left ventricular output through aorta.
- ✓ Cardiac output is the most important factor in cardiovascular system, because rate of blood flow through different parts of the body depends upon cardiac output.
- ✓ Cardiac output depends on **the heart rate** (beats per minute) and **the stroke volume** (is the amount of blood pumped out by each ventricle per beat or per contraction).Therefore, cardiac output (CO) can be calculated by multiplying the stroke volume (SV) by the heart rate (HR):

$$CO = SV \times HR$$

- ✓ Under normal conditions, the average heart rate is about 70 beats/min and stroke volume is about 80 ml and thus cardiac output is $80 \times 70 = 5.6$ L. The cardiac output is expressed in liters per minute and normally varies from 5–6 L/min.
- ✓ During exercise, cardiac output can increase to 20 to 25 liters per minute, and outputs as high as 40 liters per minute have been recorded in trained athletes during heavy endurance-type exercise.
- ✓ The difference between the cardiac output at rest and the maximum volume of blood the heart can pump per minute is called **the cardiac reserve**.



Blood Vessels

blood vessels are the part of the circulatory system that transports blood throughout the human body.

1. The arteries:

They carry the oxygenated blood away from the heart to the tissues; with the exception of the pulmonary and umbilical arteries are carrying deoxygenated blood. They have thick walls to sustain the pressure of the pumping heart.

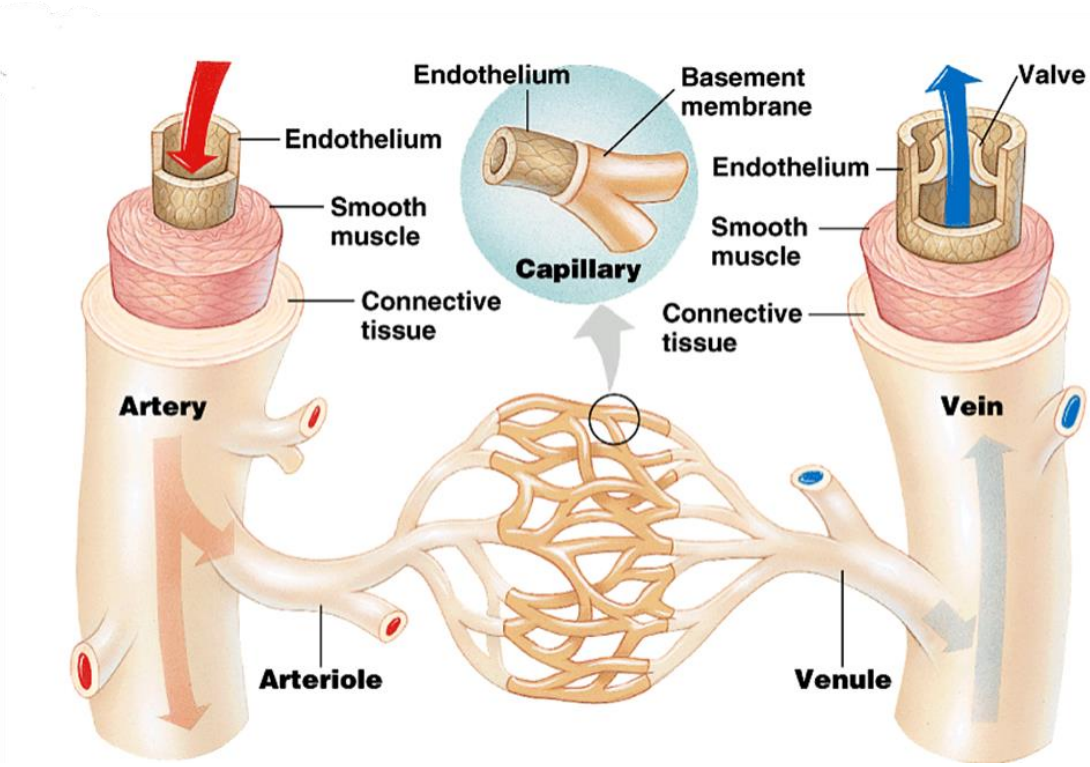
2. The veins:

They carry deoxygenated blood from the capillaries and tissues back to the heart; with the exceptions of pulmonary and umbilical veins, are carrying oxygenated blood. The veins have valves necessary to keep blood flowing toward the heart against the gravity preventing back flow of the blood.

3. The capillaries:

They are tiny thin-walled blood vessels that act as a bridge between the arteries and veins. The thin walls of the capillaries allow the nutrients, gases, water, electrolytes

and waste products are exchanged between the blood and the tissues.



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Lecture 7: Lymphatic system

The lymphatic system functions are complement the bloodstream functions, as it regulates the balance of fluids in the body and filters the pathogens from the blood.

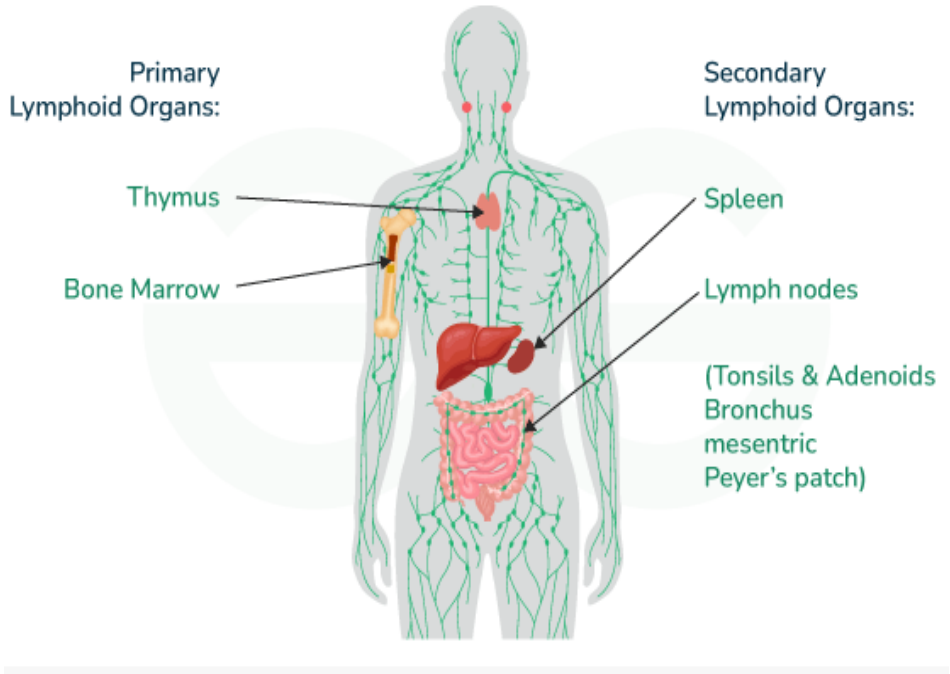
It is composed of

1. Lymphatic fluid - protein rich fluid that flows through the lymphatic system and surrounds all tissues Lymph collects fluids from tissues and returns them to blood. It carries nutrients and proteins to cells and tissues. It also collects any harmful substances found in cells and tissues. Lymph is composed of white blood cells, triglycerides, bacteria, cell debris, water, and protein. It has a composition comparable to blood plasma.

2. Lymphatic vessels - reabsorb interstitial fluid from the periphery to return it to the intravascular space, which prevents fluid buildup in peripheral tissues

3. Lymphatic cells - include macrophages, dendritic cells, lymphocytes

4. Lymphatic organs - eg spleen and thymus



There are three primary functions of the lymphatic system:

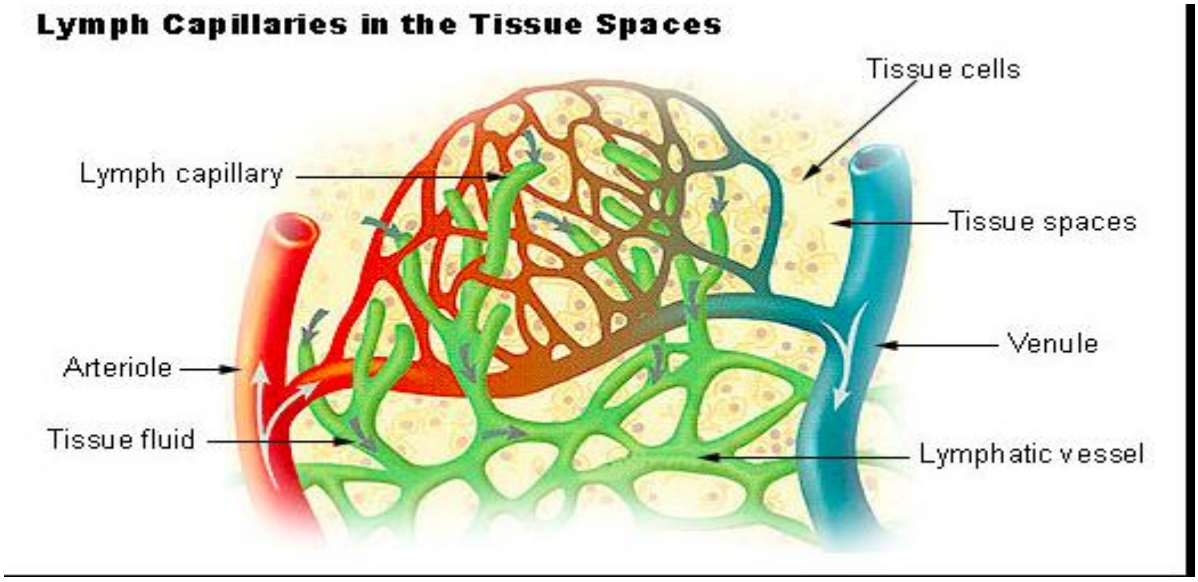
1. Maintenance of fluid balance

2. Facilitation of the absorption of dietary fats from the gastrointestinal tract to the bloodstream for metabolism or storage.

3. Prevention of infection. It picking up other cells, including bacteria, which can enter the tissue through small cuts or breaks in the skin. Bacteria and other antigens are transported by the lymphatic system from the interstation to lymphocytes in the lymph nodes, where an immune response may be initiated.

Lymphatic Transport System

The lymphatic system, which is composed of both **superficial and deep vessels** as well as **lymph nodes**, is responsible for helping prevent the buildup of interstitial fluid. This drainage system is separate from the general circulatory system and is the conduit for returning tissue fluids to it.



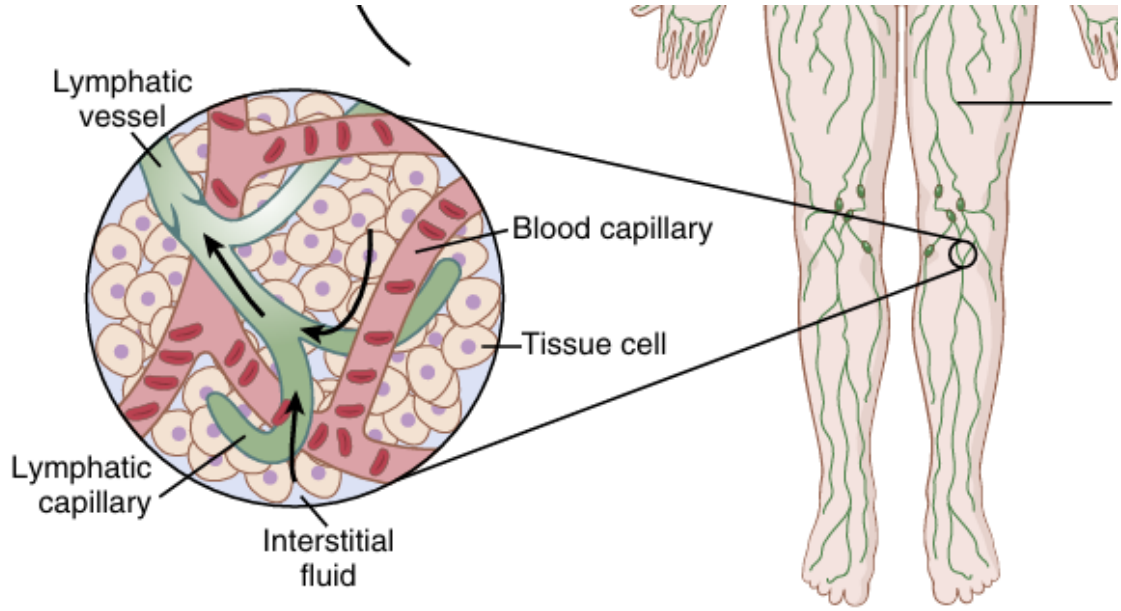
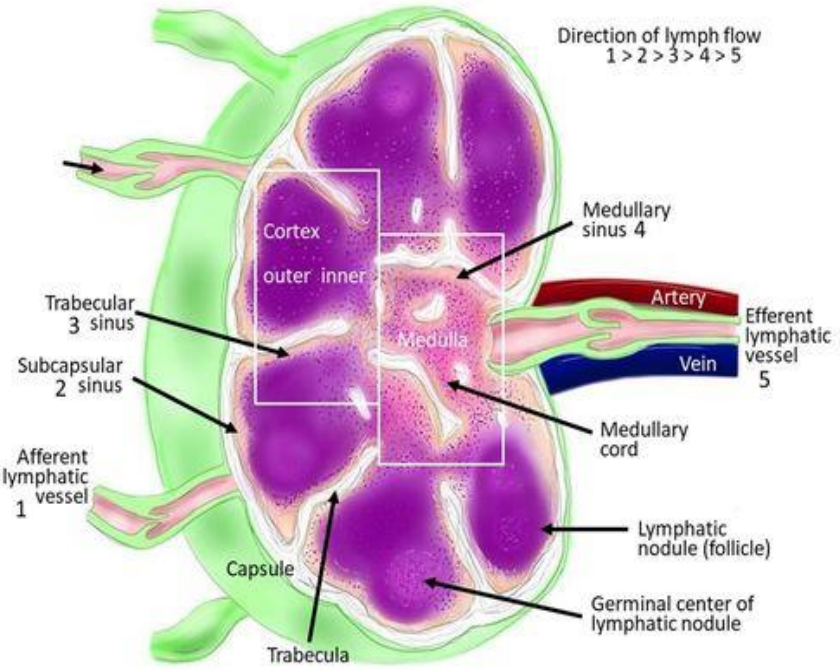


Figure 16-6. The lymphatic system.

1. **Capillaries -** The initial point of entry into the lymphatic system, a single layer of partially overlapping endothelial cells that create a valve.



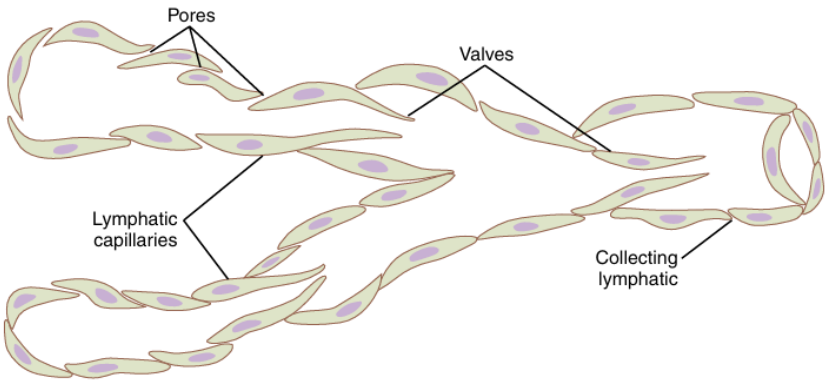


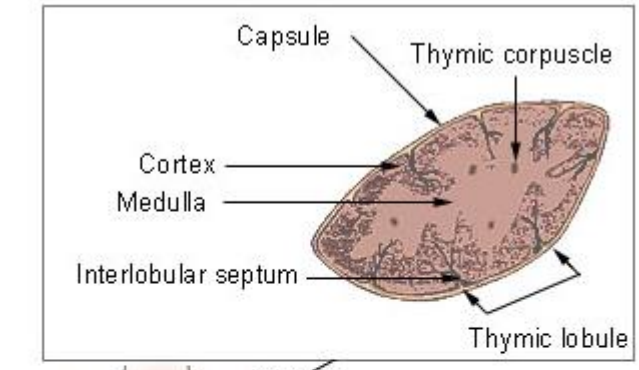
Figure 16-9. Structure of lymphatic capillaries and a collecting lymphatic, with the lymphatic valves also shown.

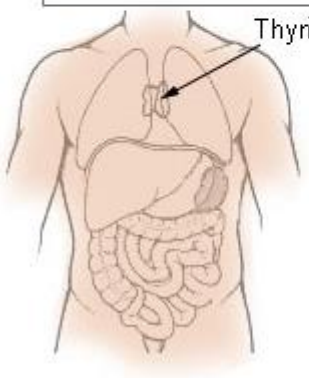
2. **Collecting vessels -** composed of an endothelial layer with many tight junctions. These collecting vessels also have intraluminal valves as well as pericytes. The pericytes contain alpha-smooth muscle actin, which functions to contract the vessel and pump the fluid further through the system. The valves prevent the backflow of the lymphatic fluid and ensure the unidirectional flow of fluid.

3. **. Lymph nodes** next point in the system. Possess a medulla, paracortex, and cortex which in combination, form the house of lymphocytes, antigen-presenting cells, and macrophages. There are approximately 450 lymph nodes in the human body. After visiting the lymph nodes, the lymphatic fluid flows into efferent lymphatic collecting vessels.

4. **Lymphatic ducts** – Final collecting vessels. Allow the entry of the lymphatic fluid into the venous system bilaterally, via the opening found at the intersection of the subclavian and internal jugular vein.

Left Duct (or thoracic duct) collects most of the lymph in the body other than from the right thorax, arm, head, and neck which are drained by the right lymphatic duct.

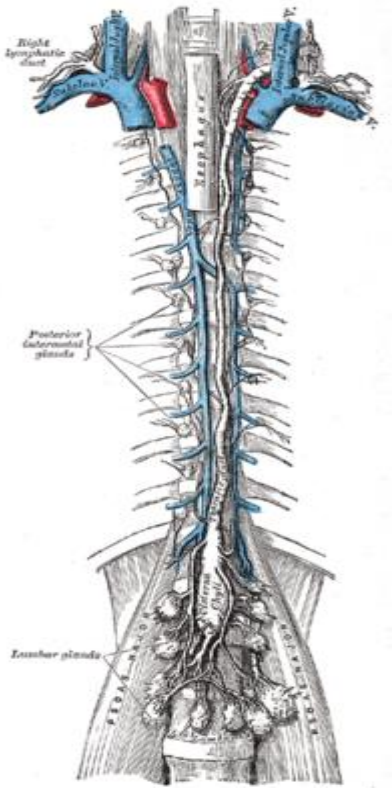




Thymus

Right Duct drains lymph fluid from:

- Upper right section of the trunk.
- Right arm
- Right side of the head and neck



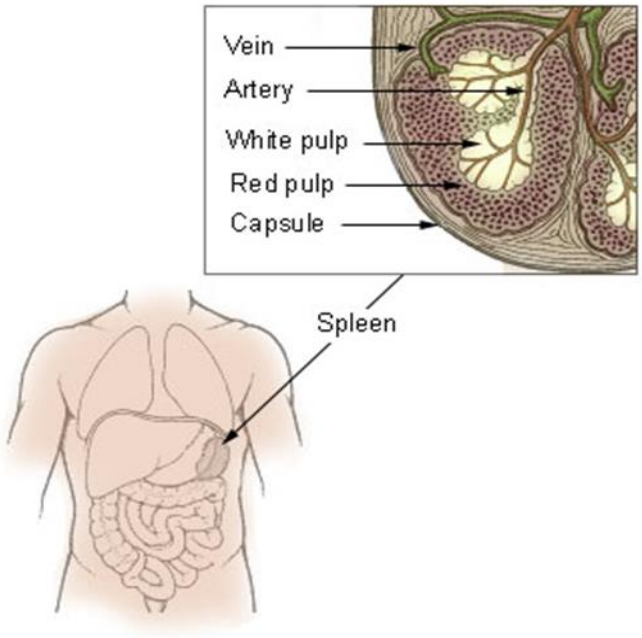
5-Lymphatic Organs and Tissues

1. Primary lymphoid organs

The primary lymphoid organs generate lymphocytes from immature progenitor cells. The thymus and the bone marrow constitute the primary lymphoid organs involved in the production and early clonal selection of lymphocyte tissues.

Thymus: A ductless gland in the upper mediastinum beneath the sternum. It develops fully by puberty and gradually declines in function with age but remains essential for immunity. During late fetal life and early infancy, it traps immature stem cells from the bone marrow

and processes them into specialized lymphocytes. These cells then enter the blood and migrate to lymphoid tissues, where they develop into **T lymphocytes**, crucial for cell-mediated immunity.



Bone marrow:is a soft, spongy tissue inside bones that produces erythrocytes (red blood cells), leukocytes (white blood cells), and platelets. Blood cells develop in the marrow and enter the bloodstream only when fully matured. During infections, the marrow increases leukocyte production to meet the body's demand.

2. Secondary lymphoid organs can be encapsulated (spleen, lymph nodes, adenoids, tonsils) or diffused tissues. They store mature naive lymphocytes and trigger adaptive immune responses. These organs are where lymphocytes encounter antigens, leading to **activation.**

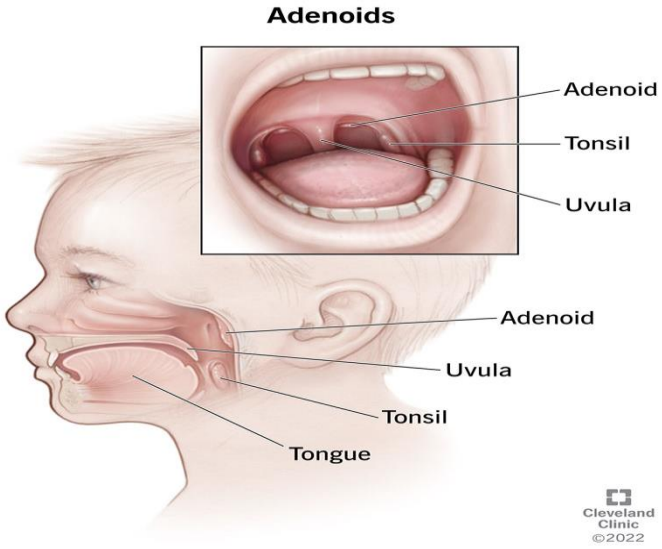
•Spleen - An organ that is located in the upper-left part of the abdomen, not far from the stomach, that produces lymphocytes. The spleen is the largest lymphatic organ in the body. The spleen also filters blood, serves as a major reservoir for blood, and destroys blood cells that are aged.

•Lymph node - Any of the accumulations of lymphoid tissue organized as definite lymphoid nodes along the course of lymphatic vessels. Lymph nodes are the main source of lymphocytes of the peripheral blood and, as part of the reticuloendothelial system

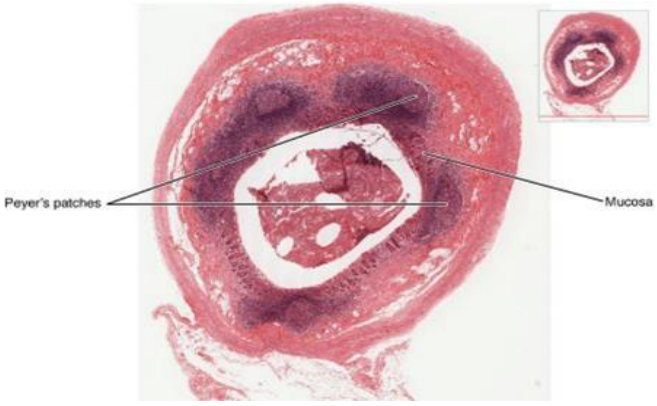
- Adenoids - A normal collection of unencapsulated lymphoid tissue in the nasopharynx. Also called pharyngeal tonsils.

- Tonsils - Oval-shaped masses of glandular tissue located on both sides at the back of the throat. Tonsils act like filters to trap bacteria and viruses.

- Peyer's Patches: PPs can be considered as the immune sensors of the intestine. PPs functions like induction of immune tolerance or defense against pathogens .



3. Other lymphoid tissue (or diffuse lymphoid regions not encapsulated) Such as Mucosa-associated lymphoid tissue (MALT) is an umbrella term for extranodal aggregates of lymphoid tissue in the bronchus (BALT), gut (GALT) and skin (SALT), as well as breast and uterine cervix. MALT is the arm of the immune defence in closest contact with exogenous antigens, thus differing from the peripheral somatic lymphoid tissues. It constitutes about 50 percent of the lymphoid tissue in the human body.



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Lecture 8&9

Digestive System

The digestive system is the organ system that processes food, extracts nutrients from it, and eliminates the residue. Digestive Function

1. Ingestion, the selective intake of food;
2. Digestion, the mechanical and chemical breakdown of food into a form usable by the body.
3. Absorption, the uptake of nutrient molecules into the epithelial cells of the digestive tract and then into the blood or lymph.
4. Defecation, the elimination of feces

Parts of digestive system:

1. Tube or tract consist:

a) Oral cavity

b). Pharynx

c) Esophagus

d). Stomach

e). Small intestine

f). Large intestine

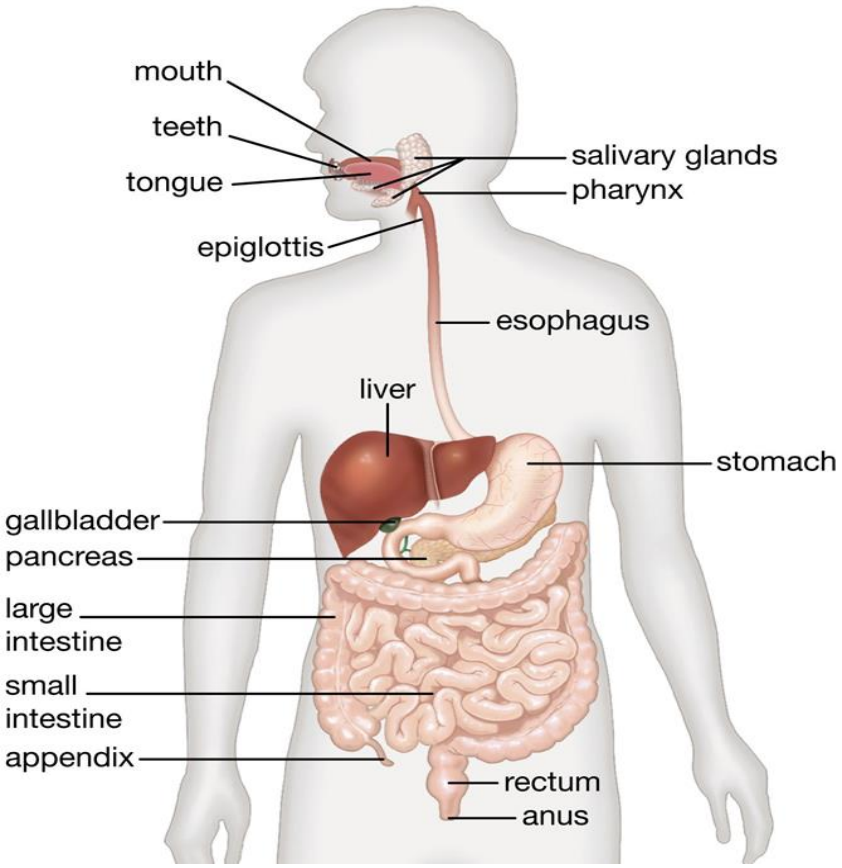
g). Anus

2. Accessory organs

a). Salivary glands

b). Liver and gall bladder

c). pancreas



Mastication (Chewing)

The teeth are designed for chewing. The anterior teeth (incisors) provide a strong cutting action, and the posterior teeth (molars) provide a grinding action. All the jaw muscles working together can close the teeth with a force

Swallowing is a complicated mechanism, principally because the pharynx subseries respiration and swallowing. The pharynx is converted for only a few seconds at a time into a tract for propulsion of food. **Swallowing** can be divided into the following stages:

(1) a voluntary stage, which initiates the swallowing process

(2) a pharyngeal stage, which is involuntary and constitutes passage of food through the pharynx into the esophagus.

(3) an esophageal stage, another involuntary phase that transports food from the pharynx to the stomach.

Digestion is the process of mechanically and enzymatically breaking down food into substances for absorption into the bloodstream. The food contains three macronutrients that require digestion before they can be absorbed: fats, carbohydrates, and proteins

Digestion is a form of catabolism or breaking down of substances that involves two

separate processes:

Mechanical digestion: involves physically breaking down food substances into smaller particles to more efficiently undergo chemical digestion.

Chemical digestion: degrade the molecular structure of the ingested compounds into basic unit by digestive enzymes into a form that is absorbable

1- The Mouth

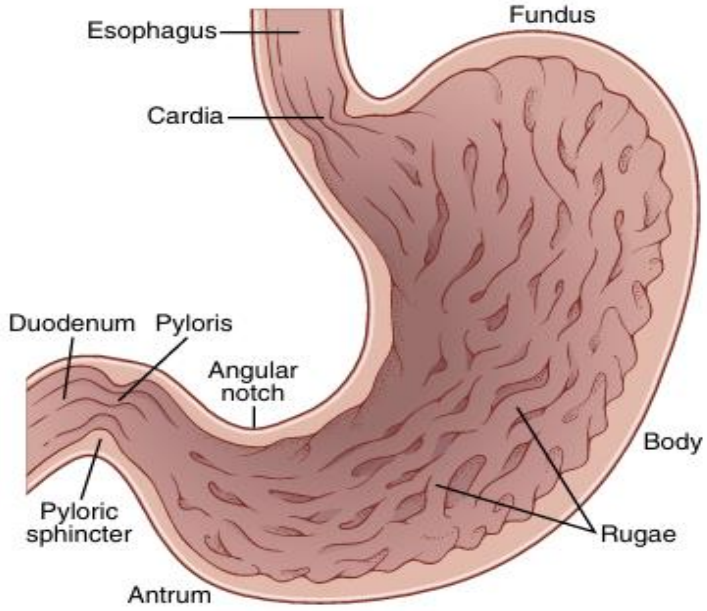
food inside the mouth, is moistened by saliva, and the teeth and tongue begin the process

of **mechanical digestion.**

2- The stomach

- The bolus enters the stomach through **a muscular valve** at the top called the **cardiac sphincter**.
- Stomach is a ‘J’ shaped enlargement of GI Tract which lies directly inferior to diaphragm. It connects esophagus to duodenum (first part of small intestine).

- Stomach serves as mixing chamber and holding reservoir for food. When food is ingested, stomach pushes a small quantity of food into duodenum periodically.
- In stomach, semisolid bolus is converted into liquid, digestion of starch continues, digestion of triglycerides and protein starts and absorption of several substances takes place.
- The stomach contains gastric juice, which contains mostly:



Physiological anatomy of the stomach.

a) Hydrochloric acid secreted by Parietal cell — create an acidic environment, which aids in the breakdown of food and the activation of digestive enzymes.

b) Pepsin secreted by The chief cell — an enzyme that breaks down proteins.

- In the stomach, peristalsis continues, which helps to mix the food with the gastric juices. Not many compounds are absorbed into the blood from the stomach; exceptions to this include water, alcohol, and non-steroidal anti-inflammatory drugs.
- After 1–2 hours in the stomach, the food is a thick paste, referred to as chyme. It leaves the stomach through the pyloric sphincter at the bottom of the stomach.

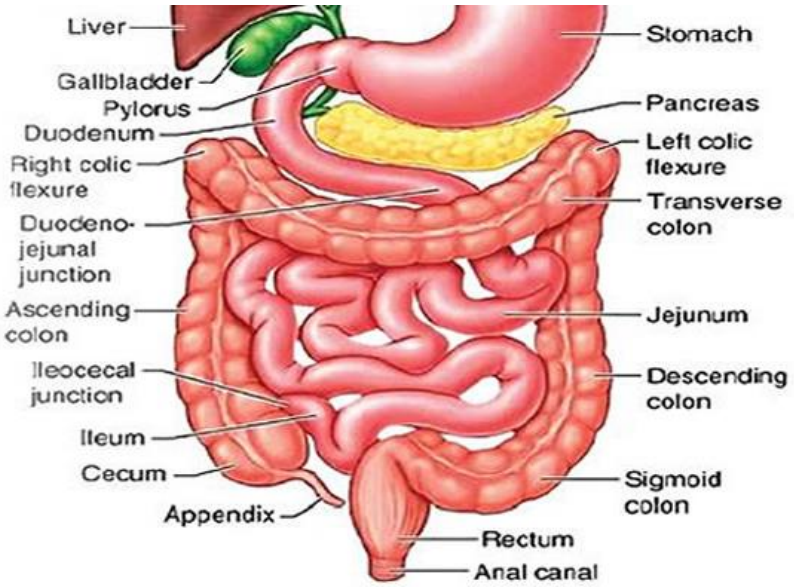
The small intestine

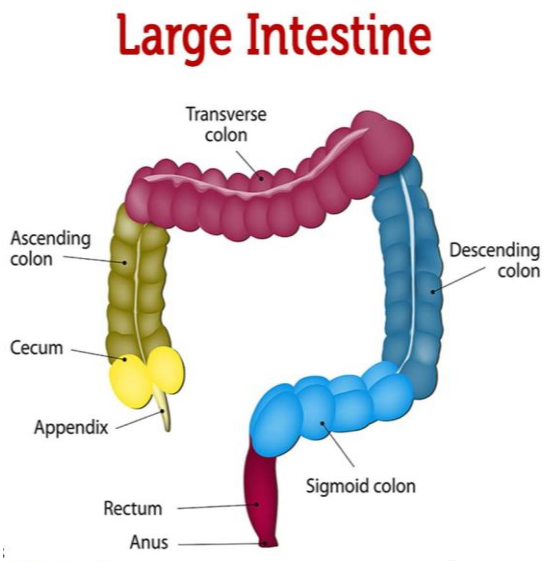
The duodenum is the first section of the small intestine. Here, the chyme mixes with enzymes from the pancreas, bile from the liver, and intestinal juice:

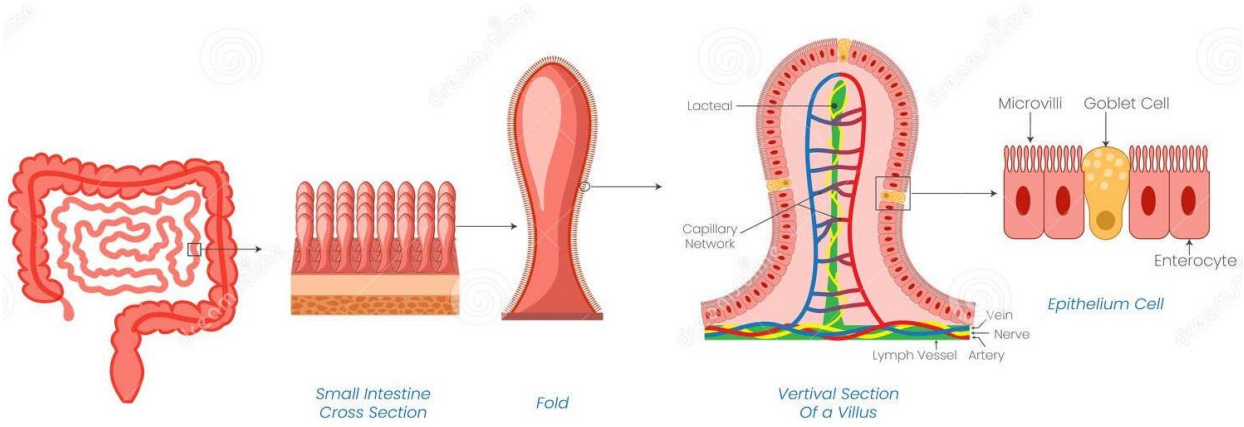
- **Bile** \ produced by the liver, it helps break down fats and is stored in the gallbladder.
- **Pancreatic juice** \ contains a cocktail of enzymes, including trypsinogen, elastase, and amylase.
- **Intestinal juice** \ this fluid activates some of the enzymes in the pancreatic juice. It also contains other enzymes, mucus, and hormones.

- The food continues its journey through the remaining parts of the small intestine **the jejunum and ileum** — being gradually digested as it goes. Once it is fully broken down, it is absorbed into the blood.

- In humans, the vast majority of nutrients are absorbed in the small intestine.
- Tiny finger-like projections called villi stick out from the walls of the duodenum and increase its surface area. Villi maximize the amount of nutrients that can be absorbed. The surface area is further increased by microvilli, which are even smaller projections that come from the cells of the intestine's epithelium (lining).







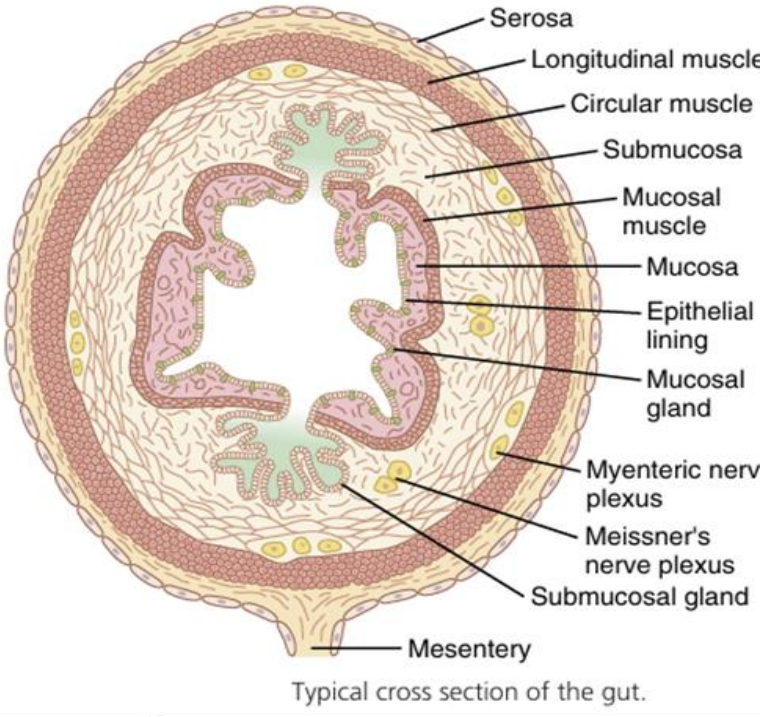
The large intestine

- Also called the colon and large bowel.
- the large intestine is 1.5 meters (5 feet) in length.
- it is shorter than the small intestine, it is thicker in diameter.
- In the large intestine, water and minerals are absorbed into the blood. Food
- travels through this region much slower to allow fermentation by gut bacteria.
- The large intestine absorbs any products produced by bacterial activity, such as vitamin K, vitamin B12, thiamine, and riboflavin.

The large intestine is divided into sections:

- The ascending colon: - this includes the cecum and the appendix
- The transverse colon: - this section Crosse the abdomen.

- The descending colon – this section has a dense population of gut bacteria and is used to store feces.
- The sigmoid (S-shaped) colon: - has muscular walls that help push feces



Typical cross section of the gut.

The rectum

Any waste left over that the body cannot use is moved to the rectum and excreted through the anus during defecation.

Function Movement in Gastrointestinal Tract

Two types of movements occur in the gastrointestinal tract:

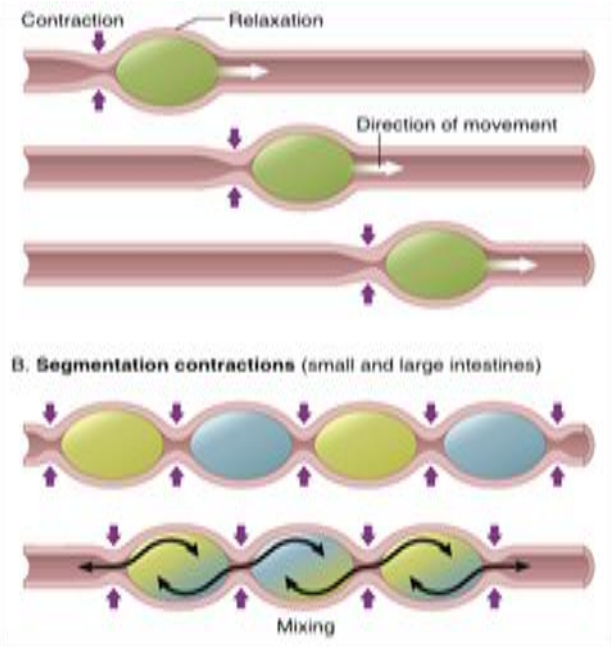
(1) propulsive movements (Peristalsis), which cause food to move forward along the tract at an appropriate rate to accommodate digestion and absorption.

(2) mixing movements, which keep the intestinal contents thoroughly mixed at all times

Physiologic Anatomy of the Gastrointestinal Wall

Gastrointestinal Wall including the following layers from the outer surface inward:

1. the serosa
2. Muscularis externa
   a- a longitudinal smooth muscle layer
   b- a circular smooth muscle layer
3. The submucosa: (thicker layer of loose connective tissue containing blood vessels and lymphatics, a nerve
4. plexus, and in some places, glands that secrete lubricating mucus into the lumen.



5. the mucosa. (The inner lining of the digestive tract)

Neural Control of Gastrointestinal Function

The **enteric nervous system** lies entirely in the wall of the gut, beginning in the esophagus and extending all the way to the anus. It important in controlling gastrointestinal movements and secretion. It is composed mainly of two plexuses,

(1) myenteric plexus or Auerbach's plexus: an outer plexus lying between the longitudinal and circular muscle layers, controls mainly the gastrointestinal movements

(2) submucosal plexus or Meissner's plexus an inner plexus, which lies in the submucosa. controls mainly gastrointestinal secretion and local blood flow.

Note: The nervous connections within and between these two plexuses

Although the enteric nervous system can function independently of these extrinsic nerves, stimulation by the parasympathetic and sympathetic systems can greatly enhance or inhibit gastrointestinal functions.

How nutrients are broken down

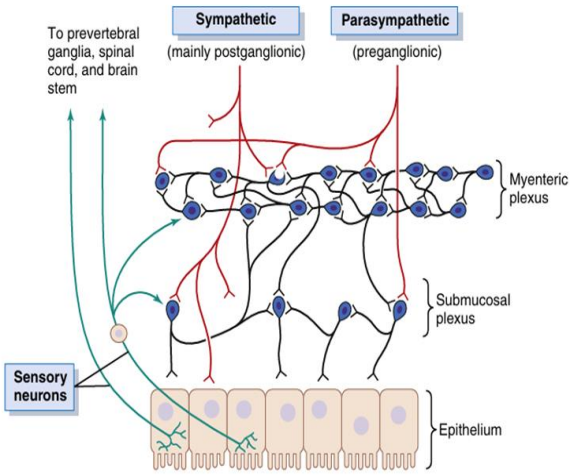
Different components of the diet are broken down in various ways:

Protein: - digested by three enzymes called pepsin (in the stomach), trypsin, and chymotrypsin (in the duodenum, secreted by the pancreas).

Fat: - lingual lipase begins fat digestion in the mouth. However, most fat is broken down in the small intestine by pancreatic lipase. Bile also helps in the process of breaking down fats.

Carbohydrate: - salivary and pancreatic amylase break down starches into individual glucose units. Lactase breaks down lactose, the sugar in milk. Sucrose breaks down sucrose.

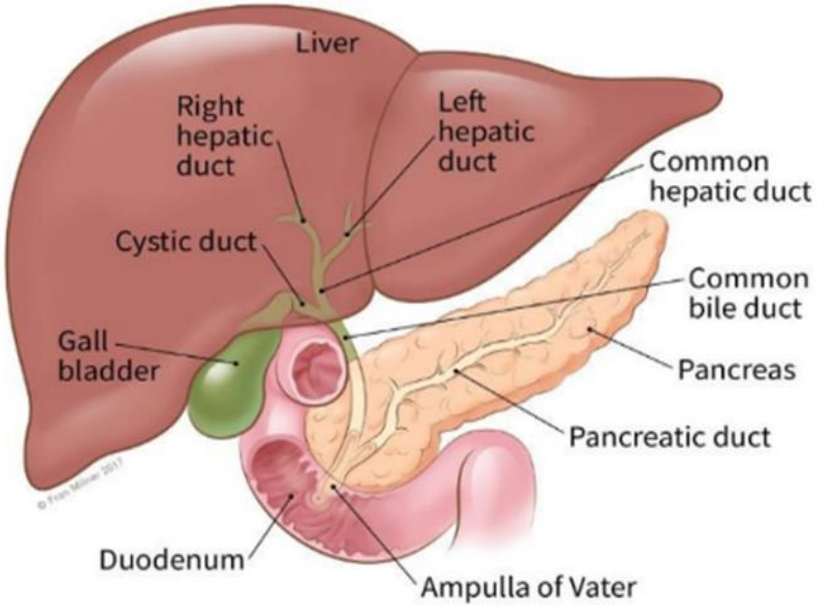
DNA and RNA: - broken down by deoxyribonuclease (DNase) and ribonuclease (RNase) produced by the pancreas



Accessory Organs of the Digestive System

1. **Definition**:
   Accessory digestive organs are not part of the

main gastrointestinal (GI) tract but are essential for proper digestion. They assist by producing, storing, and secreting enzymes and other substances that help break down food.



2. **Main Accessory Organs**:

- **Salivary glands**: is a gland that releases a secretion called saliva into the oral cavity. Saliva secreted to
- keep the mucous membranes of the mouth and pharynx moist
- cleanse the mouth and teeth. When food enters the mouth
- secretion of saliva increases, and it lubricates, dissolves
- begins the chemical breakdown of the food.
- There are 3 pairs of major salivary glands which secrete saliva.
- a- The parotid glands: b- The submandibular glands c- The sublingual glands

- **Liver**:

- The largest internal organ, located in the upper right abdomen.
- Produces bile, a fluid that emulsifies fats, making them easier to digest by enzymes.
- Also processes nutrients absorbed from the intestine and detoxifies harmful substances.

- **Gallbladder**:

- A small, pear-shaped sac beneath the liver.
- Stores and concentrates bile produced by the liver.
- Releases bile into the small intestine (duodenum) during digestion, especially after fatty meals.

- **Pancreas**:

- Functions as both an exocrine and endocrine gland.
- Produces digestive enzymes (amylase, lipase, and proteases) that are released into the small intestine to break down carbohydrates, fats, and proteins.
- Also secretes bicarbonate to neutralize stomach acid.

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Dr. Rabab Ali Al-Mosaw

Lecture 10&11
Endocrine System
Glands (Classification, Function)
Hormones (Types, Function)

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

Hormones are chemical messengers, synthesized by endocrine glands. Based on chemical nature, hormones are classified into three types:

1-Stedoidis Hormones are the hormones synthesized from cholesterol or its derivatives. Steroid hormones are secreted by adrenal cortex, gonads and placenta

2- Protein Hormones: are large or small peptides. Protein hormones are secreted by pituitary gland, parathyroid glands, pancreas and placenta

3- Tyrosine Derivatives: Two types of hormones, namely thyroid hormones and adrenal medullary hormones are derived from the amino acid tyrosine.

Note: Hormone does not act directly on target cells. First it combines with receptor present on the target cells.

The pituitary gland

The pituitary gland is also known as hypophysis. It is a small gland that lies at the base of the brain. It is connected with the hypothalamus by the pituitary stalk or hypophyseal stalk.

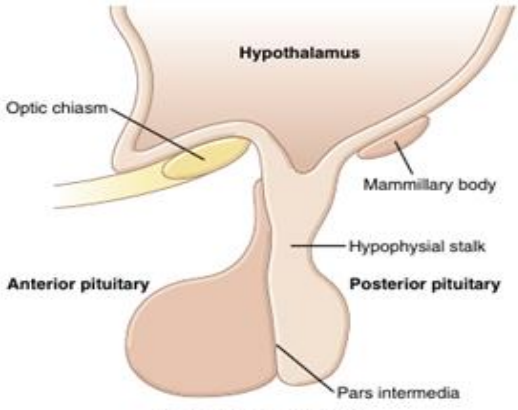


Figure 76-1. Pituitary gland.

Pituitary gland is divided into two portions:

1. Anterior pituitary or adenohypophysis

2. Posterior pituitary or neurohypophysis.

Hypothalamic Releasing and Inhibitory Hormones Are Secreted into the Median Eminence. Special neurons in the hypothalamus synthesize and secrete

the hypothalamic releasing and inhibitory hormones that control secretion of the anterior pituitary hormones.

Hormones secreted by Hypothalamic	Primary Action on Anterior Pituitary
Thyrotropin-releasing hormone (TRH)	Stimulates secretion of TSH by thyrotropes
Gonadotropin-releasing hormone (GnRH)	Stimulates secretion of FSH and LH by gonadotropes
Corticotropin-releasing hormone (CRH)	Stimulates secretion of ACTH by corticotropes
Growth hormone–releasing hormone (GHRH)	Stimulates secretion of growth hormone by somatotropes
Growth hormone inhibitory hormone (somatostatin)	Inhibits secretion of growth hormone by somatotropes
Prolactin-inhibiting hormone (PIH)	Inhibits synthesis and secretion of prolactin by lactotropes

Hormones Secreted by Anterior Pituitary

Anterior pituitary is also known as the master gland because it regulates many other endocrine glands. hormones are secreted by the anterior pituitary:

Hormone	Physiological Action
Growth hormone (GH) (somatotropin)	Stimulates body growth; stimulates secretion of insulin-like growth factor-1; stimulates lipolysis; inhibits actions of insulin on carbohydrate and lipid metabolism
Adrenocorticotropic hormone (ACTH) (corticotropin)	Stimulates production of glucocorticoids and androgens by the adrenal cortex; maintains size of zona fasciculata and zona reticularis of cortex
Thyroid-stimulating hormone (TSH) (thyrotropin)	Stimulates production of thyroid hormones by thyroid follicular cells; maintains size of follicular cells
Follicle-stimulating hormone (FSH) Luteinizing (LH) hormone	Stimulates development of ovarian follicles; regulates spermatogenesis in the testis Causes ovulation and formation of the corpus luteum in the ovary; stimulates production of estrogen and progesterone by the ovary; stimulates testosterone production by the testis
Prolactin (PRL)	Stimulates milk secretion and production

Hormones Secreted by Posterior Pituitary

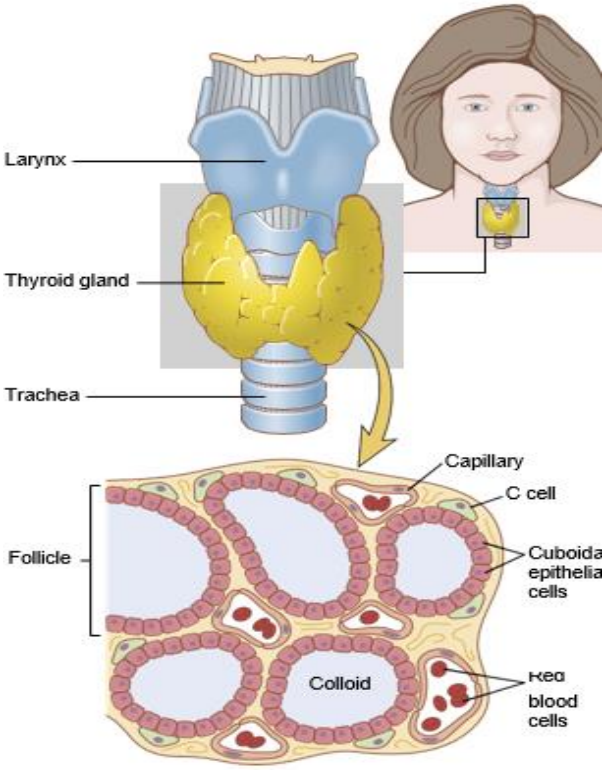
Posterior pituitary hormones are:
Actually, the posterior pituitary does not secrete any hormone. ADH and oxytocin are synthesized in the hypothalamus. Hence, these two hormones are called neurohormones.

1. Antidiuretic hormone (ADH) or vasopressin
   - The major function of ADH is retention of water by acting on kidneys. It increases the facultative reabsorption of water from the kidneys.
   - ADH shows vasoconstrictor action in all parts of the body. Due to the vasoconstriction, the blood pressure increases.

2. Oxytocin.
   - Action of oxytocin on mammary glands It causes ejection of milk from the mammary glands.
   - Oxytocin causes contraction of uterus and helps in the expulsion of fetus.

The thyroid gland

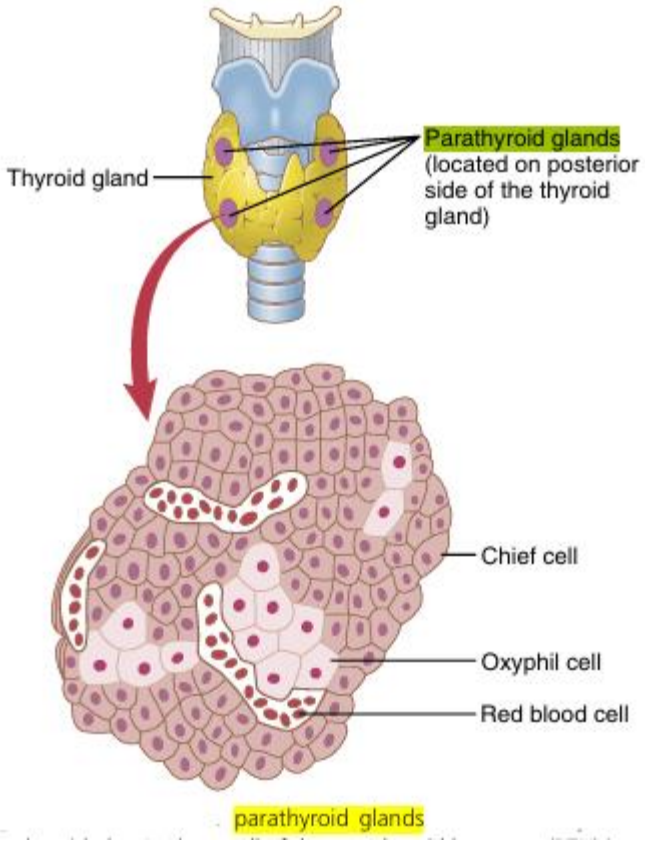
- located immediately below the larynx on each side of and anterior to the trachea, is one of the largest of the endocrine glands.
- Normally weighing 15 to 20 grams in adults.
- The thyroid secretes two major metabolic hormones. **thyroxine** and **triiodothyronine**, commonly called T4 and T3, respectively.
- Both of these hormones profoundly increase the metabolic rate of the body.
- The thyroid gland also secretes **calcitonin**, a hormone involved in calcium metabolism
- About 93% of the metabolically active hormones secreted by the thyroid gland is thyroxine and 7% is triiodothyronine.
- The thyroid gland is composed of large numbers of closed follicles that are filled with a secretory substance called colloid.



Anatomy and microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

Parathyroid Glands

- There are four parathyroid glands located immediately behind thyroid gland at the upper and lower poles.
- The parathyroid glands are very small in size measuring about 6 mm long, 3 mm wide and 2 mm thick with dark brown color.
- Each parathyroid (PTH) secrete parathormone is essential for the maintenance of blood calcium level within a very narrow critical level.
- PTH provides a powerful mechanism for controlling extracellular calcium and phosphate concentrations by regulating intestinal reabsorption, renal excretion, and exchange between the extracellular fluid and bone of these ions.

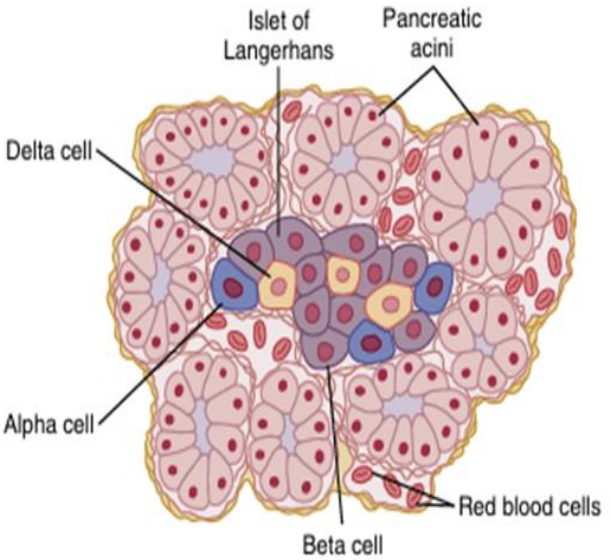


Pancreas

Islets of Langerhans

The endocrine function of pancreas is performed by the islets of Langerhans. Human pancreas contains about 1 to 2 million islets. Islets of Langerhans consist of four types of Cells:

1. A cells or α cells which secrete glucagon
2. B cells or β cells which secrete insulin
3. D cells or δ cells which secrete somatostatin
4. F cells or PP cells which secrete pancreatic polypeptide.



Physiological anatomy of an islet of Langerhans in the

The pancreas, in addition to its digestive functions, secretes two major hormones, **insulin** and **glucagon**, that are crucial for normal regulation of glucose, lipid, and protein metabolism. Although the pancreas secretes other hormones, such as amylin, somatostatin, and pancreatic polypeptide, their functions are not as well established.

Insulin is the important hormone that is concerned with regulation of carbohydrate metabolism and blood sugar level. It is also concerned with metabolism of proteins and fats.

Glucagon. Actions of glucagon are antagonistic to those of insulin. It increases the blood sugar level and peripheral utilization of lipids and facilitates the conversion of proteins into glucose.

Somatostatin is secreted from hypothalamus, D cells (δ cells) in islets of Langerhans of pancreas and D cells in stomach and upper part of small intestine. Somatostatin is a polypeptide. ACTIONS

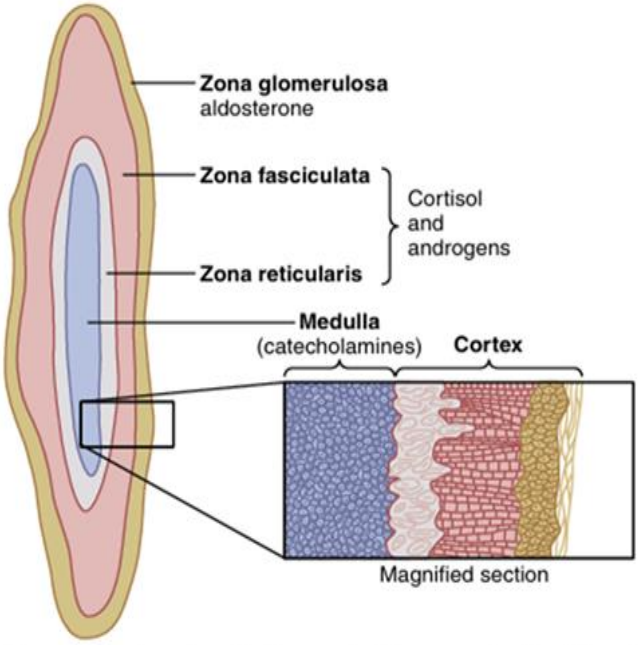
1. Somatostatin acts within islets of Langerhans and, inhibits the secretion of both glucagon and insulin
2. It decreases the motility of stomach, duodenum and gallbladder.
3. It reduces the secretion of gastrointestinal hormones
4. Hypothalamic somatostatin inhibits secretion of GH and TSH from anterior pituitary. That is why, it is also called growth hormone inhibitory hormone (GHIH).

Adrenal gland

There are two adrenal glands. Each gland is situated on the upper pole of each kidney. Each gland is made of two parts, the adrenal cortex and adrenal medulla.

Hormones of Adrenal Cortex

Adrenal cortex is the outer portion constituting 80% of the gland. The hormones secreted by adrenal cortex are collectively known as adrenocortical hormones or corticosteroids. Based on their functions the corticosteroids are classified into three groups:



Figur Secretion of adrenocortical hormones by the different zones of the adrenal cortex and secretion of catecholamines by the adrenal medulla.

1. Mineralocorticoids (aldosterone): are the corticosteroids that act on the minerals (electrolytes) particularly sodium and potassium.
2. Glucocorticoids (Cortisol, Corticosterone, Cortisone) are the corticosteroids which act mainly on glucose metabolism.
3. Sex hormones: Most of the hormones are male sex hormones (androgens). But small quantities of estrogen and progesterone are also secreted by adrenal cortex.

Hormones of Adrenal Medulla

Adrenal medulla is the inner part of the adrenal gland and it forms 20% of mass of adrenal gland.

1. Adrenaline or epinephrine
2. Noradrenaline or norepinephrine **Adrenaline and noradrenaline** stimulate the nervous system and have significant effects on cardiovascular system. **Adrenaline** has significant effects on metabolic functions.
3. Dopamine **is** secreted by adrenal medulla. Dopamine is also secreted by brain. In brain, this hormone acts as a neurotransmitter.

Testes

Testosterone Promotes development of male reproductive system and male secondary sexual characteristics

Ovaries

Estrogens Promotes growth and development of female reproductive system, female breasts, and female secondary sexual characteristics

Progesterone Stimulates secretion of "uterine milk" by the uterine endometrial glands and promotes development of secretory apparatus of breasts.

Placenta

- **Human chorionic gonadotropin** Promotes growth of corpus luteum and secretion of estrogens and progesterone by corpus luteum Probably helps promote development of some fetal tissues, as well as the mother's breasts
- Somatomammotropin
- **Estrogens and Progesterone**

Kidney

- Renin Catalyzes conversion of angiotensinogen to angiotensin I (acts as an enzyme).
- 1,25-Dihydroxycholecalciferol Increases intestinal absorption of calcium and bone mineralization.
- Erythropoietin Increases erythrocyte production

Heart Atrial natriuretic peptide (ANP) is a cardiac hormone that regulates salt-water balance and blood pressure by promoting renal sodium and water excretion and stimulating vasodilation

Stomach: Gastrin Stimulates hydrogen chloride secretion by parietal cells

Small intestine

- Secretin Stimulates pancreatic acinar cells to release bicarbonate and water
- Cholecystokinin Stimulates gallbladder contraction and release of pancreatic enzymes

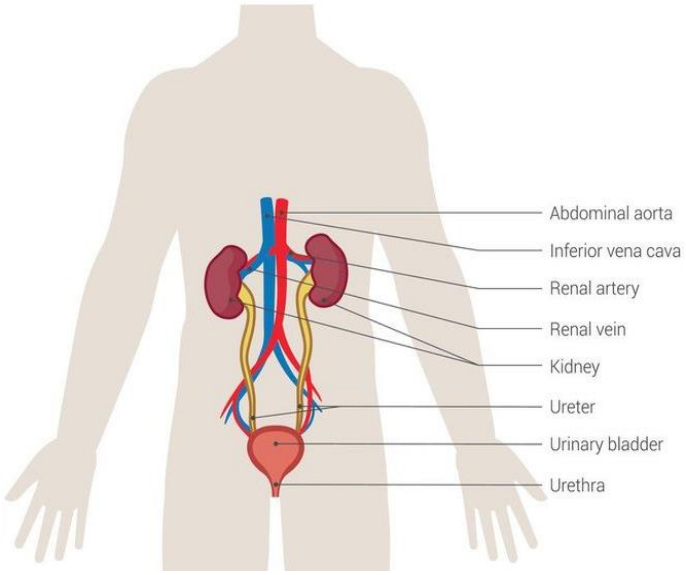
Adipocytes: Leptin Inhibits appetite, stimulates thermogenesis.

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Lecture 12&13
Urinary System
- Parts of Urinary System.
- Function each part.
- Nephron
-Urine Formation
-Micturition
- Maintenance of acid base balance

The urinary system's: function is to filter blood and create urine as a waste by-product. The organs of the urinary system include the kidneys, renal pelvis, ureters, bladder and urethra.
Also called the excretory system, the urinary system acts to remove waste products and maintain the body's balance of water and various chemical compounds.



- Function of this system

1. Excrete waste products from the body
2. Maintain the body's water balance
3. Maintain the body's salt (electrolyte) balance
4. Regulates the blood's acid-base (pH) balance
5. Regulates the body's blood volume
6. Helps to regulate blood pressure (by releasing the enzyme renin)
7. Helps stimulate red blood cell production (by releasing the hormone erythropoietin)
8. Converts Vitamin D to its active form of calcitriol

Urinary system organs

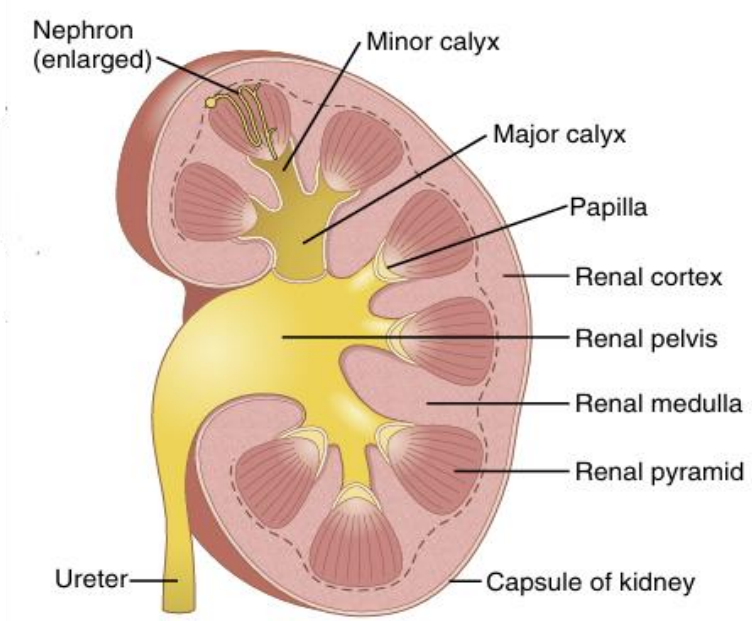
The organs of the urinary system

1. Paired kidneys.

2. Ureters.

3. Bladder

4. Urethra**.**



Kidneys:

The kidneys lie on either side of the spine in the retroperitoneal space, well protected by muscle, fat, and ribs.

Ureters:

As urine is formed, it drains into the calyces of the kidney, which merge to form the funnel-shaped renal pelvis in the hilum of each kidney. The hilum narrows to become the ureter of each kidney. As urine passes through the ureter. The ureters are approximately 30 cm long.

Bladder: This triangle-shaped, hollow organ is located in the lower abdomen. It is held in place by ligaments that are attached to other organs and the pelvic bones. The bladder's walls relax and expand to store urine, and contract and flatten to empty urine through the urethra. The typical healthy adult bladder can store up to 300 ml of urine for two to five hours.

Urethra: This tube allows urine to pass outside the body.

Kidneys' Internal Structure:

Internal Anatomy A frontal section through the kidney reveals

Renal Capsule - This dark brown fibro-connective tissue is the outermost surface of the kidney and represents the outer protective portion of this organ. It binds and encapsulates the kidney and is only breached at the renal hilus, where the renal artery and vein, ureter and nerves enter and exit each kidney.

Renal Cortex - This is the layer immediately under the renal capsule. It is the outer region and is lighter in color. It contains renal corpuscles and extends inwards as renal columns.

Renal Medulla - The medulla is below the cortex and is divided into pyramid-shaped structures called renal pyramids. The apex of the pyramid points internally.

Renal Pyramids- The renal pyramids are made up of hundreds of collecting ducts that are all arranged in parallel and are heading toward the renal papilla and minor calyx.

Renal Papillae – These are actually the tips of the renal pyramid, deep in the renal medulla. .

Renal Columns- The renal columns are situated in between each of the renal pyramids in the medulla.

Minor Calyx A is a short, cup-shaped tube that receives what is now urine from the collecting ducts. Each renal papilla projects into the space called the minor calyx.

Major Calyx – The several minor calicies merge to form larger spaces called a major calyx. Each kidney has about 2-3 major calicies.

Renal Pelvis - This is a flat, funnel-shaped tube and is the expanded superior part of the ureter. The renal pelvis is formed by the junction of all major calyces.

Nephrons:

Each human kidney contains about 800,000 to 1,000,000 nephrons, each of which is capable of forming urine. **Nephrons** are the functional units‖ of the kidneys; they cleanse the blood and balance the constituents of the circulation.

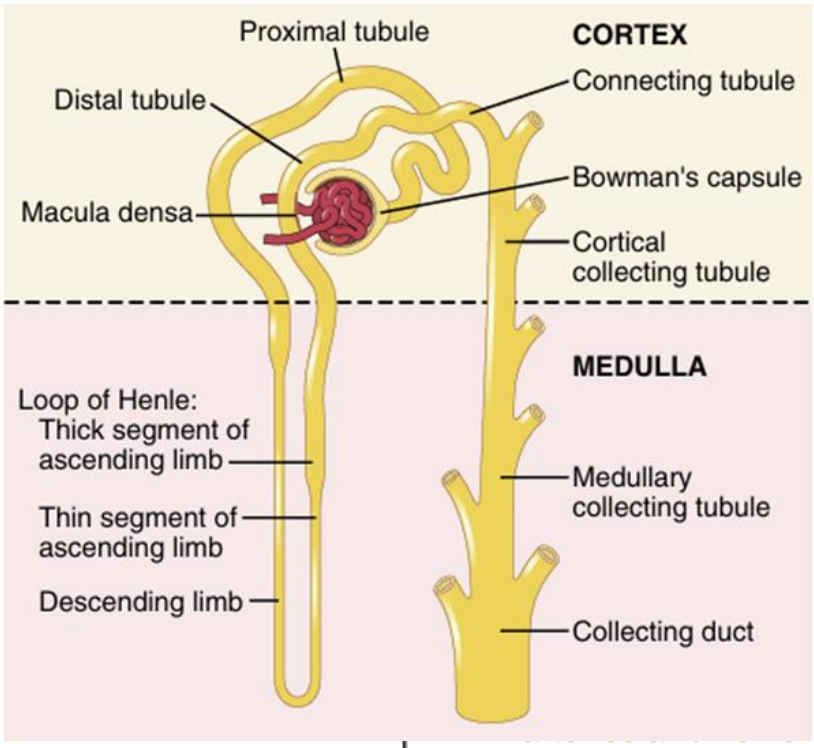
Each nephron contains

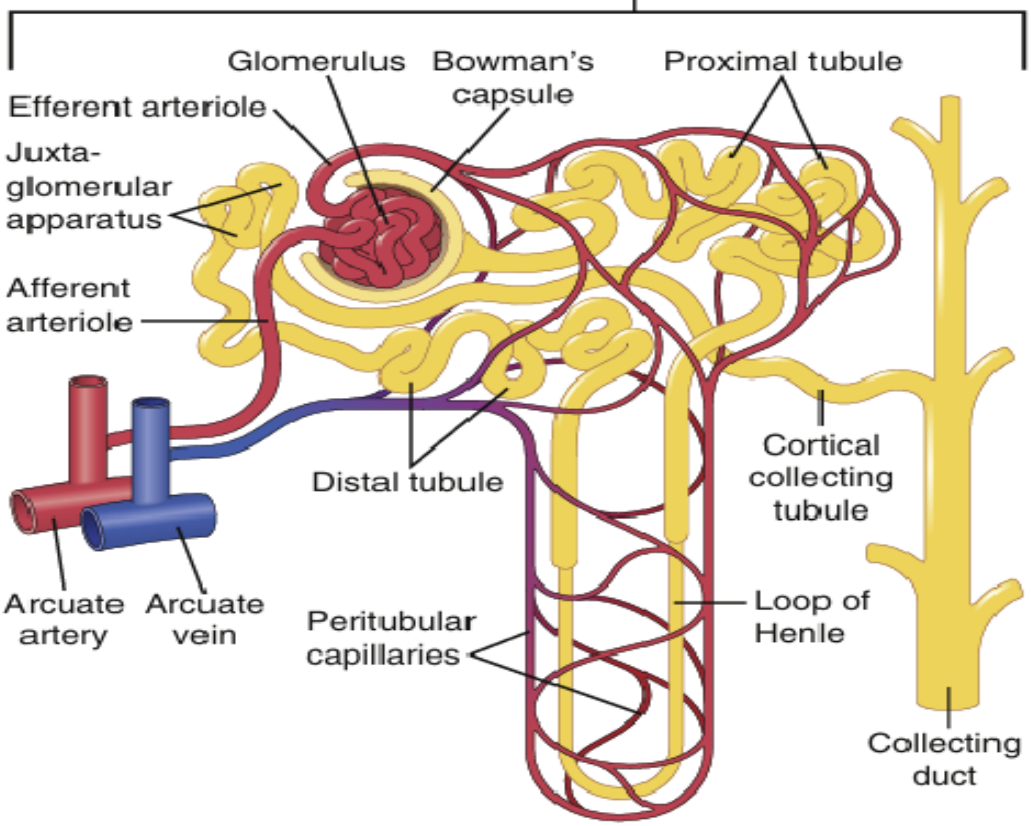
(1) a tuft of glomerular capillaries called the glomerulus, through which large amounts of fluid are filtered from the blood. The glomerular capillaries are covered by epithelial cells, and the total glomerulus is encased in Bowman's capsule.

(2) A long tubule in which the filtered fluid is converted into urine on its way to the pelvis of the kidney

- Fluid filtered from the glomerular capillaries flows into Bowman's capsule and then into the proximal tubule, which lies in the cortex of the kidney.
- From the proximal tubule, fluid flows into the loop of Henle, which dips into the renal medulla.

- Each loop consists of a descending and an ascending limb. The walls of the descending limb and lower end of the ascending limb are very thin and therefore are called the thin segment of the loop of Henle.



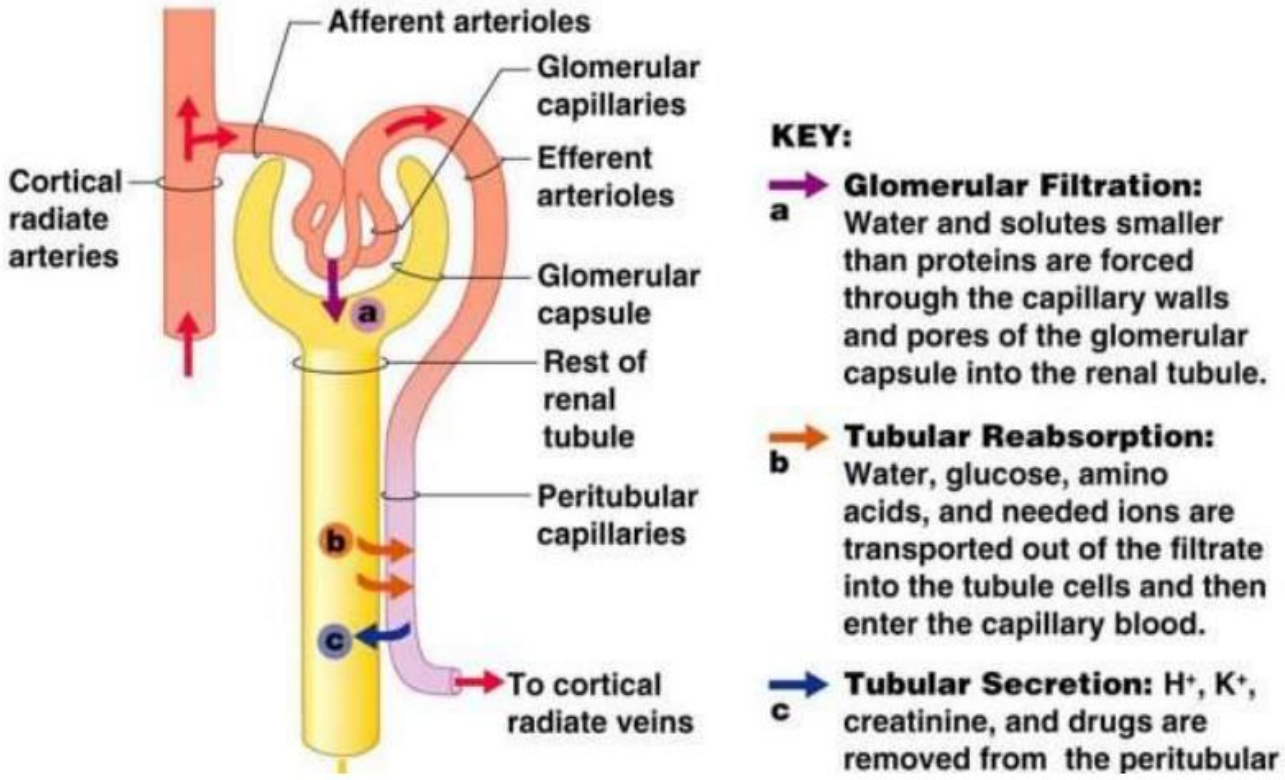


Urine formation is a blood cleansing function. Normally, about 26% of cardiac output enters the kidneys to get rid of unwanted substances. Kidneys excrete the unwanted substances in urine. Normally, about 1 to 1.5 L of urine is formed every day. The mechanism of urine formation includes three processes:

I. Glomerular filtration: is the process by which the blood that passes through glomerular capillaries is filtered through the filtration membrane. It is the first process of urine formation.

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

III. Tubular secretion: the process by which the substances are transported from blood into renal tubules. It is also called tubular excretion.



Micturition is the process whereby the urinary bladder empties when it becomes filled. This process involves two main steps.

- First, the bladder fills progressively until the tension in its walls rises above a threshold level. Collection of more than 300ml of urine in urinary bladder creates pressure on the wall.
- second This tension elicits, which is a nervous reflex called the micturition reflex that empties the bladder or, if this fails, at least causes a conscious desire to urinate.

Maintenance of acid base balance

Homeostatic Regulation of pH in Body Fluids The selective secretion of H+ (hydrogen ions) is an effective way to regulate any acidic conditions, and the secretion of HCO3 - (bicarbonate ions) is very effective for regulation of any basic or alkaline conditions that may occur. The secretion of these ions for the control of the pH of body fluids most significantly occurs in the distal convoluted tubule of the nephron, this is how the kidney contributes to the maintenance a stable pH of blood and other body fluids.

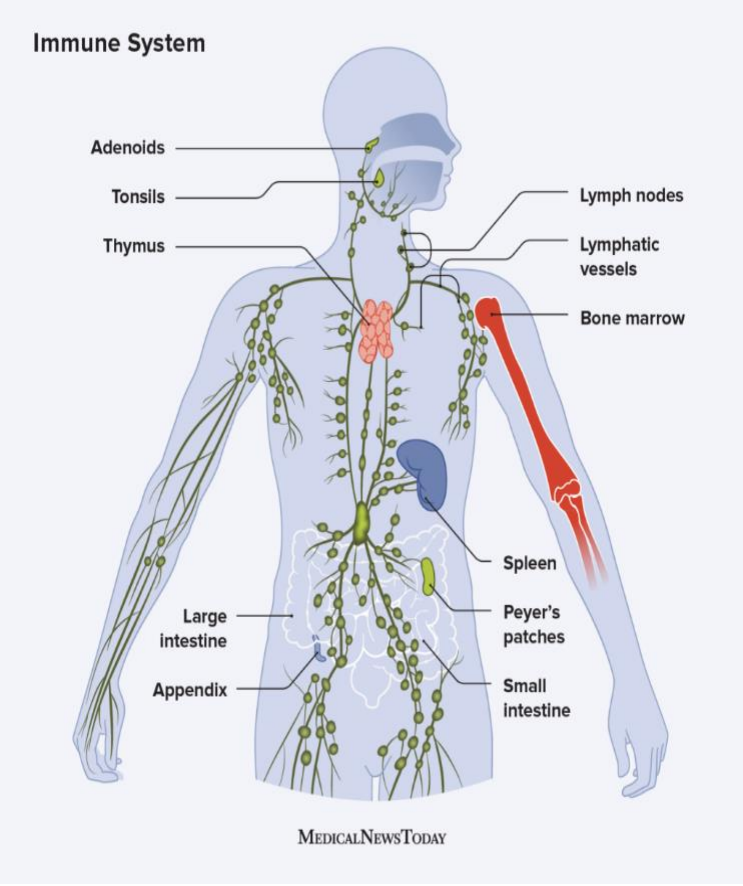
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Lecture 14&15

Dr. Rabab Ali Al-Mosawi

Introduction to Immunology

The Immune System - includes all parts of te body that help in the recognition and destruction of foreign materials. White blood cells, phagocytes and lymphocytes, bone marrow, lymph nodes, tonsils, thymus, and your spleen are all part of the immune system.



- **Immunity** refers to protection against infection.
- **The immune system** is the collection of cells, tissues and molecules
- functions to defend us against infectious microbes.
- The coordinated reaction of the immune system against infections (and other foreign substances) is known as the **immune response**.

Cells and Organs of the Immune System

Immune responses are mediated by

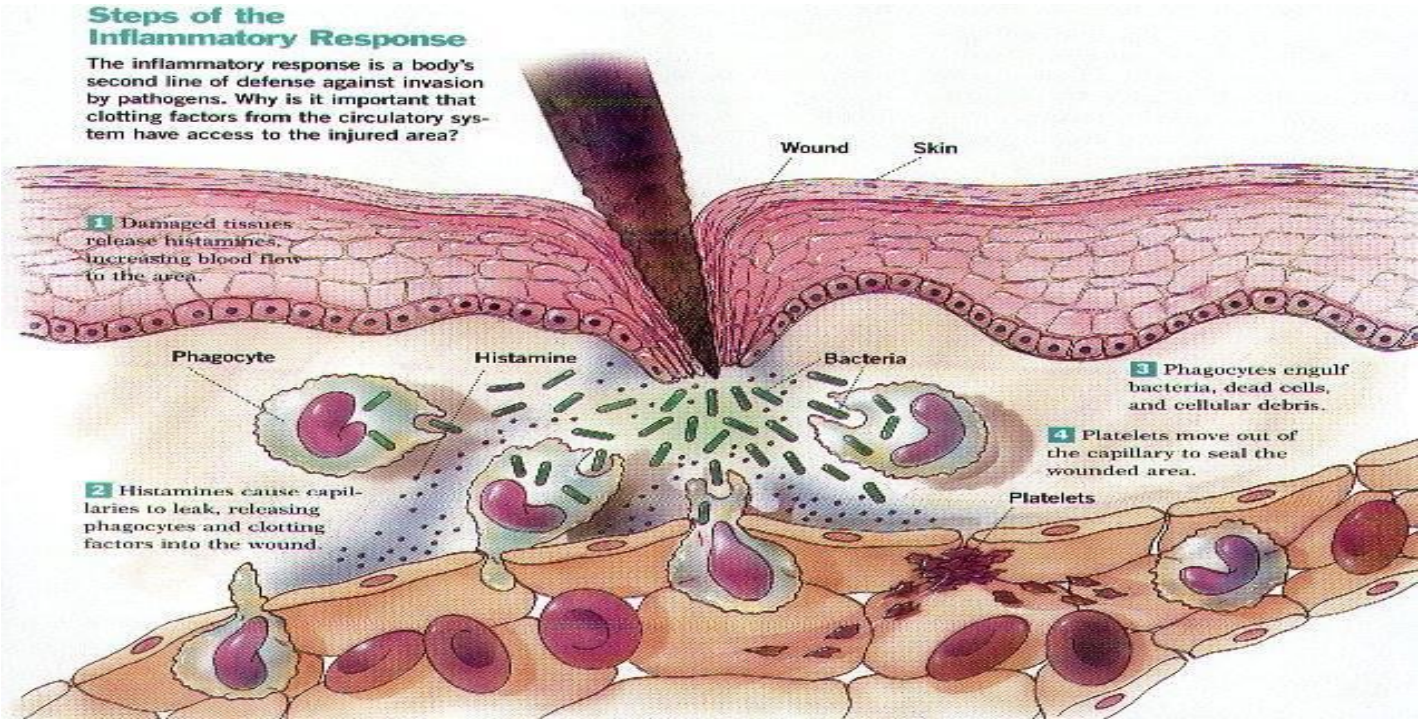
- ✓ a variety of cells and by the soluble molecules that they secrete.
- ✓ Leukocytes (WBCs) are central to all immune responses.
- ✓ Other cells in the tissues, such as macrophages and cytokines liberated by lymphocytes, also contribute to the immune response.

✓ A number of morphologically and functionally diverse organs and tissues function in the development of immune responses. These can be divided as **Primary Lymphoid Organs** and Secondary Lymphoid Organs. Primary Lymphoid Organs include (Thymus and Bone marrow) **Secondary Lymphoid Organs** include (Tonsil, Lymph node, Spleen, Peyer's patches, Appendix and Tissue lymphatic).

The immune system is typically divided into two categories **innate** and **adaptive**

Innate immunity (nonspecific immunity)

- **Innate Immune System / First-Line Defenses - The body's first line of defense against pathogens use mostly physical and chemical barriers such as**
  - Skin – acts as a barrier to invasion
  - Sweat – has chemicals which can kill different pathogens.
  - Tears - have lysozyme which has powerful digestive abilities that render antigens harmless.
  - Saliva – also has lysozyme.
  - Mucus - can trap pathogens, which are then sneezed, coughed, washed away, or destroyed by chemicals.
  - Stomach Acid – destroys pathogens
- **Second-Line Defenses - If a pathogen is able to get past the body's first line of defense,** and an infection starts, the body can rely on its second line of defense. This will result in what is called an **Inflammatory response** causes:
  - Redness - due to capillary dilation resulting in increased blood flow
  - Heat - due to capillary dilation resulting in increased blood flow
  - Swelling – due to passage of plasma from the blood stream into the damaged tissue
  - Pain – due mainly to tissue destruction and, to a lesser extent, swelling.



- Adaptive (Acquired) immunity (Specific Mechanisms of Defense)

Adaptive immunity refers to antigen-specific immune response. The adaptive immune response is more complex than the innate.

- Third-Line Defenses - Sometimes the second line of defense is still not enough and the pathogen is then heading for the body's last line of defense, the immune system.
- The immune system recognizes, attacks, destroys, and remembers each pathogen that enters the body. It does this by making specialized cells and antibodies that render the pathogens harmless.
- Unlike the first line and second line defense the immune system differentiates among pathogens.
- For each type of pathogen, the immune system produces cells that are specific for that particular pathogen.

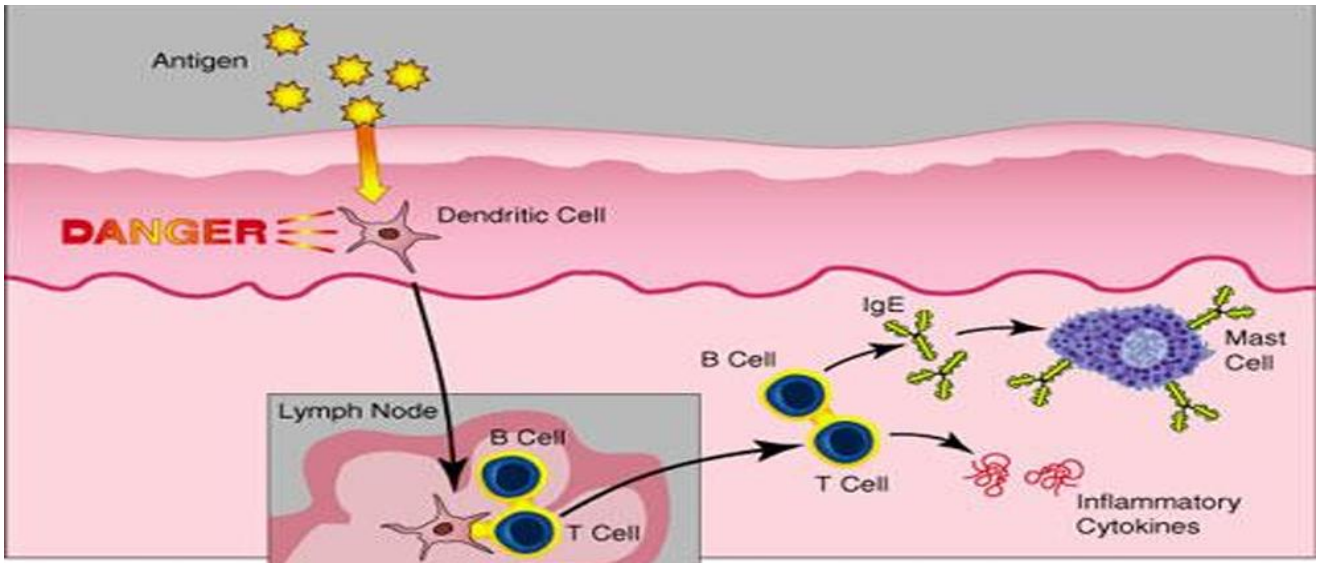
The Immune System		
Innate (nonspecific) defense mechanisms		**Adaptive (specific) defense mechanisms**
First line of defense	**Second line of defense**	**Third line of defense**
• Skin • Mucous membranes • Secretions of skin and mucous membranes	• Phagocytic cells • Natural killer cells • Antimicrobial proteins • The inflammatory response	• Lymphocytes • Antibodies • Macrophages and other antigen-presenting cells

Active Immunity or Passive Immunity

- ✓ **Active immunity** is the resistance developed by an individual, as a result of an antigenic stimulus. This involves the active functioning of a person's immune system, leading to the synthesis of antibodies and/or the production of immunologically active cells. **Active immunity** sets in only after a latent period, which is required for the immunological machinery to be set in motion.
- ✓ **passive immunity** The resistance that is transferred to a recipient in a ready-made form is known as **passive immunity**. Here, the recipient's immune system plays no active role. There is no antigenic stimulus. Instead, pre-formed antibodies are administered.

Antigen

Any substance (usually foreign) that binds specifically to an antibody, or a T cell receptor, is referred to as an 'antigen'. A substance capable of inducing a specific immune response is called an antigen.



Antigens are macromolecules that elicit an immune response in the body. The most common antigens are proteins and polysaccharides.

Antigens can enter the body from the environment. These include

- inhaled macromolecules (e.g., proteins on cat hairs that can trigger an attack of asthma in susceptible people)
- ingested macromolecules (e.g., shellfish proteins that trigger an allergic response in susceptible people)
- molecules that are introduced beneath the skin (e.g., on a splinter or in an injected vaccine)

Types of antigens. Certain types of antigens are distinctive. **Autoantigens**, for example, are a person's own self antigens. **Alloantigens** are antigens found in different members of the same species (the red blood cell antigens A and B are examples). **Heterophile antigens** are identical antigens found in the cells of different species.

Antibody

A protein (immunoglobulin) that recognizes a particular antigen and binds specifically to it is called an ‘antibody’.

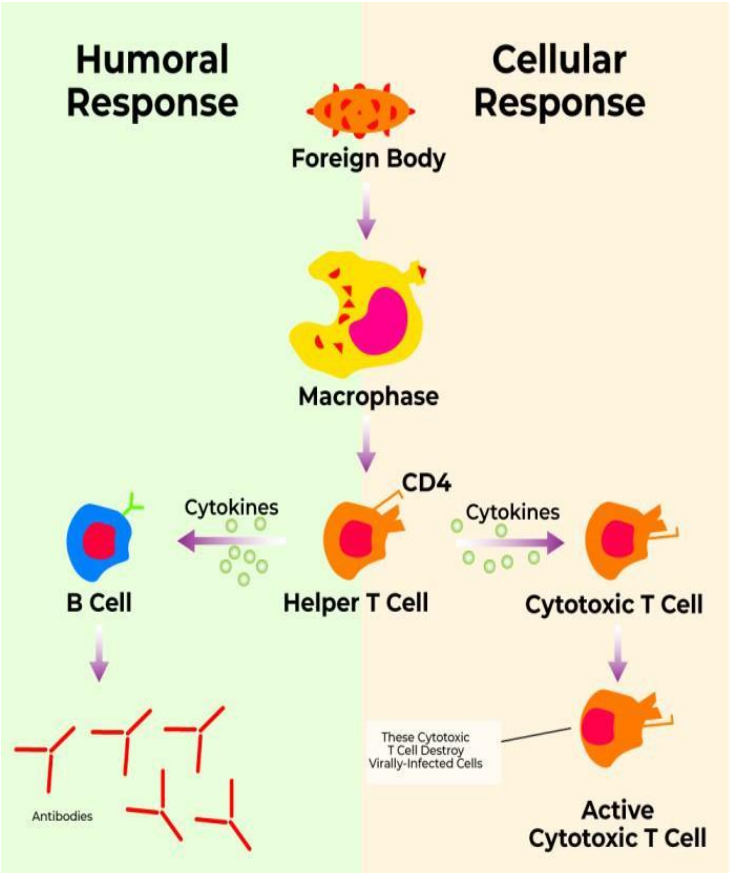
Antibodies are produced by B cells.

Classification of Antibodies (Immunoglobulins)

* Immunoglobulin M (IgM)
* Immunoglobulin G (IgG)
* Immunoglobulin A (IgA)
* Immunoglobulin D (IgD)
* Immunoglobulin E (IgE)

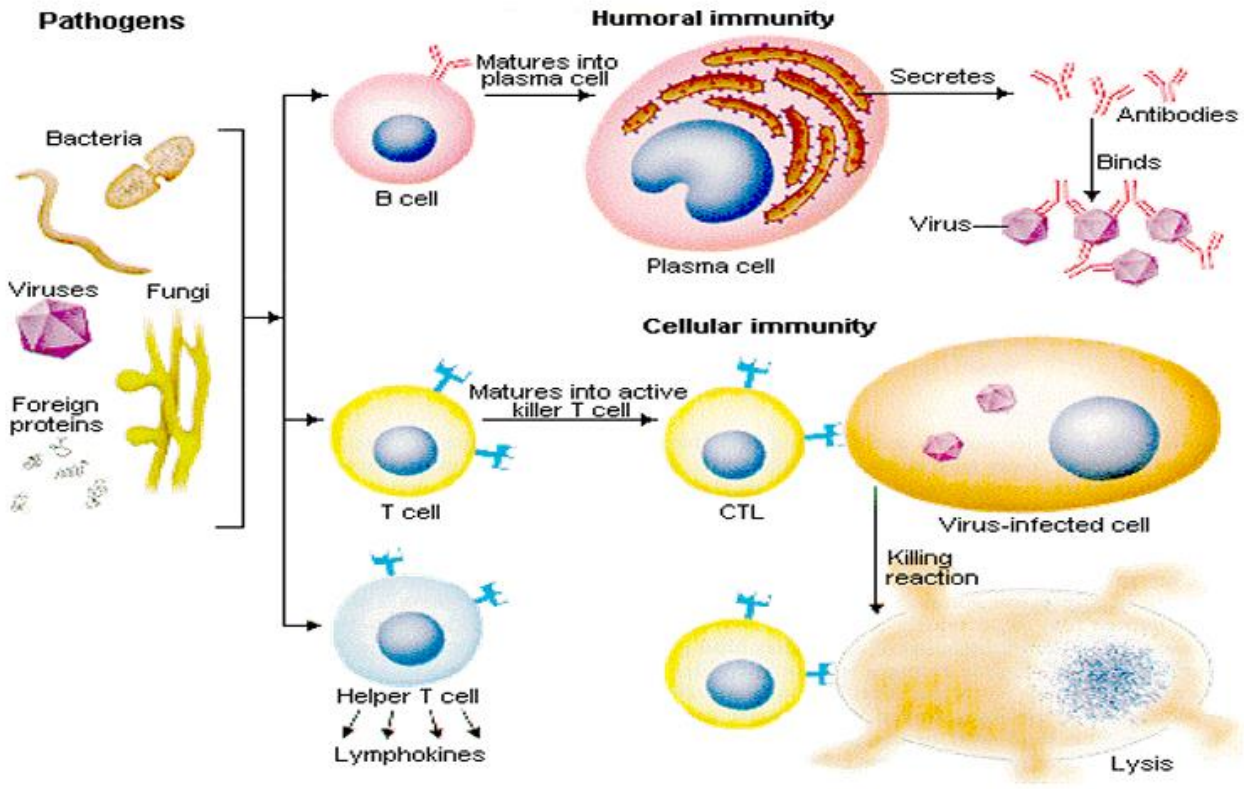
Humoral and Cellular Immunity

The immune system comprises of two parallel, but interrelated, systems: these are: **Humoral immune response** and **Cellular immune response**.



The humoral immune response, soluble proteins called antibodies (immunoglobulins) function as recognition elements and they bind specifically to antigens. Antibodies are secreted by plasma cells that are derived from B-lymphocytes (B cells).

- **The cellular immune response**, **Cytoxic T- lymphocytes** kill cells that display foreign motifs on their surfaces. The cellular immune response is mediated by specific receptors that are expressed on the surface of the T cells.
- **Helper T-lymphocytes**, contributes to both humoral and cellular immune responses by stimulating the differentiation and proliferation of appropriate B cells and T cells. The site of infection and type of pathogen largely determine which immune response will be effective.



Immunization

- Passive immunization (patient is given preformed antibodies form of immunotherapy)
- Active immunization (patient is vaccinated with a microbe or its antigens providing a form of advance protection)