Physiology

Chapter -1

BLOOD

- Blood is a bright to dark red , viscous, slightly alkaline **(** pH 7.4)
- Accounts about 8 % of the body weight .
- The total volume of blood in the healthy adult human is about 5 L.
- **Taste**: metallic.
- It is heavier than water and five times thicker.
- **Temperature**; 38ºC or 100.4º F.
- Blood rich in oxygen is bright red (arterial blood)
- The blood rich in carbon dioxide gives blood its bluish color (venous blood).

- **Blood is made up of two parts:**

1. **Formed Elements (Blood cells) which consist of :**
    - **Erythrocytes** (Red Blood Cells)
    - **Leukocytes** (White Blood Cells)
    - **Platelets** (thrombocytes)

2. Plasma , the liquid in which the blood cells are suspended .

The Function of Blood.

1. Transport ,gases , nutrients , hormones, antibodies, chemical ions ,
2. Defends against harmful Microorganisms , cells and viruses.
3. Prevent blood loss through coagulation (clotting)
4. Helps regulate body temperature
5. Regulation of pH and osmosis

When blood is removed from the body and placed in a test tube clotting occurs unless the tube is coated by an anticoagulant such as an heparin. .

Centrifugation the blood separates into two layers:

1. The lower layer that represents **44 %** of the blood volume, is red and made of **Red Blood Cells.**

2. The layer immediately above (**1%** of the blood volume **)** which is called Buffy coat and consist of **White Blood Cells** and **Platelets**

3 .The fluid (plasma)remains on top as the supernatant (55 % of the blood volume).

Plasma

It is the yellowish colored slightly alkaline —liquid part of blood in which the blood cells float in it .

- It is about **91 °/o water**.
- **2 %** composed of electrolytes, enzymes , hormones .metabolic wastes , and traces of many inorganic and organic molecules.
- **7 %** proteins **(** albumin , fibrinogen , and globulins **)**.

- Fibrinogen can removed from the plasma, the remaining fluid is called **serum**
- So Plasma ═ serum ┼ fibrinogen
- OR Serum ═ plasma ─ fibrinogen
- . Fibrinogen is necessary for blood coagulation (clotting **)** .
- The globulin functions in immune response because it consists of antibodies.

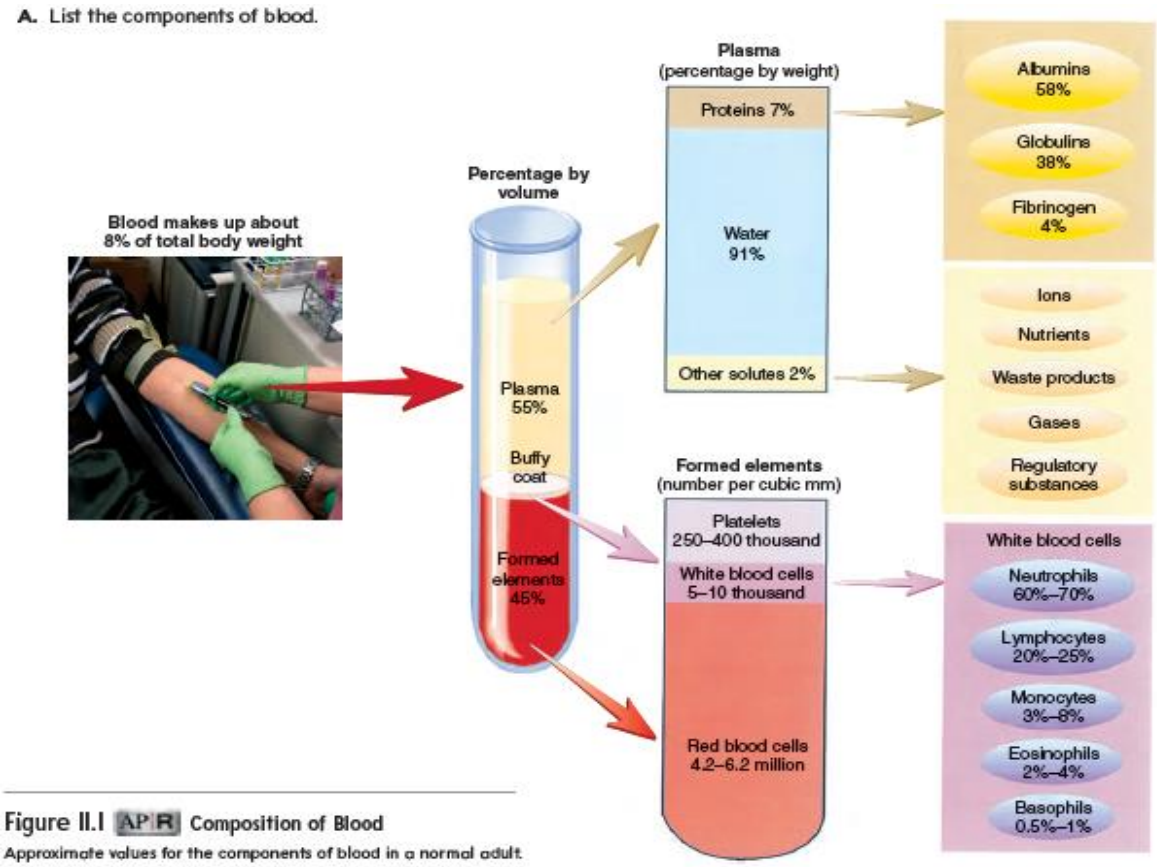


Figure II.I APR Composition of Blood

Approximate values for the components of blood in a normal adult.

Formation of blood cells

The process by which formed elements of blood develop is called **haemopoiesis**.

Red bone marrow is the primary center for haemopoiesis in the last three months of birth and throughout life.

Under normal conditions, about 2.5 million red blood cells are destroyed every second. Fortunately, new red blood cells are produced just as rapidly.
In this process all blood cells are derived from single type of stem cell in bone marrow , this stem cell is capable of producing all blood cell types.

Erythrocytes (Red blood cells….RBC)

RBC is characterize by the followings :

1. RBCs are the most abundant blood cells : The normal number of erythrocytes in blood is: **4 .2–6.2** million per micro liter

2. They are biconcave disks. The biconcave shape is maintained by a network of proteins called spectrin
The biconcave shape provides a larger surface area for gas exchange this network of protein will allow the red blood cells to change shape as they are transported through the blood vessel.

3. Without nuclei : Young red blood cells contain a nucleus; however, the nucleus is absent in a mature red blood cell which is without any organelles such as mitochondria thus increasing the oxygen carrying capacity of the red blood cell.

4. . They contain protein carrying for oxygen- called **hemoglobin**

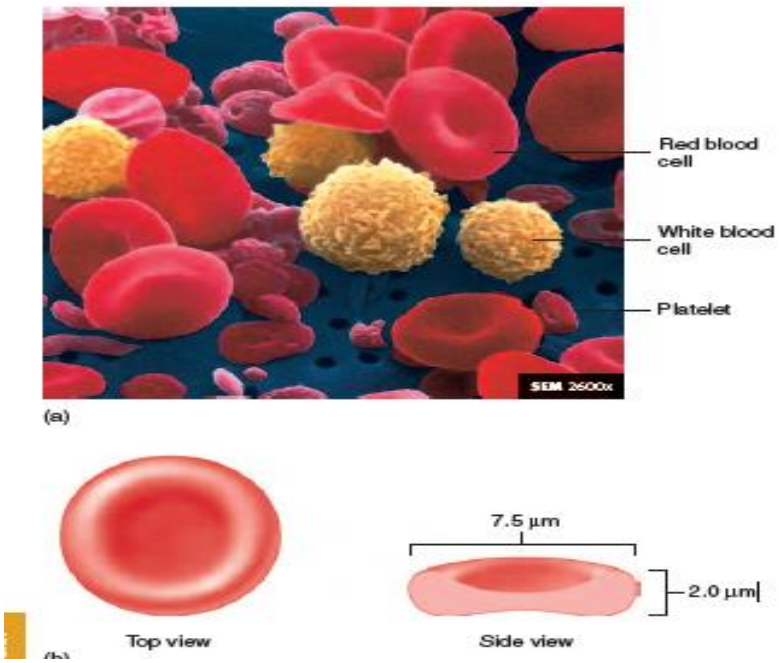


Figure 6.1 Red blood cell shape

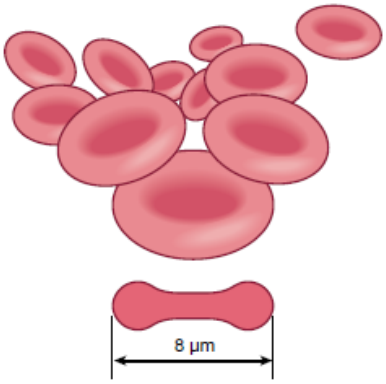
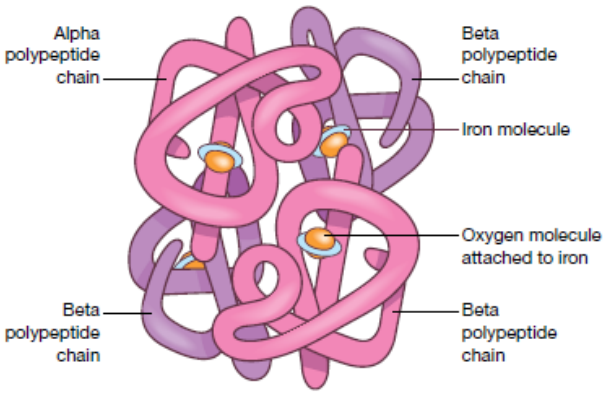


Figure 6.2 Haemoglobin molecule



Haemoglobin

1. Haemoglobin is composed of the **protein called globin** bound to the **iron containing pigments called heme**.

2. . Each globin molecule has four polypeptide chains consisting of

2 alpha and 2 beta chains (Figure 6.2). Each haemoglobin molecule has 4 atoms of iron and each atom of iron will transport 1 molecule of oxygen, therefore, 1 molecule of haemoglobin will transport 4 molecules of oxygen.

Quiz(1) :
How many haemoglobin molecules in one red blood cell?

The primary functions of RBC:
are to transport oxygen from the lungs to the various tissues of the body and to help transport carbon dioxide from the tissues to the lungs.

Hemoglobin that is bound to oxygen is bright red, ----whereas
Hemoglobin without bound oxygen is a darker red.

Hemoglobin is responsible for 98.5% of the oxygen transported in blood
The remaining 1.5% is transported dissolved in plasma.

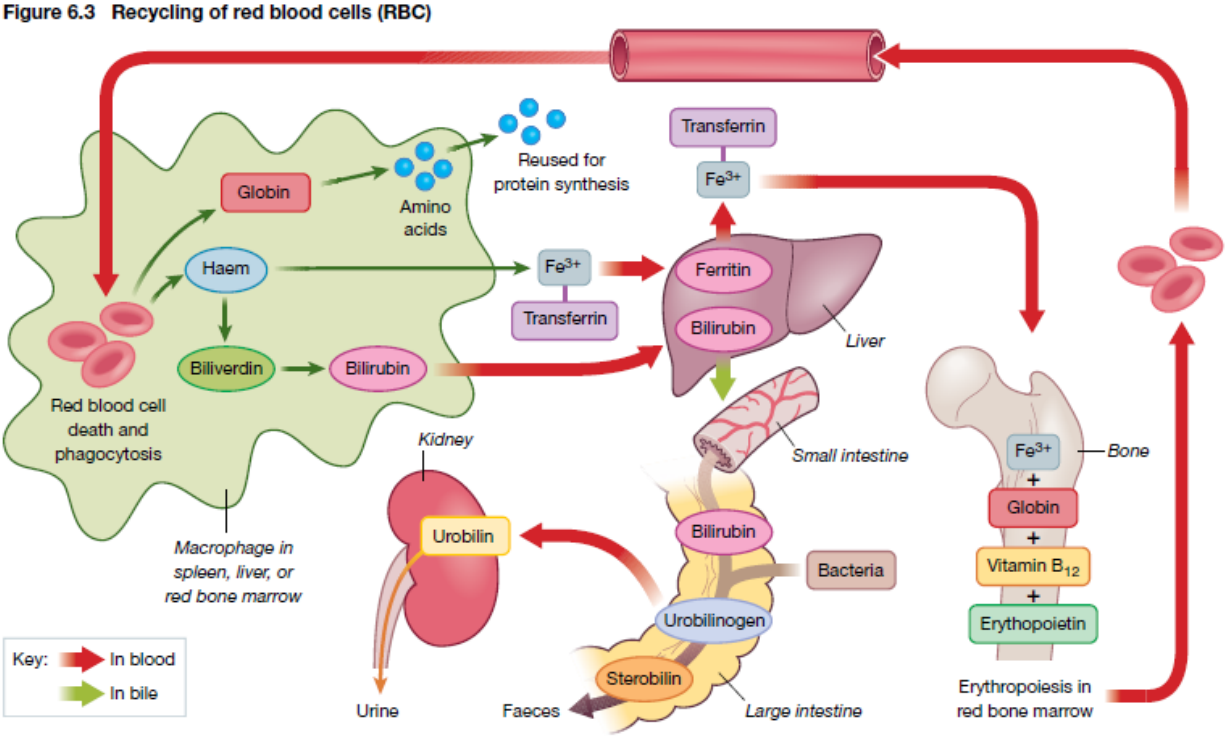
Recycling of RBC

Without a nucleus and other organelles, the red blood cell cannot synthesize new structures to replace the ones that are damaged and therefore their life span is approximately about 120 days.

The breakdown (haemolysis) of the red blood cell is carried out by macrophages in the spleen, liver and the bone marrow (Figure 6.3).

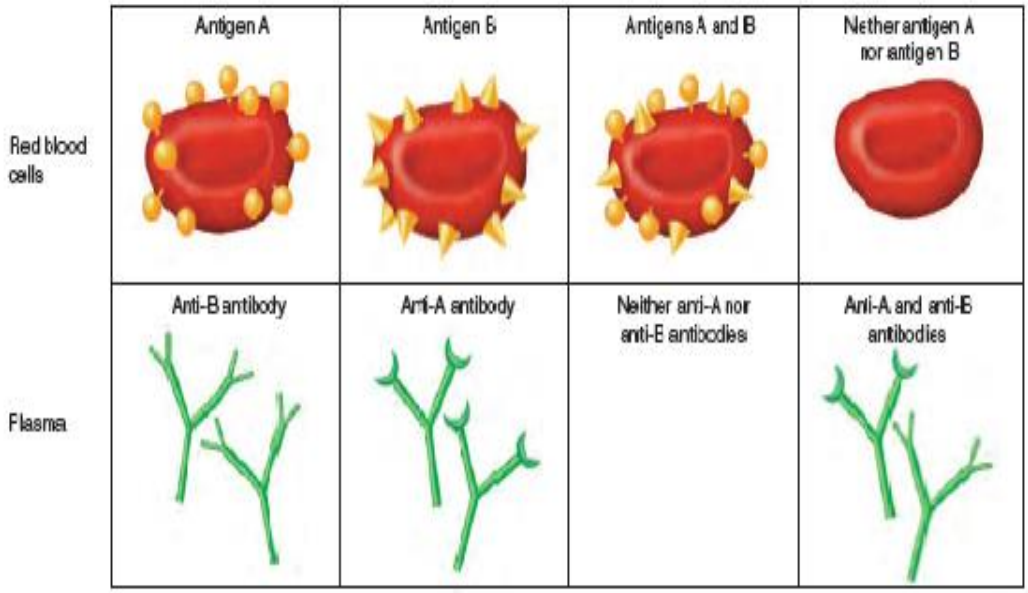
The globin is broken down and reused for protein synthesis. Iron is removed and stored in the muscles and the liver and reused to manufacture new red blood cells.

Figure 6.3 Recycling of red blood cells (RBC)



ABO Blood Group

The extracellular surfaces of red blood cells have molecules called **antigens** and the plasma have proteins called **antibodies.**



Type A
Red blood cells with type A surface antigens and plasma with anti-B antibodies

Type B
Red blood cells with type B surface antigens and plasma with anti-A antibodies

Type AB
Red blood cells with both type A and type B surface antigens and neither anti-A nor anti-B plasma antibodies

Type O
Red blood cells with neither type A nor type B surface antigens but both anti-A and anti-B plasma antibodies

The **ABO blood group** system is used to categorize human blood.

In this blood group system, there are two types of antigens (A&B) that may appear on the surface of the red blood cells :

1. Type A blood ------- has type A antigens
2. Type B blood--------- has type B antigens
3.Type AB blood--------- has both types of antigens.
4.Type O blood ----------has neither A nor B antigens .

Antibodies against the antigens are usually present in the plasma of blood.

Plasma from -- type A blood contains-- -anti-B antibodies
Plasma from ---type B blood contains ---anti-A antibodies,.
Plasma from --type AB blood plasma ---has neither type of antibody
Plasma from --type O blood plasma -----has both anti-A and anti-B antibodies

ABO Blood Group System

Blood group	Antigens present	Antibody present	blood that can be received
A	Antigen A	Anti- B	A,O
B	Antigen B	Anti-A	B,O
AB	Both antigen A and B	None	A,B.AB,O, **universal recipient**
O	Neither antigen A or B	Anti-A , Anti- B	O **universal donor**

- **Type AB Blood: is the universal recipient.**
- **Type O Blood: is the universal donor.**

An important blood group is Rh groups. Three of the Rh antigens (C, D, and E) are so common in the human .when the R.B.C have one of these antigens on their surface they are said to be Rh+

Leukocytes (WBC)

The number of leukocytes **(** White Blood Cells **)** is much smaller than that of red blood cells ; in a normal adult there are only between 4,000- 11,000 White Blood Cells per mm of blood.
Leukocytes are nucleated cells and are classified into two groups :

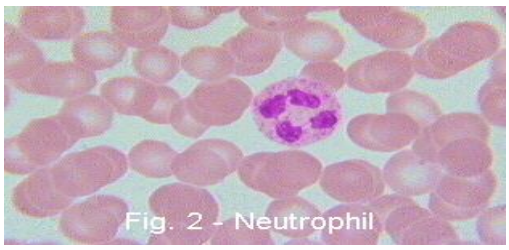
1- Granulocytes , which have specific granules . and non specific granules in their cytoplasm .
There are three types of granulocytes :**(** Neutrophils, Eosinophils , and Basophils **)**

2- **Agranulocytes** , they do not have specific granules .
There are two types of agranulocytes (Lymphocytes and Monocytes) .

- # Granulocytes

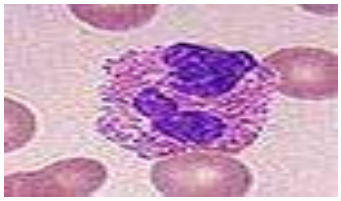
Neutrophils (poly morphonuclear leukocytes)

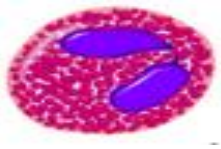
They comprising 40 % - 70% of the total WBC . Neutrophils constitute a defense against invasion of microorganisms by active vagocytosis



Eosinophils

They constituting only 1-4 % of the WBC in normal blood.
The cells increase in number during parasitic infection and allergic reaction.





Basophils

Basophils make up less than 1% of blood leukocytes..The function of basophils is similar to that of **Mast cell.** Their granules contain **histamine** and **heparin** .

- **Agranulocytes**

Monocytes :

- **Monocytes** constitute 3 %- 8 % of the blood leukocytes.
- Monocytes can live in the blood for 2 to 3 days , after which they move into the connective tissue , where they may remain for a few months or longer .
- In connective tissue, Monocytes change to **macrophages** which destroy bacteria, foreign bodies and dead cells .

Monocytes **macrophages**

Lymphocytes :

- They make up 20 – 25 % of white blood cells .
  Lymphocytes can be subdivided into
- **,** **B-lymphocytes (B-cell) ,**
  , **T –lymphocytes (T- cells)**
  ,
- Lymphocytes have a central role in the immunological defense of the body.
- B-lymphocytes when stimulated by specific antigen, change to into plasma cells and produce antibodies.

Platelets (Thrombocytes)

- Platelets are the smallest formed elements in the blood .
- They have no nucleus .

- Platelets are produced when small portions of cytoplasm separate from the Megakaryocytes.
- The main function of platelets is to promote blood clotting

Plasma Proteins

Plasma proteins are any of the proteins found in blood plasma,

Plasma protein composes three major groups of proteins--albumin, fibrinogen and globulins; each of them has separate functions

Functions of the plasma proteins include :

Protein type	*Primary function/s*
Total	
Albumin	• contributes to the osmotic pressure of blood, which acts to keep water in the blood stream . • reduces fluid leakage out of capillaries& maintaining fluid and electrolyte balance. • Transport of insoluble substances (like cupper ,iron ----) around the body by binding to protein molecules
Globulin	immunity [antibodies] Protection from infection
Fibrinogen	Promote blood clotting

Anemia

What is anemia?

Anemia is a medical condition in which the **red blood cell count or hemoglobin** is less than normal.

Men: anemia is defined as hemoglobin level of less than 13g /100ml

Women : hemoglobin of less than 12 g /100ml.

What causes anemia?

The three main classes of anemia include

1. Excessive blood loss (hemorrhage) : loss of red blood cell due to trauma, ulcers, or excessive bleeding
2. Excessive blood cell destruction (hemolysis)
3. Deficient red blood cell production (ineffective hematopoiesis).

Quiz 2

What are the differences between **transfusion** and **infusion ?**.

Chapter -2

Cardiovascular System

Physiology of The Heart

- **In the embryo, the heart begins to beat at 4 weeks of age, even before its nerve supply has been established**.

- **The primary function** of the heart is to pump blood through the arteries, capillaries, and veins.

Conduction system of the heart

Intrinsic conduction system or nodal system is composed of the following:

a. **Sino-atrial node (SA)** located in the right atrium. It's called the pacemaker, **because it has the highest rate of depolarization and the impulses spreads from SA node to other parts of nodal system**

b. **Atrio-ventricular (AV)** node located at the junction of the atria and ventricles.

c. **Atrio-ventricular bundle (AV)**: (bundle of His) located in the interventricular septum.

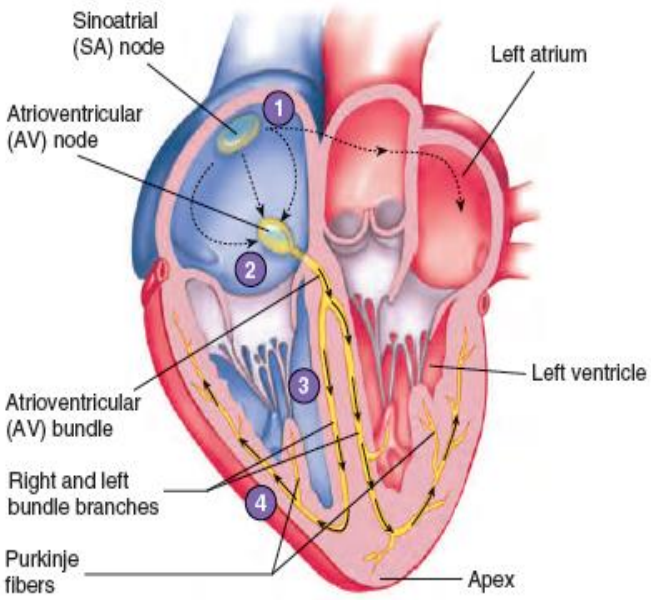
d. **Purkinje fibers**: which spread within the muscle of the ventricle walls.

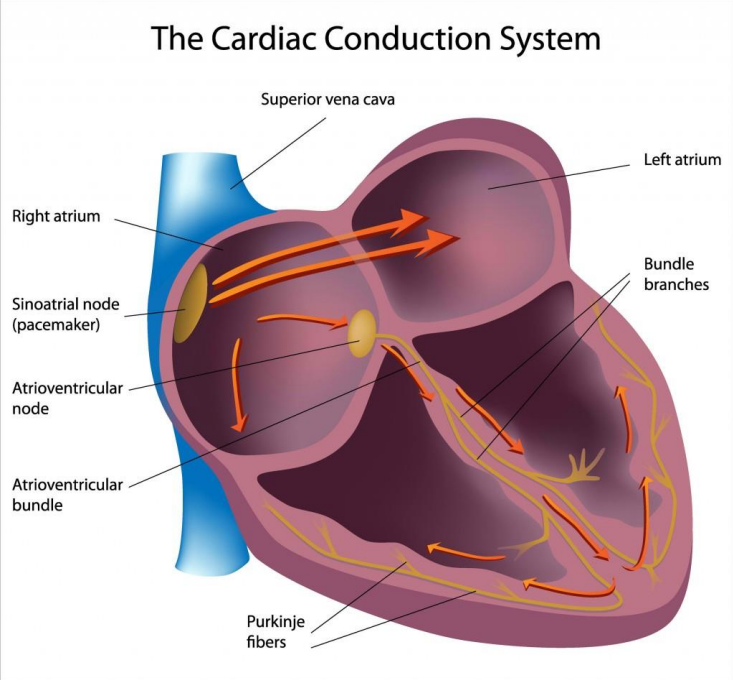
1. Action potentials originate in the sinoatrial (SA) node and travel across the wall of the atrium (*arrows*) from the SA node to the atrioventricular (AV) node.

2. Action potentials pass through the AV node and along the atrioventricular (AV) bundle, which extends from the AV node, through the fibrous skeleton, into the interventricular septum.

3. The AV bundle divides into right and left bundle branches, and action potentials descend to the apex of each ventricle along the bundle branches.

4. Action potentials are carried by the Purkinje fibers from the bundle branches to the ventricular walls.





Notes

- The natural pacemaker of the heart is the **sinoatrial (SA) node**, a specialized group of cardiac muscle cells located in the wall of the right atrium just below the opening of the superior vena cava. The SA node is considered specialized because it has the most rapid rate of contraction, that is, it depolarizes more rapidly than any other part of the myocardium (60 to 80 times per minute).

- The SA node produces action potentials at a faster rate than other areas of the heart and has a larger number of Ca2+ channels than other cells in the heart.

- In addition, the Na+ and Ca2+ channels in the SA node spontaneously open and close at a rhythmic rate

- The natural SA node is the pacemaker of the heart, but other cells of the conduction system are also capable of producing action potentials spontaneously. For example, if the SA node is unable to function, another area, such as the AV node, becomes the pacemaker. The resulting heart rate is much slower than normal. When action potentials originate in an area of the heart other than the SA node, the result is called an **ectopic beat.**

- When action potentials reach the AV node, they spread slowly through it**.** The slow rate of action potential conduction in the AV node allows the atria to complete their contraction before action potentials are delivered to the ventricles.

Electrocardiogram ECG

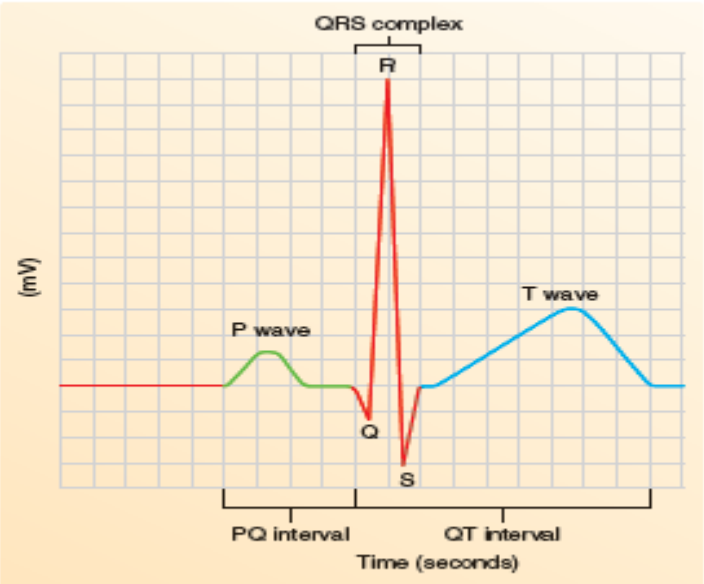


Figure 12.16 Electrocardiogram

Action potentials conducted through the heart during the cardiac cycle produce electrical currents that can be measured at the surface of the body.

Electrodes placed on the body surface and attached to a recording device can detect the small electrical changes resulting from the action potentials in all of the cardiac muscle cells. The record of these electrical events is an **electrocardiogram ECG**)

The normal ECG consists of a **P wave**, a **QRS complex**, and a **T wave**.

- The **P wave** results from depolarization of the atrial myocardium, and the beginning of the P wave precedes the onset of atrial contraction.
- The **QRS complex** consists of three individual waves: the Q, R, and S waves. The QRS complex results from depolarization of the ventricles, and the beginning of the QRS complex precedes ventricular contraction.
- The **T wave** represents repolarization of the ventricles, and the beginning of the T wave precedes ventricular relaxation.
- A wave representing repolarization of the atria cannot be seen because it occurs during the QRS complex.
- The time between the beginning of the P wave and the beginning of the QRS complex is the **PQ interval,** commonly called interval, the atria contract and begin to relax.
-
- At the end of the PQ interval, the ventricles begin to depolarize.
- The **QT interval** extends from the beginning of the QRS complex to the end of the T wave and represents the length of time required for ventricular depolarization and repolarization

Regulation of the Heart

1. Nervous regulation: *(*Baroreceptor Reflex)

Nervous system regulation of the heart originates in the **cardioregulatory center** in the medulla oblongata **,** which receives action potentials from the baroreceptors.

Baroreceptors *(baro :* pressure) : are stretch receptors that monitor blood pressure in the aorta and in the wall of the internal carotid arteries, which carry blood to the brain.

Nervous influences of heart activity are carried through the autonomic nervous system. Both sympathetic and parasympathetic nerve fibers innervate the heart and have a major effect on the SA node.
- Stimulation by **sympathetic nerve** fibers causes **increase** heart rate
- Stimulation by **parasympathetic** nerve causes **decrease** heart rate.

Changes in blood pressure result in changes of action potentials produced by the baroreceptors.
The action potentials are transmitted along nerve fibers from baroreceptors to the medulla oblongata .
.

- **When the blood pressure increases**
  More stimulation of the baroreceptors occurs -------action potentials are sent along the nerve fibers to the cardioregulatory center -----**increase parasympathetic** stimulation of the heart.--------- ------ as a result, the heart rate and stroke volume decrease, causing blood pressure to decline.

- **When the blood pressure decreases**,
  less stimulation of the baroreceptors occurs------ lower frequency of action potentials is sent to the cardioregulatory center ------ which responds by **increasing sympathetic** stimulation of the heart . Consequently, the--------- heart rate and stroke volume increase, causing blood pressure to increase.

- **If the decrease in blood pressure is large** ----- increases sympathetic stimulation of the adrenal gland--------- epinephrine and norepinephrine secretion increase ---------- the heart rate and stroke volume increase---, lead to increase blood pressure toward its normal value .

1. Sensory neurons (*green*) carry action potentials from baroreceptors to the cardioregulatory center. Chemoreceptors in the medulla oblongata influence the cardioregulatory center.

2. The cardioregulatory center controls the frequency of action potentials in the parasympathetic neurons (*red*) extending to the heart. The parasympathetic neurons decrease the heart rate.

3. The cardioregulatory center controls the frequency of action potentials in the sympathetic neurons (*blue*) extending to the heart. The sympathetic neurons increase the heart rate and the stroke volume.

4. The cardioregulatory center influences the frequency of action potentials in the sympathetic neurons (*blue*) extending to the adrenal medulla. The sympathetic neurons increase the secretion of epinephrine and some norepinephrine into the general circulation. Epinephrine and norepinephrine increase the heart rate and stroke volume.

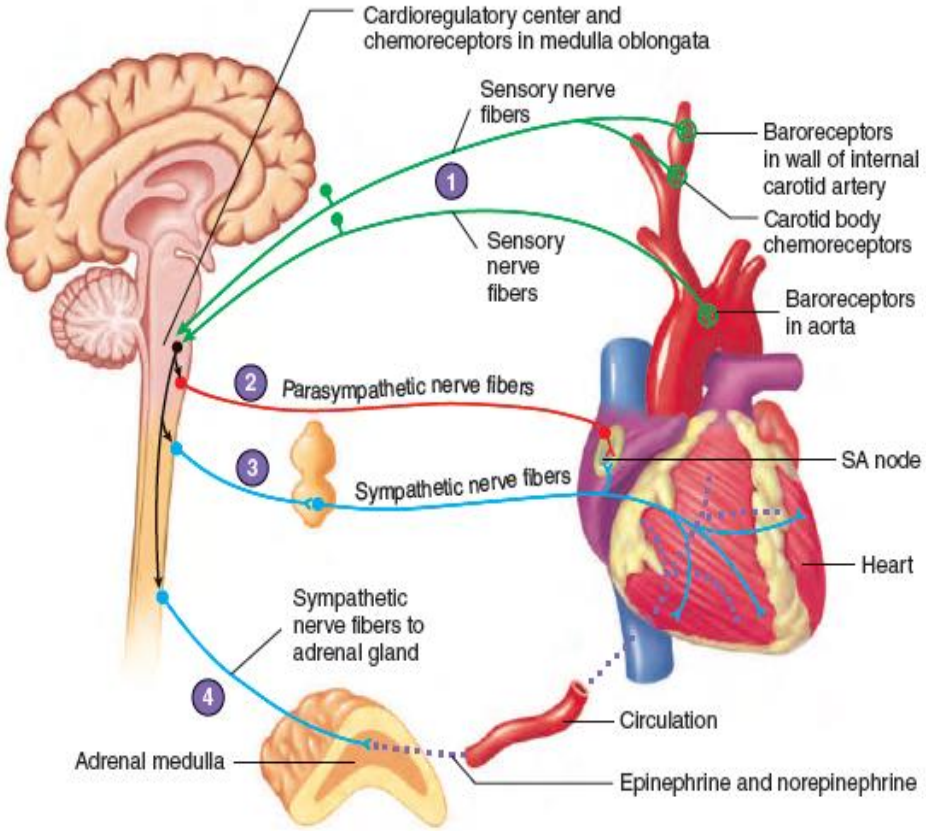
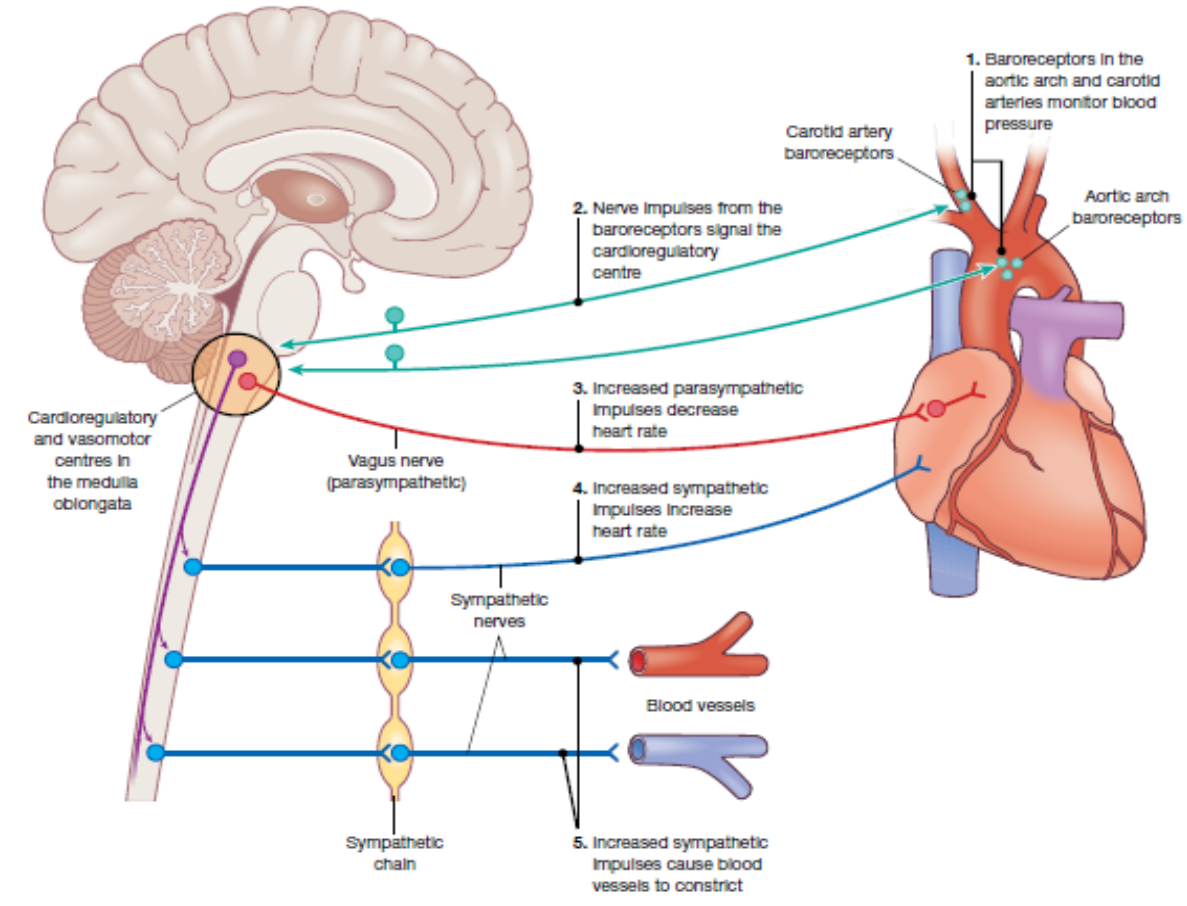


Figure 18.1 Cardioregulatory centre



2. Chemical regulation of the heart : (Chemoreceptor Reflex)

Certain chemicals influence the heart rate. **Hypoxia**, **acidosis** and **alkalosis**-- -------- all depress cardiac activity.

a. Hormones

- **Epinephrine and norepinephrine** from the adrenal gland in response to exercise, emotional excitement, or stress increase the heart rate and contractility.

- **Thyroid hormones** from the thyroid gland also increase the heart rate and contractility. These hormones affect cardiac muscle fibers in much the same way as norepinephrine by the sympathetic nervous system; they increase both heart rate and contractility.

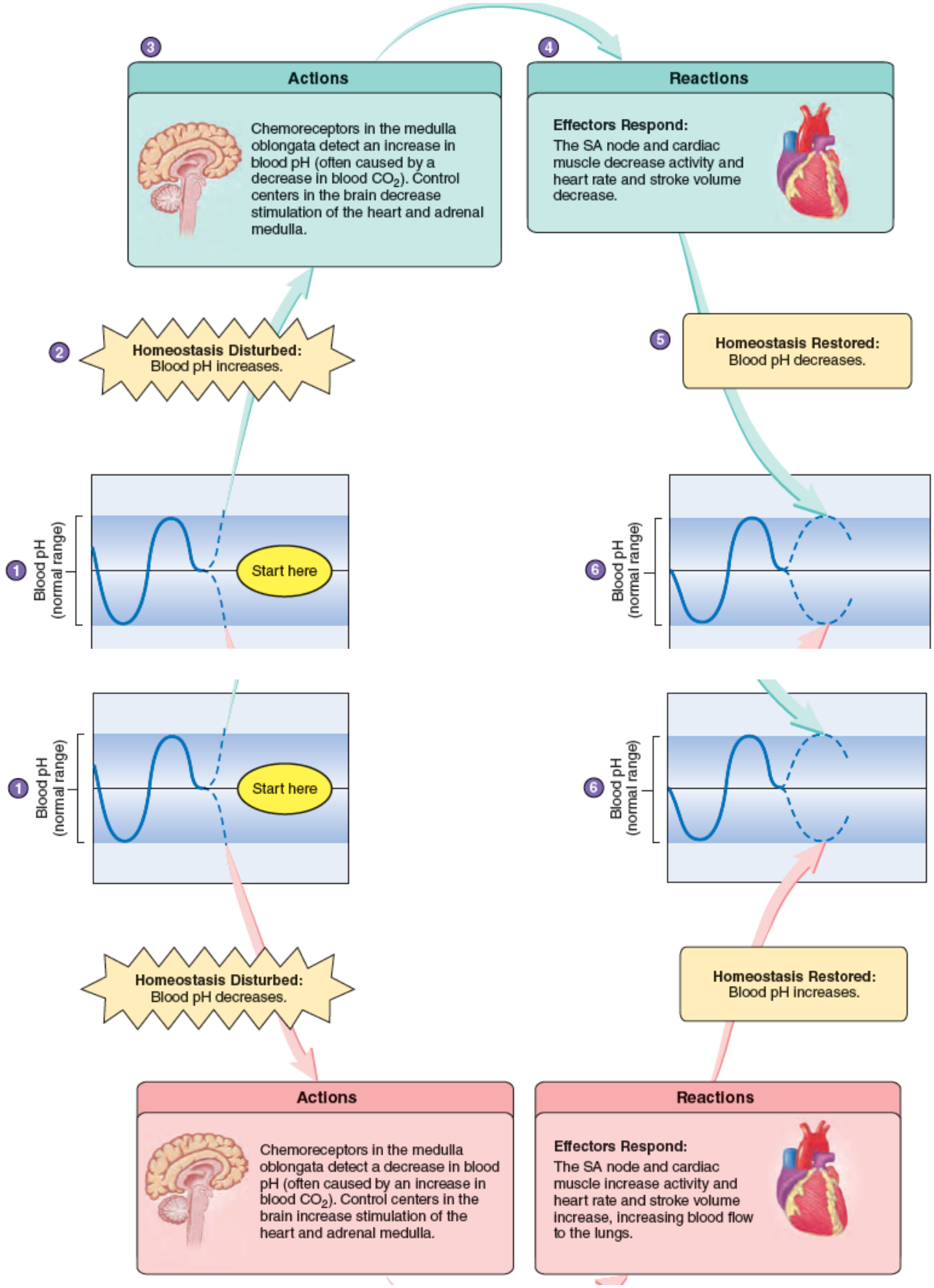
b. Ions

The difference in the levels of cations between the intracellular and extracellular fluid are important for the production of action potentials in all nerve and muscle fibers. For example,

The concentration of K^+ or Na^+ and Ca^{2+} have a large effect on cardiac function.

- An elevated level of K^+ or Na^+ ----- **decrease** the heart rate and contractility.
- An increase level of Ca^{2+} ---------- **increases** the heart rate and contractility.
- **Reduced** level of Ca^{2+} decrease heart rate and stroke volume

C. The medulla oblongata of the brain also contains chemoreceptors that are sensitive to changes in pH and CO_2 levels.
A decrease in pH, often caused by an increase in CO_2, results in sympathetic stimulation of the heart .


3
Actions
Chemoreceptors in the medulla oblongata detect an increase in blood pH (often caused by a decrease in blood CO_2). Control centers in the brain decrease stimulation of the heart and adrenal medulla.
4
Reactions
Effectors Respond:
The SA node and cardiac muscle decrease activity and heart rate and stroke volume decrease.
2
Homeostasis Disturbed:
Blood pH increases.
5
Homeostasis Restored:
Blood pH decreases.
1
Blood pH (normal range)
Start here
6
Blood pH (normal range)
1
Blood pH (normal range)
Start here
6
Blood pH (normal range)
Homeostasis Disturbed:
Blood pH decreases.
Homeostasis Restored:
Blood pH increases.
Actions
Chemoreceptors in the medulla oblongata detect a decrease in blood pH (often caused by an increase in blood CO_2). Control centers in the brain increase stimulation of the heart and adrenal medulla.
Reactions
Effectors Respond:
The SA node and cardiac muscle increase activity and heart rate and stroke volume increase, increasing blood flow to the lungs.

Heart rate :

A healthy adult has a resting heart rate (**pulse**) of **60 to 80 beats per minute**, which is the rate of depolarization of the SA node.

A rate **less** than **60 beats \ minute** is called **bradycardia**;
A prolonged or consistent rate **more than** 100 beats \ minute is called **tachycardia**.

Stroke volume : is the amount of blood pumped by a ventricle in **one beat** .

an average resting stroke volume is 60 to 80 mL per beat.

Cardiac output :is the amount of blood pumped by a ventricle **in 1 minute**.

A simple formula then enables us to determine cardiac output:

Cardiac output = stroke volume X pulse (heart rate)

Let us put into this formula :

average stroke volume, 70 mL,
average pulse 70 beats per minute (b\ m):

Cardiac output = 70 mL X 70 (b\ m)

Cardiac output = 4900 mL per minute …..(approximately 5 liters)

Answer of Quiz 1(last lecture)

There are approximately 250 million haemoglobin molecules in one red blood cell and therefore one red blood cell will transport 1 billion molecules of oxygen.

Answer of Quiz 2

A transfusion : is the transfer of blood or blood components from one individual to another.

An infusion is the introduction of a fluid other than blood, such as a saline or glucose solution, into the blood

Chapter -3

Digestive system

Gastrointestinal Tract (GIT).

Salivary glands:

3- pairs of salivary glands empty their secretions into the mouth:

1. The parotid glands (large glands lies anterior to the ear)
2. The submandibular gland
3. Small sublingual gland

The function of salivary glands is to secrete saliva into the floor of the mouth.
1.0 - 1.5 liters of saliva secreted per day :

a. 25% by parotid glands,
b. 5% by sublingual glands, and
c. 70% by submandibular glands

Composition and Functions of Saliva

- Water 99.4%.
- Electrolytes (Na+,Cl-, Hco3-) to regulate osmotic pressure.
- Buffers keep pH near (7.0).
- Glycoprotein.
- Antibody (IgA) and lysozyme . 0.6%
- Enzyme –amylase (ptyalin) to digest carbohydrates.
- Waste product like urea.

Function of saliva

1. Contain bacteriocidal agents
2. Facilitate swallowing
3. Aid speech by facilitating movement of the lips and tongue
4. The PH of the saliva ranges between 6-7 which help to neutralize gastric acid and relieve heartburn when there is regurgitation from the stomach to esophagus.

Deficient salivation is called xerostomia(and those are more liable for dental caries ulceration and infection of the gums and oral cavity than normal people.

Histological Structure of the Stomach

Gastric glands: found in the fundus and body of stomach and composed from the following cells:

a. Mucous cells. Produce alkaline mucous, which protects the stomach wall itself from being damaged by the acid.

b. Parietal cells. Produce Hcl – hydrochloric acid, which makes the stomach content acidic .

c. Chief cells. Produce enzymes, mostly pipsonogen.

d. G-cells . Produce Gastrin hormone .

e. D-cells. Secrete Somatostatin.

SMALL INTESTINE

Digestive Hormones that secreted from small intestine and Their Functions

Hormone Origin Effect(function)

Cholecystokinin (CCK)	Duodenum	contraction of gallbladder
Gastric inhibitory peptide (GIP)	Duodenum	Stimulate release of insulin
Gastrin	Stomach.	Stimulate production of acid and enzyme
Secretin	Duodenum	.increase bile secretion

LARGE INTESTINE

Functions of Large Intestine

1. Absorptions of less than 10% of the nutrients in large intestine.
2. Large intestine prepares fecal material for ejection from the body.
3. Reabsorption of water and other substances such as, bile salts, vitamins, urobilinogen, toxins of bacteria.
4. Bacteria in the colon produce 3 vitamins .

a. Vitamin K. b. Biotin. c. Vitamin B5.

LIVER

Functions of the liver:

1. Formation and secreted of bile.--
2. Nutrients and vitamins metabolism.--
3. Inactivated some substances(toxins, steroid, and other hormones)--
4. Synthesis of plasma proteins.--
5. Contributes with immunity.--

• Produces bile that leaves the liver through the common hepatic duct and enters the duodenum through the common bile duct.

• **Bile** is a yellow-to-green watery solution containing bile salts, bile pigments, cholesterol, phospholipids and a variety of electrolytes.

• Bile Functions : Bile secretion contain bile salts and phospholipids which break the fat globules , in the process called "Emulsification"

. The gall bladder is a small sac

Function : storage of bile

PANCREAS

. Exocrine tissue (pancreatic acini):

1. Secrete pancreatic digestive enzymes.
2. The pancreatic enzymes secreted into the duodenum are an alkaline fluid (pH 8), which neutralizes the acidic chyme coming from the stomach.
3. The acini glands of the exocrine pancreas produce 1 – 1.5 L of pancreatic juice daily.

Pancreatic juice consists of the following enzymes :

1. Amylase: which digest carbohydrates;
2. Lipase: which digest of fat;
3. Trypsin, chymotrypsin, which digest protein

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Chapter -4

Nervous System

The nervous system

The Nervous System controls and coordinates all the functions of the body
It is the major controlling and communicating system of the body.

- The Nervous System consists of two main sub-divisions:
  - Central Nervous System (CNS): consist of **brain** and **spinal cord**
  - Peripheral Nervous System (PNS)

- The **Peripheral Nervous System** -- is the nerves outside the brain and spinal cord divided into two sub-divisions:
  - Somatic - voluntary (sensory and motor)
  - Autonomic - involuntary (sympathetic and parasympathetic)

Somatic ------ convey messages from the sense organs to the CNS
and from the CNS to the muscles and glands

Autonomic -----a set of neurons that control the heart, the intestines, and other organs

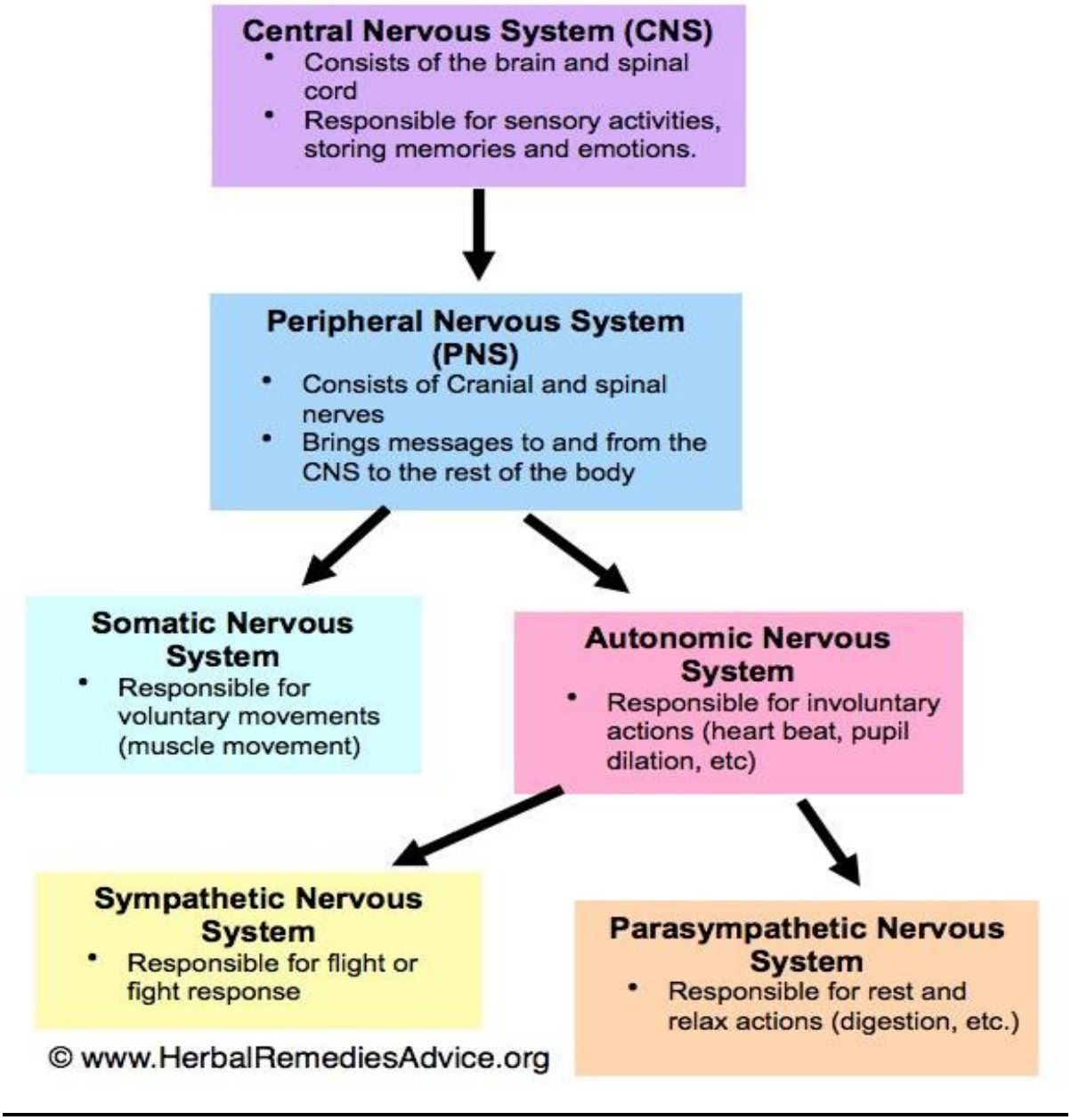
- **Type of neurons :**

1. **Sensory neurons (afferent)**: send information from sensory receptors (e.g., in skin, eyes, nose, tongue, ears) TOWARD the central nervous system

2. **Motor neurons (efferent)**: carries impulses from the CNS to organs, muscles and glands.

3. ·**Interneurons:** send information BETWEEN sensory neurons and motor neurons.

Most interneurons are located in the central nervous system

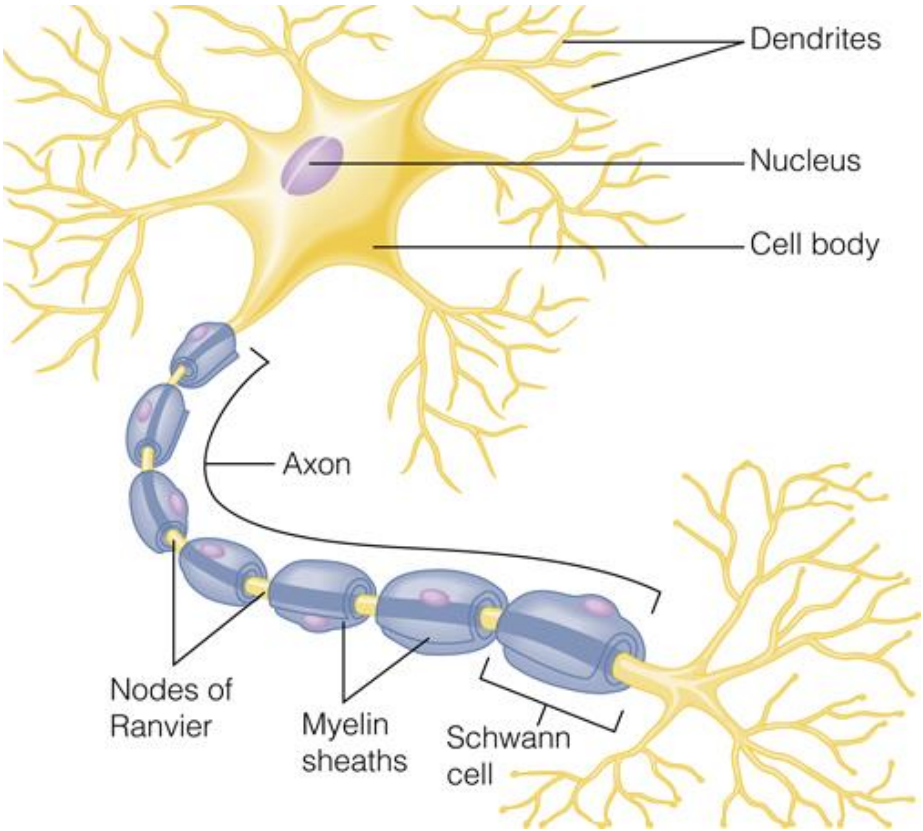


Neurons : Also it called nerve cells.

Anatomical structures:

- **Cell body**: which contains the nucleus and is the metabolic center of the cell.
- **Dendrites**: highly branched processes that conduct electrical currents towards the cell body (receive input from many other neurons).
- **Axon**: a long process extending out from the neuron cell body. It conducts impulses away from the cell body to other cells.
- **Myelin**: It is a wax like membrane that covers the longest nerve fibers. Myelin protects and insulates the fibers and increases the transmission rate of nerve impulses.
- **Schwann cells**: Specialized supporting cells that wrap tightly around the axon .

- **Myelin sheath**: encloses the axon
- **Synaptic vesicle:** secreted **acetylcholine.**
- **Neurotransmitter**: It is a chemical substance secreted by axon terminals into the extra cellular space when the impulses reach the axon terminals.



Brain ventricles:

It is a system of four communicating cavities within the brain and continuous with the central canal of the spinal cord.

The four ventricles consist of the **a. two lateral ventricles**,

b. Third ventricle

c. Fourth ventricle:

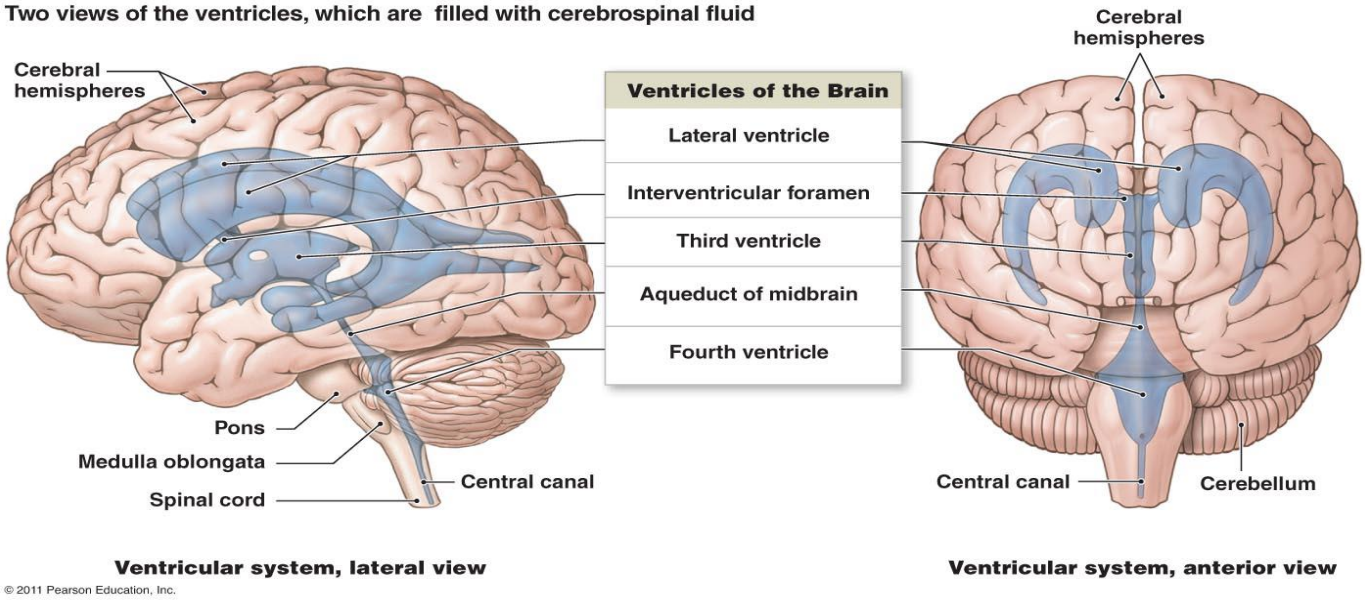
- **Lateral ventricles** The lateral ventricles are two cavities located within the cerebrum. The lateral ventricles communicate with the third ventricle through the interventricular foramen (opening).

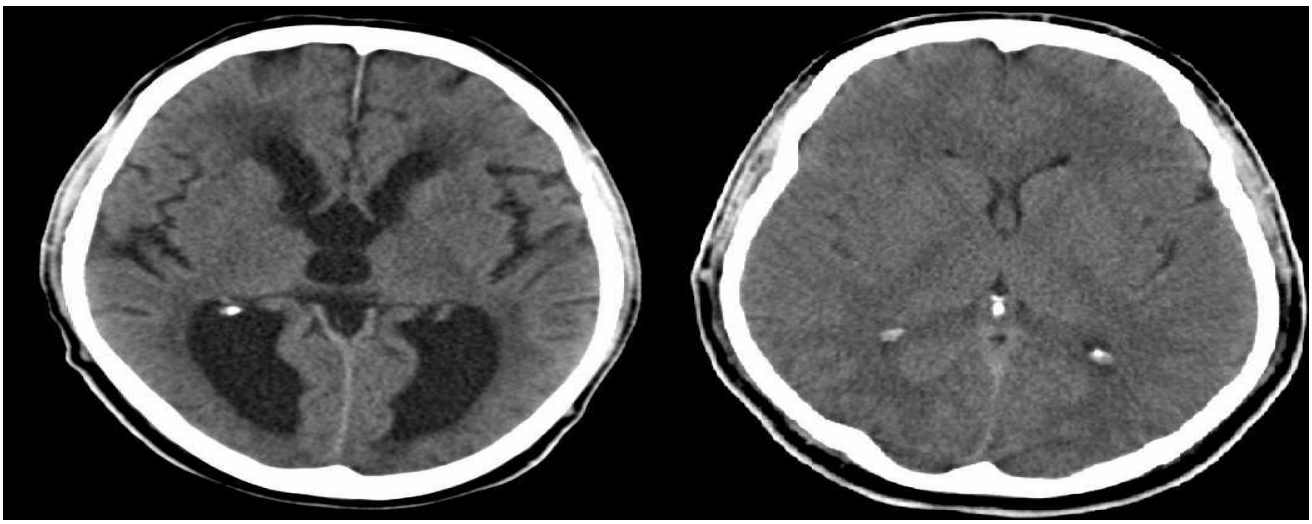
- **The third ventricle** is a median (midline) cavity in the brain that is bounded by the thalamus and hypothalamus on either side.
- The third ventricle is a narrow cavity located between the two hemispheres

- **The fourth ventricle** is the most inferior (lowest) of the four ventricles of the brain.
- The fourth ventricle has a characteristic diamond shaped cavity located behind the Pons and medulla oblongata.
  - **Function of ventricles:**
  - a. Forms the central canal of the spinal cord
  - b. Protects the brain from trauma

The ventricles are filled with cerebrospinal fluid, which is formed by structures called choroid plexuses located in the walls and roofs of the ventricles.

Hydrocephalus /also known as "water on the brain," is a medical condition in which there is an abnormal accumulation of cerebrospinal fluid (CSF) in the ventricles of the brain. This may cause increased intracranial pressure inside the skull and progressive enlargement of the head, convulsion, , and mental disability. Hydrocephalus can also cause death. Although it does occur in older adults, it is more common in infants



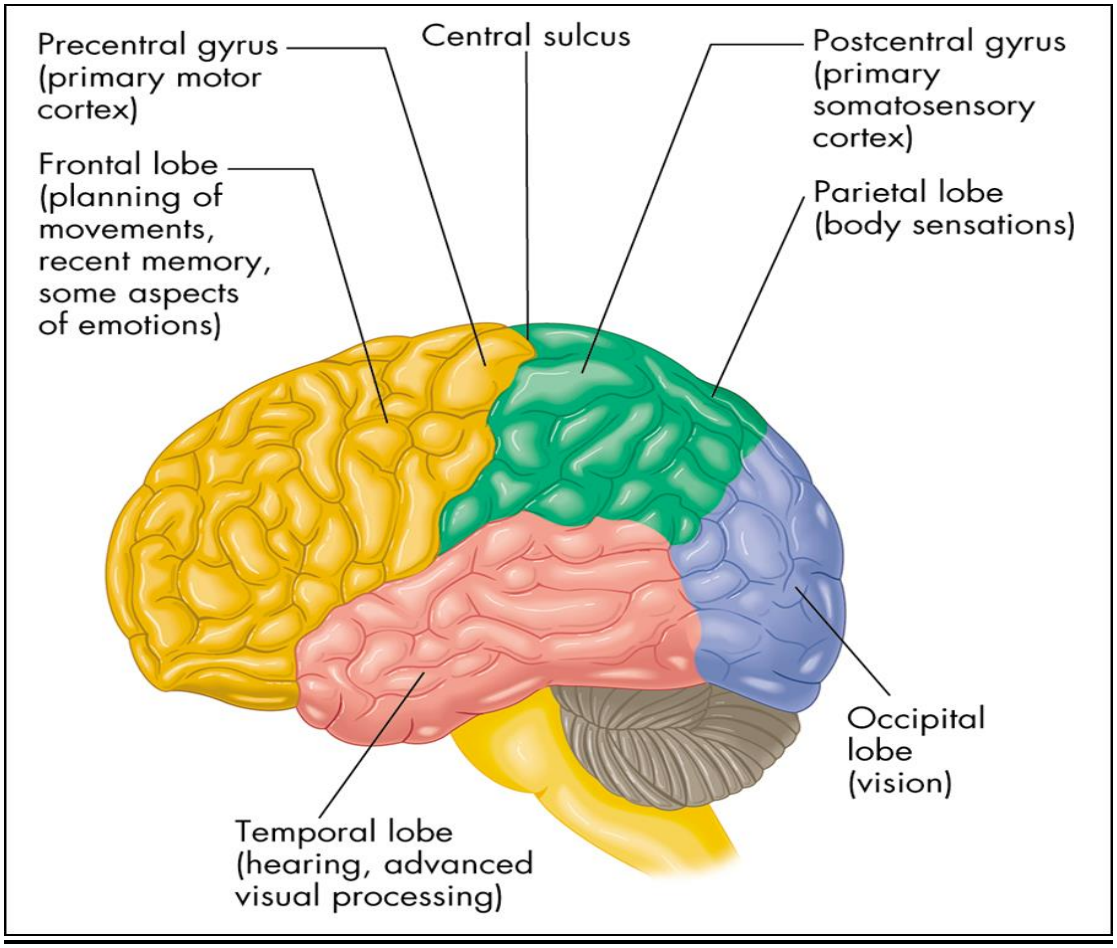


Cerebrum (Cerebral Hemispheres): Cerebrum is the largest part of the human brain, which consists of two hemispheres separated by longitudinal fissure. It covers the superior part of the brain.

Cerebral cortex: its functions include speech, memory, logical and emotional response as well as consciousness, interpretation of sensations and voluntary movement.

Lobes of cerebral cortex

Cerebral Lobe	Function
1. Frontal lobe	Planning of movement , recent memory, Emotion
2. Parietal lobe	Interprets the body sensation
3. Temporal Lobe	Receives impulses from inner ear.
4. Occipital Lobe	Interprets vision



- **Broca's area**: A specialized area that is very much involved in our ability to speak. It's located in the left hemisphere.

Diencephalons (interbrain)

The major structures of the diencephalons are the **thalamus, hypothalamus and epithalamus.**

1. **Thalamus**: responsible for:
   Touch, pain and temperature and control the level and state of consciousness.

2. **Hypothalamus**: (under the thalamus).
   a. Regulates the body temperature, water balance and metabolism.
   b. Regulates the pituitary gland (an endocrine gland) .

3. **Epithalamus:** The important parts of the epithalamus are the
   pineal body (part of the endocrine system) and the choroids plexus

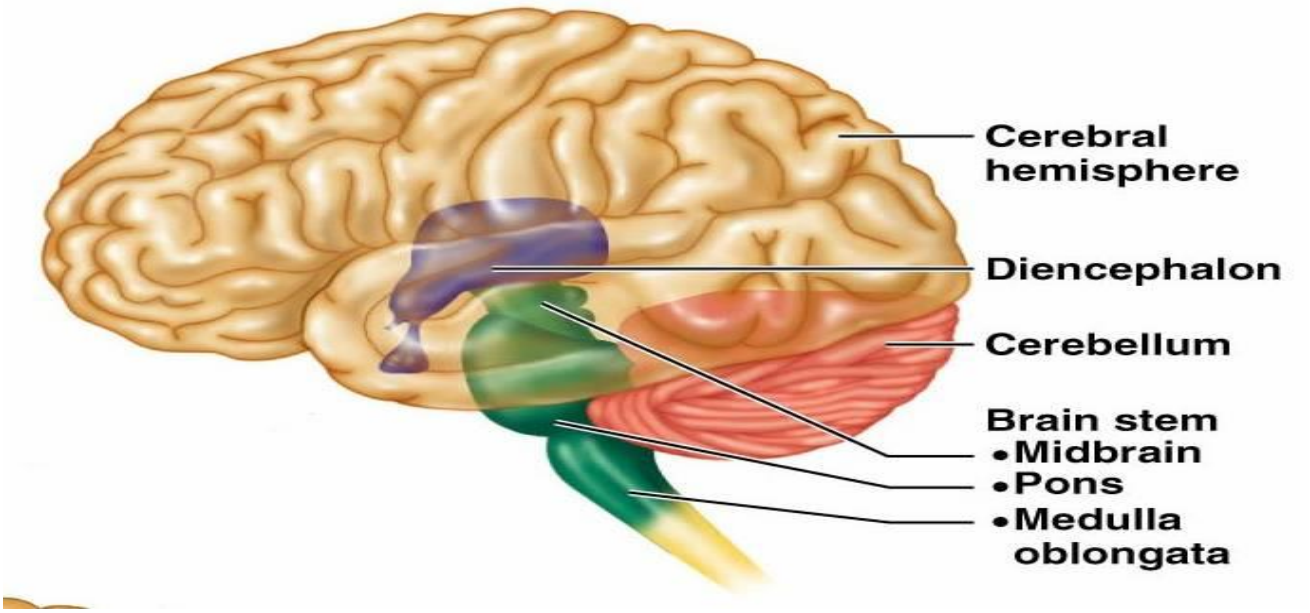
Brain stem

It is about the size of a thumb in diameter and approximately 3 inches long. Its structures are **midbrain, pons and medulla oblongata**.

1. **Midbrain الدماغ المتوسط** : It is the smallest part of brain stem, contains the centers of visual and auditory reflexes and it helps to control skilled muscular movements.
2. **Pons** (الجسر) : just below the midbrain. It is important in the control of breathing.
3. **Medulla oblongata**: It is the most interior part of the brain stem.

   Functions:

   a. Controls heart rate, blood pressure.
   b. Controls breathing, swallowing and vomiting.



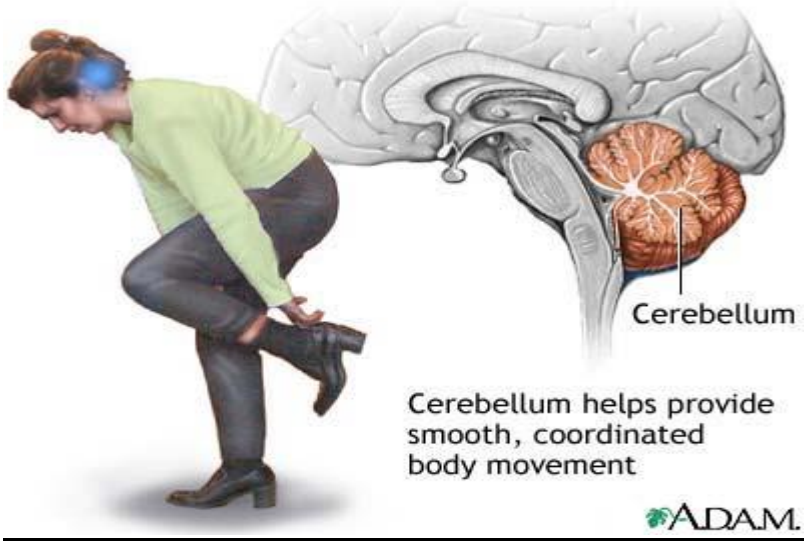
Cerebellum

The large cauliflower like structure, projects dorsally from under the occipital lobe of cerebrum.

Functions:

a. Provides the precise timing for skeletal muscle activity.
b. Controls balance and equilibrium.

When cerebellum is damaged, ataxia occurs and the patient loss his balance .



Cerebrospinal fluid (CSF): Circulate around the brain and spinal cord.
It is like blood plasma but has very little protein, less K+, glucose and Hco3, but more Na+, Cl and Mg^2.
Volume 150 ml – specific gravity: 1.005 – 1.008

Choroids plexus: the structure that **produces CSF**
Arachnoids villi :the structure that **drains CSF**.

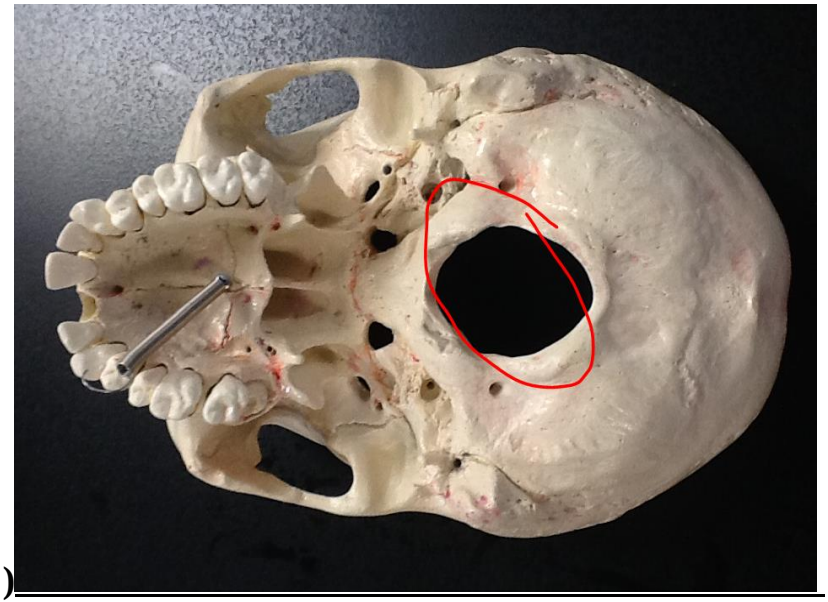
Functions of CSF.

1. Acts as shock absorber
2. Keeps total volume of cranial contents constant.
3. Low K+ concentration allows neurons to generate very high electrical potentials.

Spinal cord: is a continuation of brain stem. It extends from the large opening (foramen magnum) in the base of skull down to the lower back (1st lumbar vertebrae). It is a cylindrical shaped structure about 42 cm long and about 2.5 cm in diameter.

Functions:

- It provides a two-way conduction pathway to and from the brain.
- It is a major reflex center of the body



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Cranial nerves

The 12 pairs of cranial nerves primarily supply the head and neck. **Only one pair (vagus nerves) extends to the thoracic and abdominal cavities**.

Classification

Sensory nerves S 821	**Motor nerves 12, 11,643**	**Mixed nerves 1975**
I Olfactory	III Oculomotor	V Trigeminal
II Optic	IV Trochlear	VII Facial
VIII Vestibulo-cochlear	VI Abducens	IX Glossopharyngeal
	XI Spinal accessory	X Vagus
	XII Hypoglossal	

Functions of cranial nerves

Number and Name	Origin	Function(s)
I Olfactory	Sensory	Sense of **smell**
II Optic	Sensory	Sense of **sight** (Vision)
III Oculomotor محرك العين	Motor	• **Eyeball movement** • constriction of the pupil.
IV Trochlear بكرة	Motor	**Eyeball movement**
V Trigeminal العصب التوامي الثلاثي	Mixed	*Sensation of face, scalp and teeth, *Contraction of chewing muscles.
VI Abducens (المبعد)	Motor	Eyeball lateral movement.
VII Facial وجهي	Mixed	• Sense of taste, • Contraction of facial muscles, • Secretion of saliva.
VIII Vestibulocochlear (Acoustic) السمعي	Sensory	• Sense of hearing, • Sense of equilibrium.
IX Glossopharyngeal لساني بلعومي	Mixed	• Motor for throat muscles. • Sensory for taste
X Vagus	Mixed	• Sensory in cardiac, respiratory and blood pressure reflexes, • Sensory and motor to larynx (speaking), • decreases heart rate, • Contraction of alimentary tube (peristalsis), • Increase digestive secretions.
XI Accessory	Motor	• Contraction of neck and shoulder muscles, • Motor to larynx (speaking).
XII Hypoglossal	Motor	• Movement of the tongue.

The Effects of autonomic nervous system on the different body organs.

Organ	Sympathetic response	Parasympathetic response
Heart	Increases heart rate	Decreases heart rate
Lungs	Bronchodilatation .	Bronchoconstriction
Digestive system	• Decreases peristalsis • constricts digestive system sphincters	• Increases peristalsis • relaxes sphincters. • Increase glands secretion
Urinary bladder	Constricts sphincters (Prevents voiding)	Relaxes sphincters (allows voiding)
Sweat glands	Stimulate to produce perspiration	No effect.
Metabolism	• Increase metabolic rate • increase blood sugar levels • stimulate fat breakdown.	Glycogen synthesis
Eye	**Dilates pupil** , and prepares for **distant** vision.	**Constricts pupil** and prepares for **close vision.**

Chapter -5

Urinary system

Physiology of kidney

The formation of urine is the function of the kidneys, and the rest of the system is responsible for eliminating the urine.
Body cells produce waste products such as urea, creatinine, and ammonia, which must be removed from the blood before they accumulate to toxic levels.

The kidneys receive about 20 % of the cardiac output(1000-2000 ml /min). this huge blood supply, is not only for nutrition but also for the main function of the kidneys that is clearing or cleaning. This is done by the nephrons that are about one million arranged beside the other

The primary function of the kidneys :

The major function of the urinary system is to **control the composition and volume of body fluids**. The kidneys perform this function through multiple processes:

1. **Excretion.** The kidneys are the major excretory organs of the body. They remove waste products from the blood. Many waste products are toxic, but most are metabolic by-products of cells.
The skin, liver, lungs, and intestines eliminate some of these waste products

2. The excretion of the end-products of protein metabolism(urea). Urea, which forms about 2% of urine .
3. The excretion of ions and regulation of the acid-base balance and pH of the blood.
4. The excretion of drugs, toxins and chemical substances.
5. Formation of active form of vitamin D .
6. They produce erythropoietin when oxygen level is decreased stimulating the bone marrow to produce new RBCs

The formation of urine

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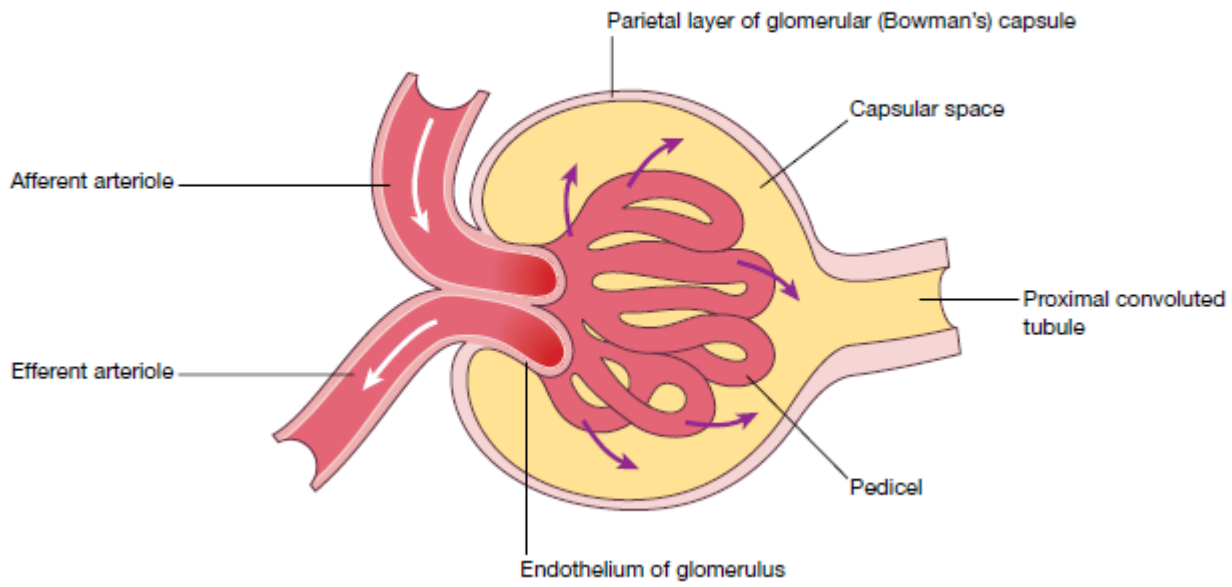
Renal filtration



Three processes are employed by the nephrons of the kidney in the production of urine:

(A) Glomerular Filtration
(B) Tubular Reabsorption
(C) Tubular Secretion

A. Glomerular Filtration

The kidneys form urine from blood plasma. Blood flow through the kidneys is a major factor in determining urinary output.

This is a simple physical process. Water, salts and other substances are filtered from the blood in the glomerular capillaries into Bowman's capsule and they quickly pass into the renal tubule.

(*Filtration is selective only in terms of size.*)

Filtration occurs when high blood pressure in the glomeruli forces water , small molecules and small proteins out of glomerular capillaries into the Bowman capsule, forming a fluid called filtrate.

GLOMERULAR FILTRATION RATE (GFR): It is defined as:
the rate of filtration in all the nephrons in the 2 kidneys per unit of time.

Each kidney has 1,000,000 nephron so GFR is the rate of filtration of 2 million of nephrons , normally these 2 million filter 120-125 ml/min because not all the blood received by the kidney is going to be filtered but only 20 % of it is filtered whereas the remaining 80 % go to the efferent arterioles then to the circulation without filtration

The GFR can be increased or decreased by many factors e.g. any factors that cause dilatation of the afferent arteriole will increase the blood coming to the glomeruli and therefore plasma is also increased so the GFR increase.

1. Sex →GFR is more in male
2. Surface area → GFR is more in subject with larger surface area
3.Age → GFR is reduced normally in old age .
4. Pregnancy →GFR increased during pregnancy
5. Exercise → GFR is reduced during exercise

B. Tubular Reabsorption

Tubular reabsorption is selective in terms of usefulness.

The cells of the renal tubule use ATP to transport most of the useful materials from the filtrate to the blood in the peritubular capillaries.

- **Active transport** --- These useful reabsorbed materials include :
  a. Nutrients such as (**glucose**, **amino acids**, and **vitamins**).
  b. Positive ions (Na^+, K^+…….

- **Passive transport** …... Negative ions(Cl…

- **Osmosis** …. … Water
- **Small proteins** are reabsorbed by **pinocytosis.(** The cell membrane pinches in to engulf protein)

Only 1% of the glomerular filtrate actually leaves the body and 99% is reabsorbed back into the blood stream

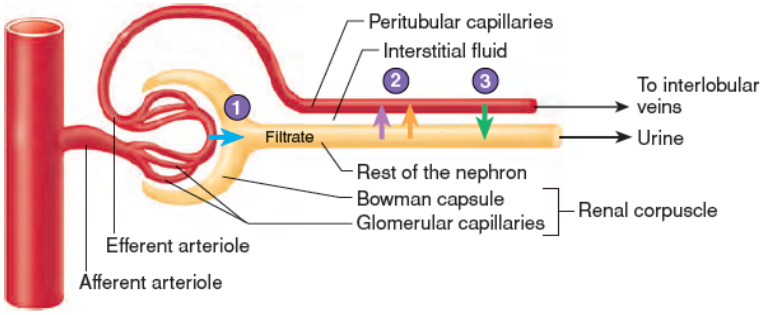
C. Tubular secretion :

This takes place mainly in the convoluted tubules and it is mainly takes place by **active transport system** (need energy) performed by the cells of the cuboidal epithelium lining the tubules.
These cells select either abnormal substances or normal substances from the blood when their concentration exceeds their normal value, and pass them into the lumen of the

tubules. **(H+), (K+), ammonia (NH3), creatinine , excess H_ ions and certain drugs.**

Urine formation results from the following three processes:

1. **Filtration** — Filtration (*blue arrow*) is the movement of materials across the filtration membrane into the Bowman capsule to form filtrate.
2. **Tubular reabsorption** — Solutes are reabsorbed (*purple arrow*) across the wall of the nephron into the interstitial fluid by transport processes, such as active transport and cotransport. Water is reabsorbed (*orange arrow*) across the wall of the nephron by osmosis. Water and solutes pass from the interstitial fluid into the peritubular capillaries.
3. **Tubular secretion** — Solutes are secreted (*green arrow*) across the wall of the nephron into the filtrate.



Hormones that Influence Reabsorption of Fluids and Electrolytes

1. Aldosterone :

is secreted by the adrenal cortex in response to :

a. high blood potassium level,
b. low blood sodium level,
c. decrease in blood pressure.

Aldosterone will stimulates the reabsorption of sodium and water back to the blood. This helps maintain normal blood volume and blood pressure.

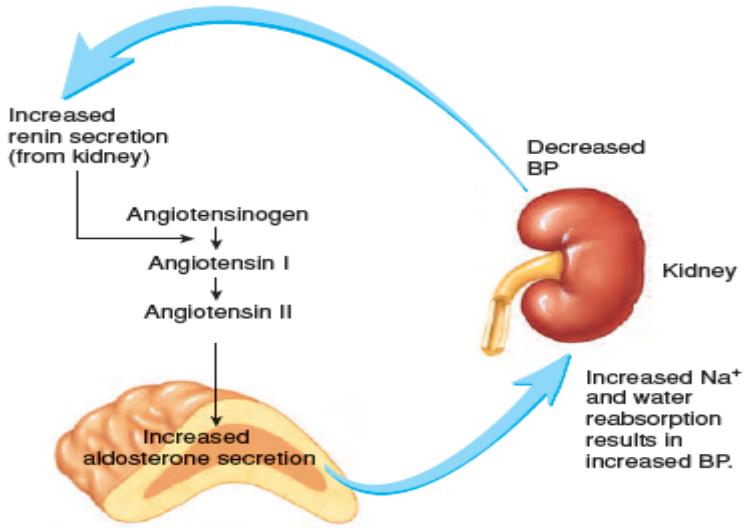


Figure 18.14 **Aldosterone and the Regulation of Na^+ and Water in Extracellular Fluid**

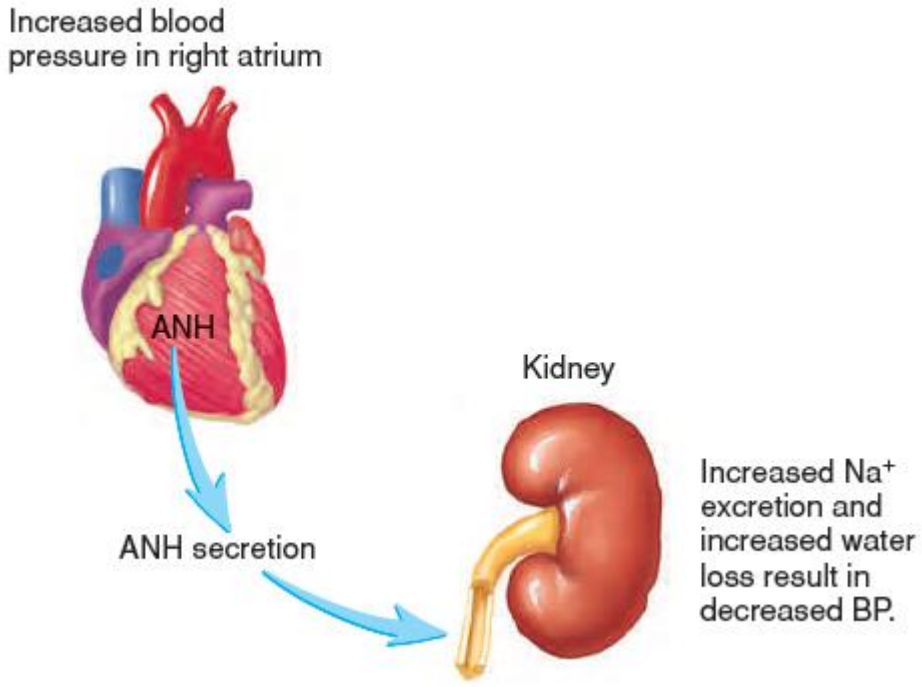
Low blood pressure (BP) stimulates renin secretion from the kidney. Renin stimulates the production of angiotensin I, which is converted to angiotensin II, which in turn stimulates aldosterone secretion from the adrenal cortex. Aldosterone increases Na^+ and water reabsorption in the kidney.

2. Atrial natriuretic peptide (ANP)

It is the antagonist to aldosterone .

It is secreted by the atria of the heart when the atrial walls are stretched by high blood pressure or greater blood volume.

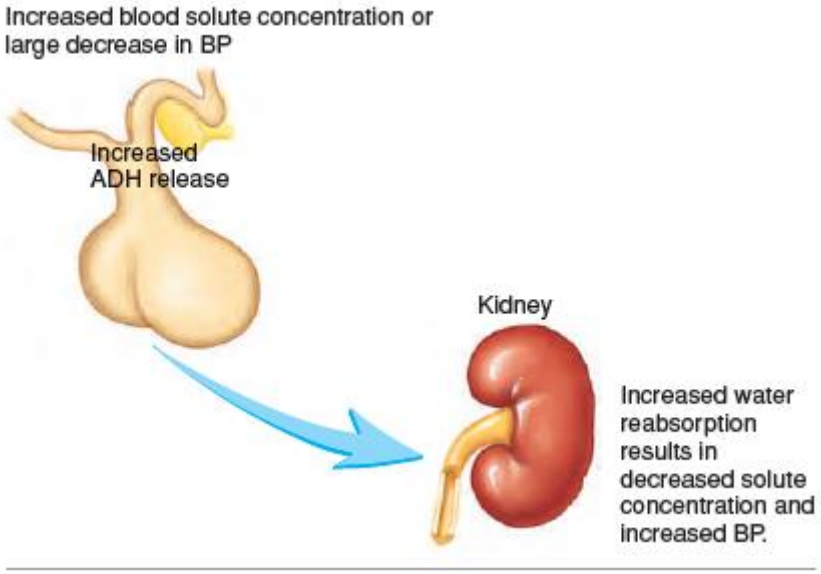
By increasing the elimination of sodium and water, ANP will lowers blood volume and blood pressure.



***3.Antidiuretic hormone** (ADH)* :

is released by the posterior lobe of pituitary gland when the amount of water in the body decreases.

Under the influence of ADH, the distal convoluted tubules and collecting tubules are able to reabsorb more water from the renal tubule and therefore the patient will pass less urine..



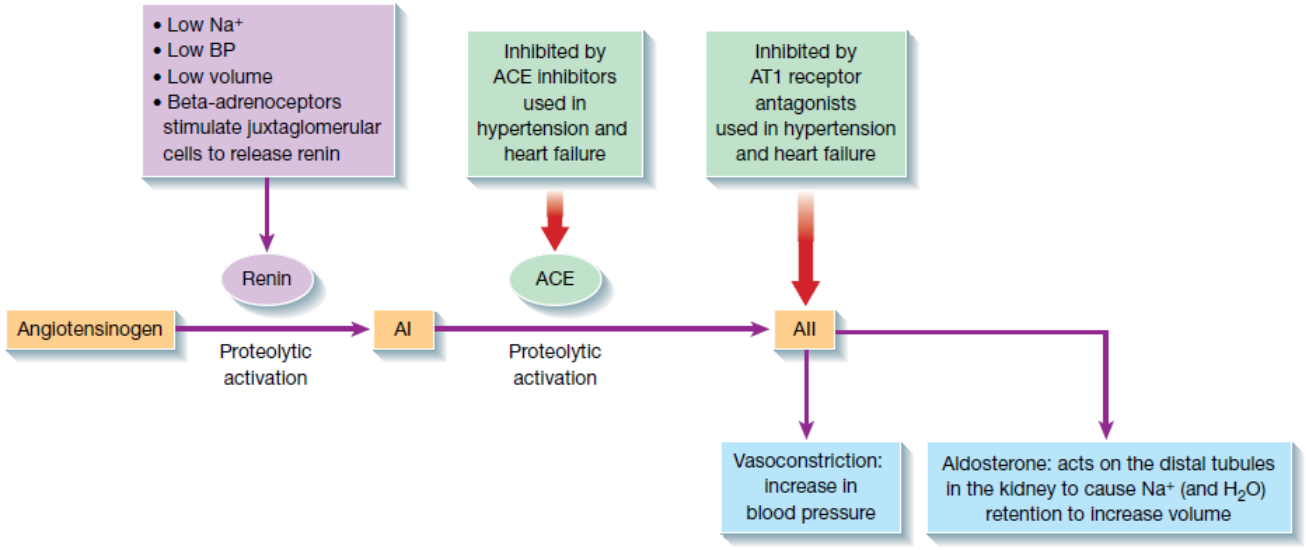
4. Angiotensin

Renin-angiotensin is a hormone system that regulates blood pressure and water (fluid) balance. When blood volume is low, juxtaglomerular cells in the kidneys secrete renin directly into circulation.

Plasma **renin** then carries out the conversion of **angiotensinogen** released by the liver to **angiotensin I**., which is subsequently converted to **angiotensin II** by the angiotensin converting enzyme found in the lungs which is a potent vaso-active peptide that causes blood vessels to constrict, resulting in increased blood pressure.

Angiotensin II also stimulates the secretion of the hormone aldosterone from the adrenal cortex. Aldosterone causes the tubules of the kidneys to increase the reabsorption of sodium and water into the blood. This increases the volume of fluid in the body, which also increases blood pressure (Figure 34.2).

Figure 34.2 Renin-angiotension pathway



THE KIDNEYS AND ACID–BASE BALANCE

The kidneys are the organs most responsible for maintaining the pH of blood and tissue fluid within normal ranges.

This regulatory function of the kidneys is complex, but at its simplest it may be described as follows.

If body fluids are becoming too acidic,
the kidneys will secrete more H_ ions into the renal filtrate and will return more HCO3 _ ions to the blood. This will help raise the pH of the blood back to normal.

If body fluids are becoming too alkaline.

The kidneys will return H_ ions to the blood and excrete HCO3 _ ions in urine. This will help lower the pH of the blood back to normal.

Characteristics of urine:

- Freshly voided urine is clear and pale to deep yellow. The normal yellow color is due to urochrome, a pigment that results from body's destruction of hemoglobin.
- Abnormal color may be a result of eating certain foods or the presence of bile or blood in the urine.
- **Odor**: aromatic, if it is allowed to stand. It takes on an ammonia odor caused by the action of bacteria on the urine. Some drugs, and various diseases, such as diabetes mellitus, alter the usual odor of urine.
- Urine pH is slightly acidic (around 6).
- A diet containing a large of amount of protein (eggs and cheese) and whole-wheat products causes urine to become acidic.

- A vegetarian diet is called Alkaline-ash diet because it makes urine quite alkaline.
- Bacterial infection of the urinary tract also may cause the urine to be alkaline.
- **Specific gravity**: 1.001 – 1.035, denser than water, heavier than water.
- When a person drinks excessive fluids, uses diuretics or has chronic renal failure, it means that urine has low specific gravity.
- Inadequate fluid intake, fever and a kidney inflammation called pyelonephritis causes urine to become higher specific gravity.

Solutes normally found in the urine

- Sodium and potassium ions (Na+, K+)
- Urea
- Uric acid
- Creatinine
- Ammonia
- Bicarbonate ions
- Various other ions depending on blood composition.

Substances not normally found in urine:

- Glucose
- Blood proteins (albumin)
- RBC
- Hemoglobin
- WBC (pus)
- Bile

The first successful human organ transplant was a kidney transplant performed in 1953. Because the donor and recipient were identical twins, rejection was not a problem.

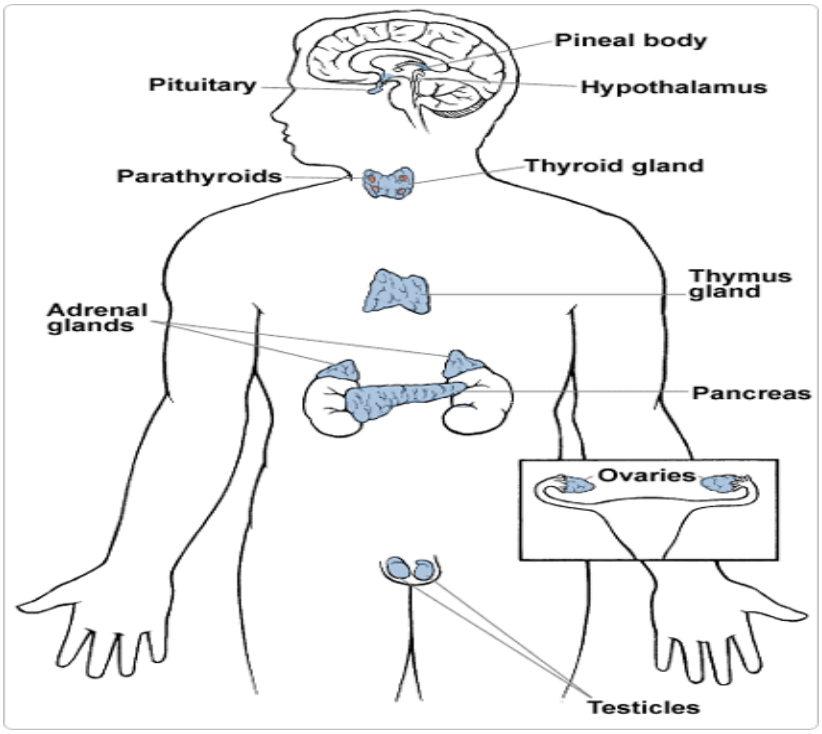
Chapter -6

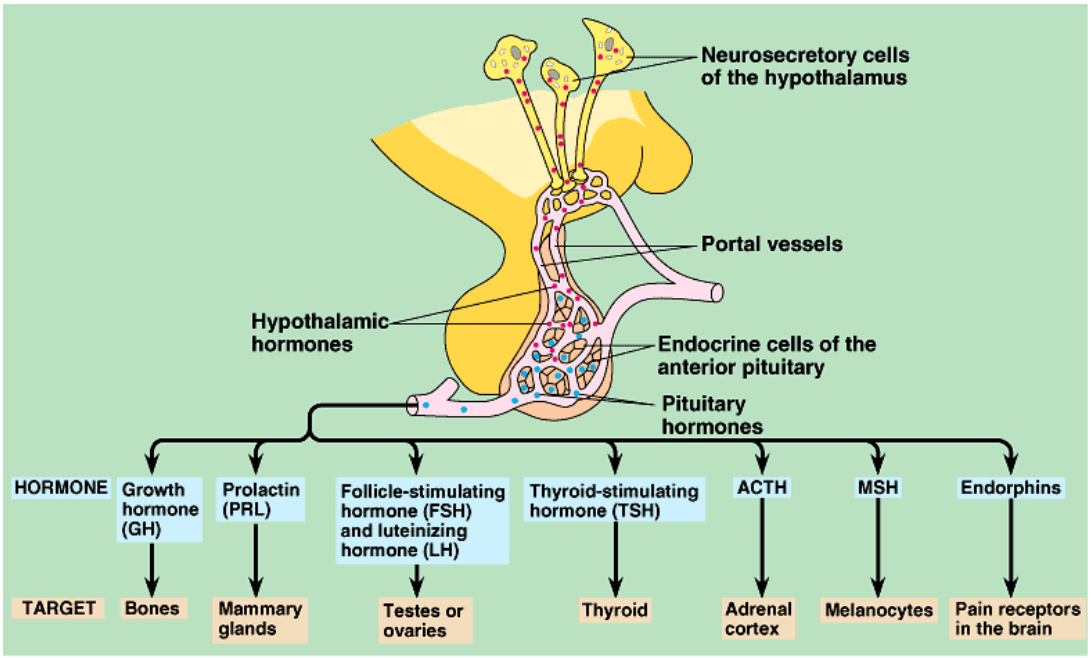
Endocrine System

Hormones: Chemical substances secreted by cells into the extra cellular fluids, that regulate the metabolic activity of other cells in the body.

Difference between endocrine and exocrine glands :

1. **Endocrine glands**: are ductless glands that produce their hormones and release into the blood or lymph. They have a very rich blood supply. The endocrine glands of the body include: **pituitary, thyroid, parathyroid, adrenal, pineal , thymus, pancreas, the gonads (ovaries and testes) and hypothalamus.**
2. **Exocrine glands**: These glands release their products at the body's surface or into body cavities through ducts.





(b) The anterior pituitary

Pituitary glands

The hypothalamus is responsible for the control of pituitary gland

Pituitary gland has two functional lobes :

* **Anterior** pituitary (**glandular tissue)**

* **Posterior** Pituitary (**nervous tissues**)

- **Hormones of the anterior pituitary**

1. Growth hormone (GH):

- **Action**:
  - **a.** Directed to growth of skeletal muscles and long bones.
  - **b.** Stimulate protein synthesis .
  - **c.** Maintain blood sugar homeostasis.

2.Prolactine (PRL):

- **Action:**

It stimulates and maintains milk production by the mother breast

Its function in males is not known

3.Adrenocorticotropic hormone (ACTH):.

- **Action**:

Regulates the endocrine activity of the cortex of the adrenal gland

4. Thyroid – stimulating – hormone (TSH)

- **Action**:

It control the activity of the thyroid gland to secrete thyroid hormones(T3 and T4).

TSH : its **deficiency** leads to deficiency of T3 and T4 → **hypothyroidism** ,
Increase in TSH leads to increase of T3 and T4 → **hyperthyroidism**

5.Gonadotropic hormones. (FSH, LH).

Regulate the activity of the gonads (ovaries and testes)

a. Follicle – stimulating – hormone (FSH)

- **Action**:

Female: ovaries : Development of follicles; secretion of estrogen
Males: testis : Stimulate sperm development by the testes.

b. Luteinizing hormone (LH).

- **Action**:

Females: ovaries : - Rupture of follicle and ovulation
Males: testes. **:** stimulates testosterone production

- **Hormones of the posterior pituitary gland**

1. Antidiuretic hormone (ADH or vasopressin)

Actions:

a. Antidiuretic action : increase water re-absorption by the kidneys (raises blood pressure),

b. . Vasoconstrictor : constriction of arterioles during severe hemorrhage.

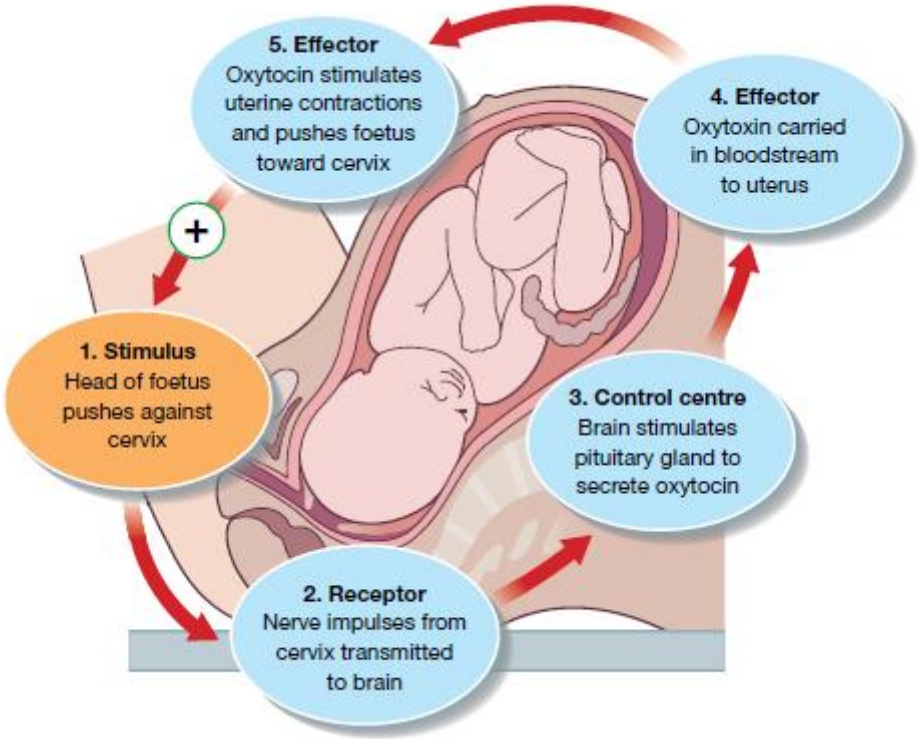
2. Oxytocin (OT):

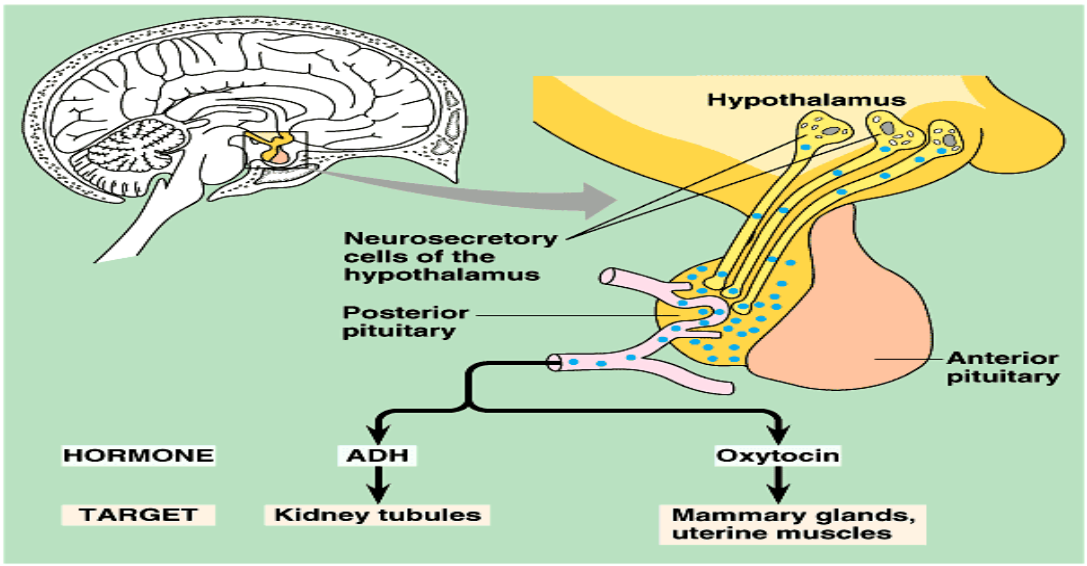
- **Action**: - **In the female**:

- - stimulates uterine contractions during labor,

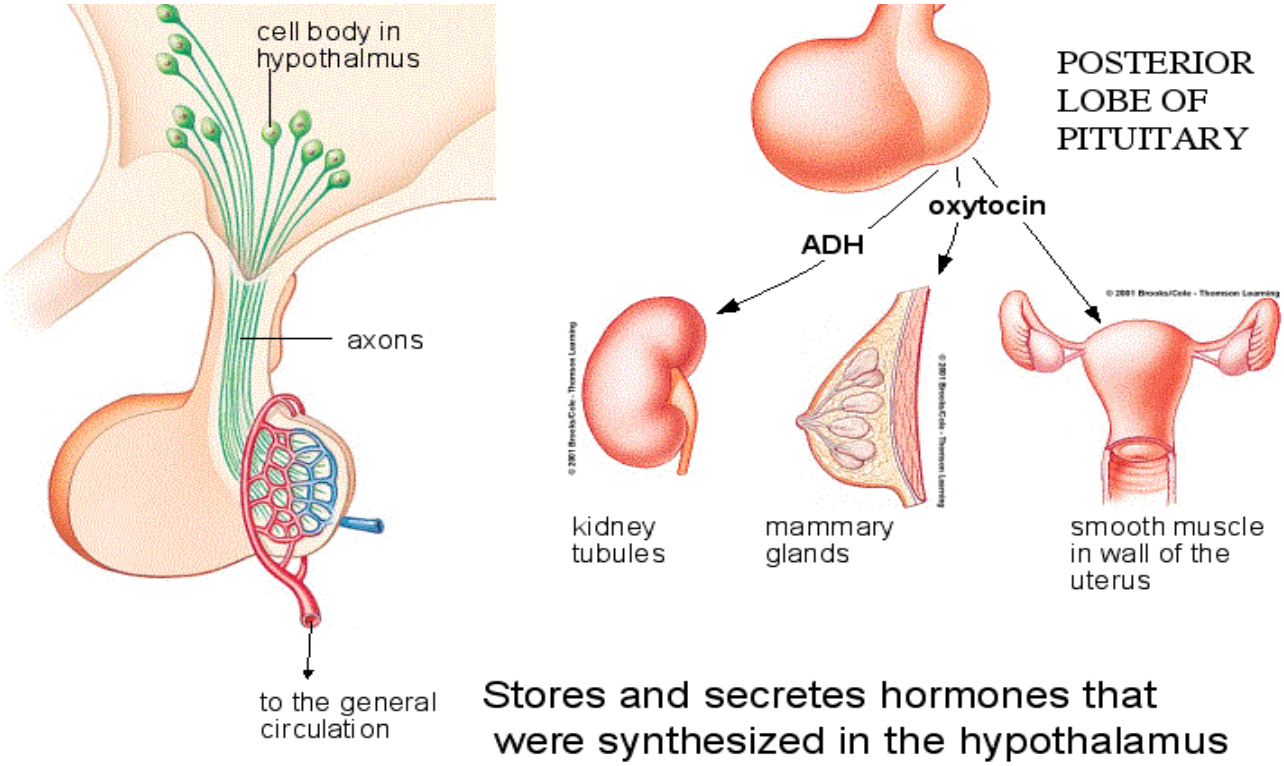
- stimulates milk ejection

-**In the male** : contraction of vas deferens to transport of sperm



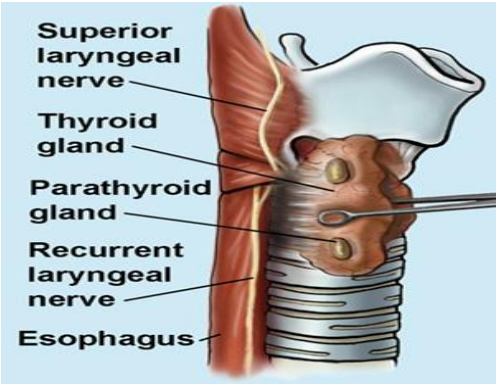


(a) The posterior pituitary



Thyroid gland

- It is a big structure located at the midline of the neck in front of the larynx and trachea below Adam's apple. It consists of 2 lobes right and left



It secretes two hormone

1. Thyroid hormones - thyroxin T4
   - T3
2. Calcitonin

The T means thyroid and the (3,4) refers to the numbers of iodine atoms that are present in the molecule of the hormone

- **<u>The function of thyroid hormone as follows</u>**:

1. Control and regulate the amount of O2 that are consumed by the cells.(regulation of cellular respiration).
2. Control and regulate the rate of metabolism of lipids, carbohydrates , and proteins
3. Important for normal growth and maturation of somatic and mental cells.
4. Important in fertility.

<u>Calcitonin :</u>

It acts **<u>antagonistically</u>** to parathyroid hormone**.**

- **Secreted** by Para follicular cells (C cells).
- **Actions**: decreases blood calcium levels.

<u>Parathyroid gland</u>

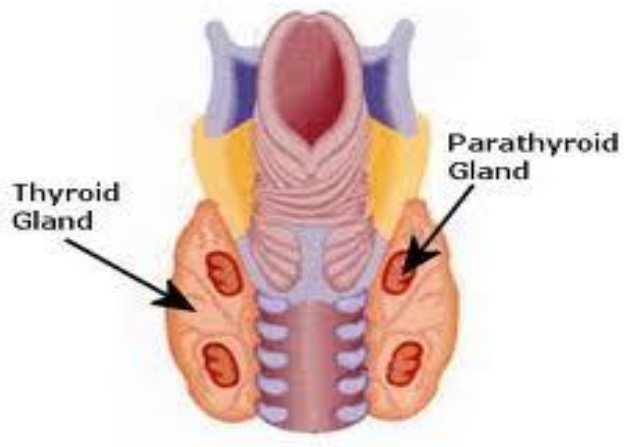
They are four collection of cells embedded in the substances of the thyroid gland.

Secrete **Parathormone hormon**e,.

The action of the parathyroid hormones

is to keep the level of calcium and phosphate within normal limit

- **Action**: increases calcium levels, decreases blood phosphate levels.
- **Bone**: increase the rate of calcium release from bones.
- **Kidneys**: increase calcium re-absorption .
- **Small intestine**: increase calcium absorption.

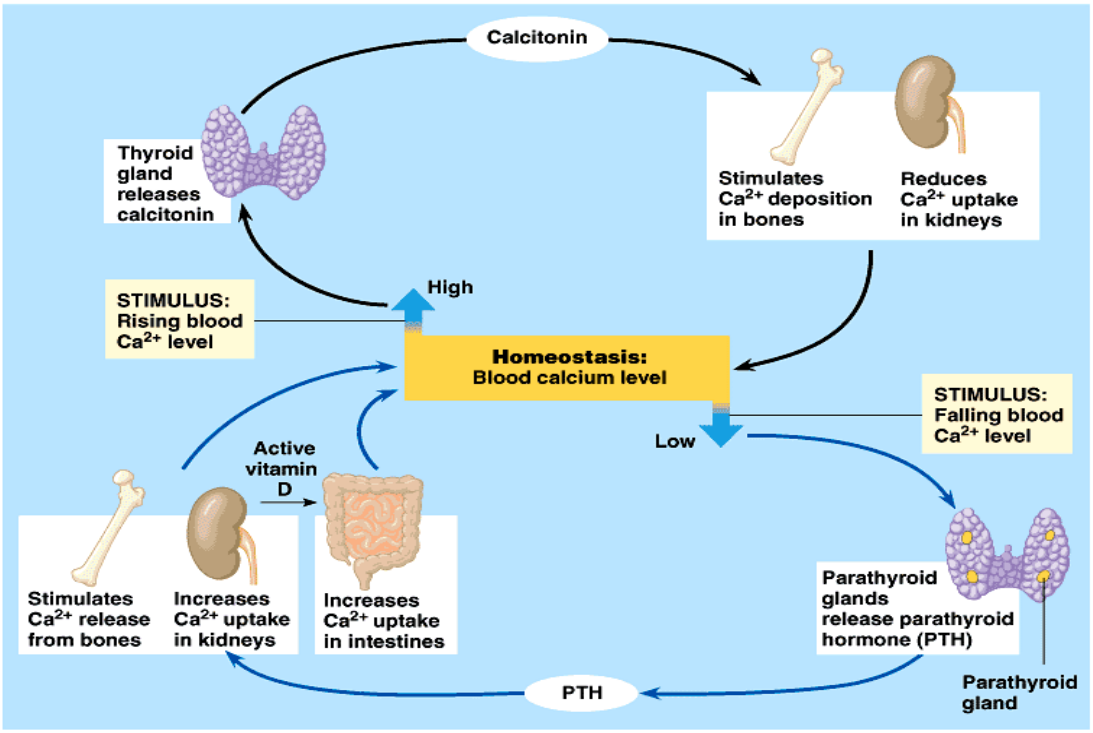


The hormones that regulate calcium (Ca) level :

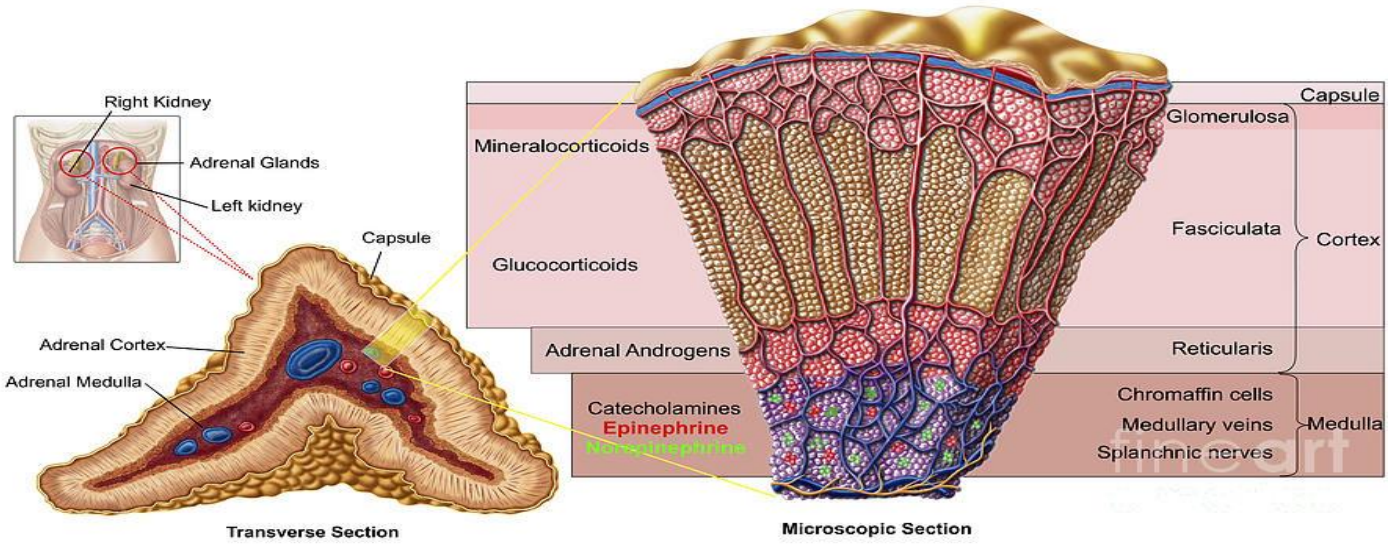
1. Parathyroid hormone (PTH)
2. 1,25 –dihydroxycholecalciferol (DHCC) , it is the active form vitamin D
3. Calcitonin : it is secreted by special cells in thyroid gland called clear cells(C-cells)

- **The target organs of these hormones are**
    1. Bone
    2. Urinary tubules of the kidneys
    3. Intestine.

- Calcitonin are secreted when there is hypercalcemia to decrease Ca level
- PTH and DHCC are secreted when there is hypocalcemia to increase Ca level.



Adrenal glands



There are two adrenal glands, one above each kidney. The outer portion of each gland is called the adrenal cortex; the inner portion is called the adrenal medulla.

Histologically , the glands consist of **cortex** and **medulla** .

The adrenal cortex has three layers:

1. **<u>The outer layer</u>** is secretes **Aldosterone.**
2. **<u>The middle layer</u>** is secretes **Cortisol.**
3. **<u>The inner layer</u>** is **(Sex hormones)** androgen and estrogens in both sexes.

Aldosterone

- **<u>Their target organs are mainly :</u>**
    1. Renal tubules
    2. Sweat glands
    3. Intestine.

- **<u>The effects of aldosterone on its target organs</u>**:
  <u>keep the level of sodium and potassium in blood within normal limit by increase reabsorption of the sodium and secretion of potassium.</u>
- **<u>The effects of Cortisol</u>**

.

- **<u>Effect of cortisol on</u> <u>carbohydrates metabolism:</u>** Elevated blood glucose

<u>The adrenal medulla is the center of the adrenal gland.</u>

It secretes catecholamine hormone (epinephrine (80%) and non-epinephrine (20%)).

Hormones of adrenal medulla-

- The hormones secreted by the adrenal medulla are called <u>catecholamine</u> and include <u>adrenaline</u> and <u>noradrenalin</u>.

- . The catecholamines increased the peripheral resistance and cause, thus increase blood pressure.

<u>Pancreas</u>

The pancreas is located close to the stomach in the abdominal cavity. It contains both exocrine and endocrine cells.

- **The exocrine cells** release digestive enzymes into the duodenum via the pancreatic duct.

- **The endocrine cells** release hormones into the blood stream. The endocrine portion of the pancreas called islets of Langerhans which contain 4 distinct types of cells, but we are just going to look at the main two.

1. Alpha cells: secrete **glucagons.**

- **Action**: increases blood glucose levels.

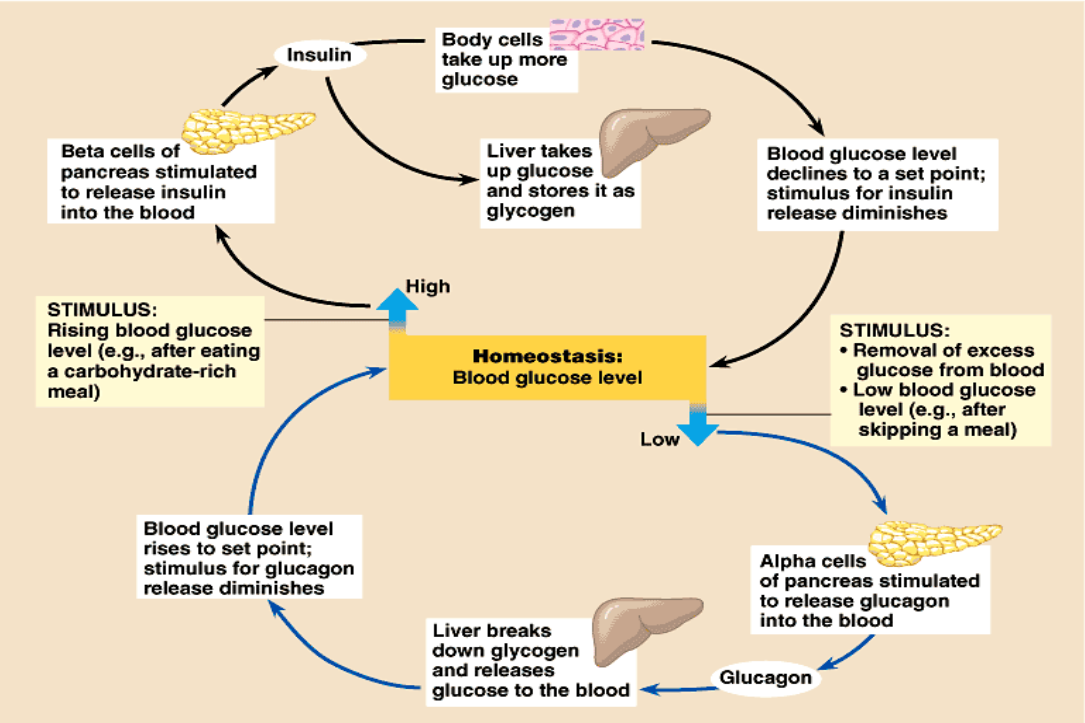
  Its primary target organ is the liver, which is stimulated to breakdown the stored glycogen to glucose and to release the glucose into the blood stream .

2. Beta cells: secretes **insulin**

- **Action**: decreases blood glucose levels**.**
- **Body cells**: stimulate the uptake of glucose and its conversion into glycogen.
- **Liver cells**: stimulate the conversion of glucose into glycogen.

CONTROL AND REGULATION OF SECRETION OF INSULIN:

- B- cells of islets of Langerhans are highly sensitive to glucose level in blood,
- After the meals, increase in glucose level will stimulate the B-cells to secrete insulin to deal with this excess of glucose. In **contrast** ,hypoglycemia inhibits the B-cells to secrete insulin



Chapter -7

Female Reproductive System

Female reproductive organs composed from :

1.Ovary 2. Fallopian tube 3. Uterus 4. Cervix 5.Vagina

1.Ovaries

The ovaries are small, oval-shaped paired glands that are attached to each side of the uterus by a thin, fibrous ovarian ligament.

2. Fallopian tubes

The Fallopian tubes, sometimes simply called tubes, are two channels that connect the ovaries to the uterus. They are the main structure that facilitate fertilization. Each tube is further divided into 3main portions:

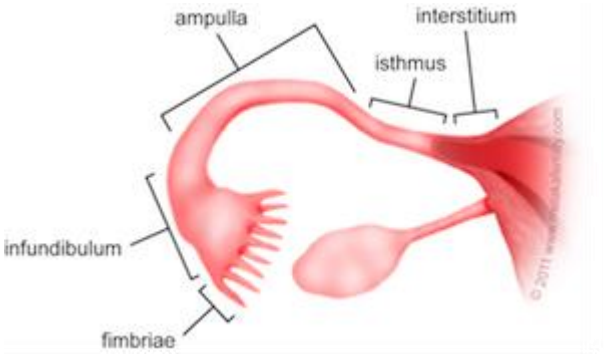


Figure 3: Anatomy of Fallopian tube.

- **Fimbriae**:

  The fringe-like structure

  located at the end of the tube that captures egg released from the ovary and draws it into the tube.

- **Infundibulum**: The funnel-like structure of the tube which is margined with fimbriae.
- **Ampulla**: The longest portion of the tube with thin wall (almost muscle-free) and wide lumen. It is usually the portion where fertilization takes place.

Uterus:

Regions of the uterus:

There are three regions:

1. **The body**: The major portion of the uterus.
2. **The fundus**: It is a superior rounded region above the entrance of the uterine tubes.
3. **Cervix**: It is a narrow outlet, which protrudes into the vagina below.

The walls of the uterus are thick and composed of three layers.

1. Endometrium: The inner layer or mucosa.

Functions:

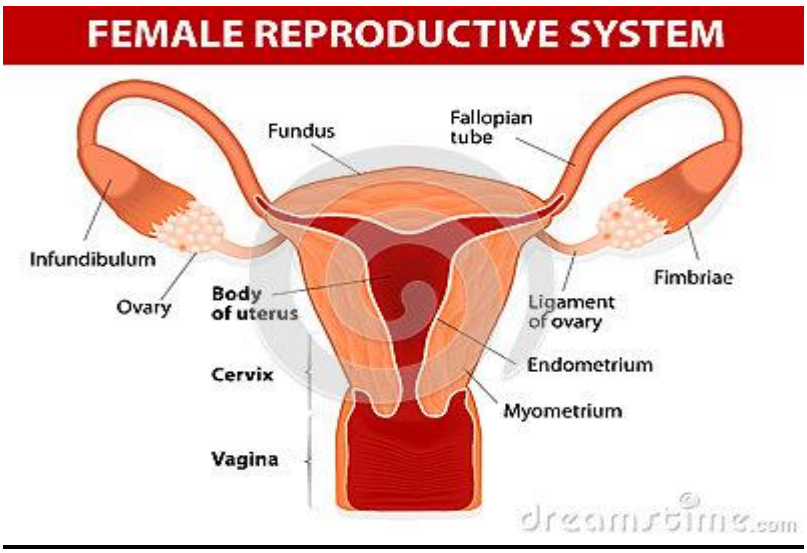
- If fertilization occurs, the young embryo implant into the endometrium (this process called implantation and stay there for the rest of its development).
- If the woman is not pregnant, the endometrium lining sloughs off periodically (about 28 days) in response to hormonal changes, this process called menses.

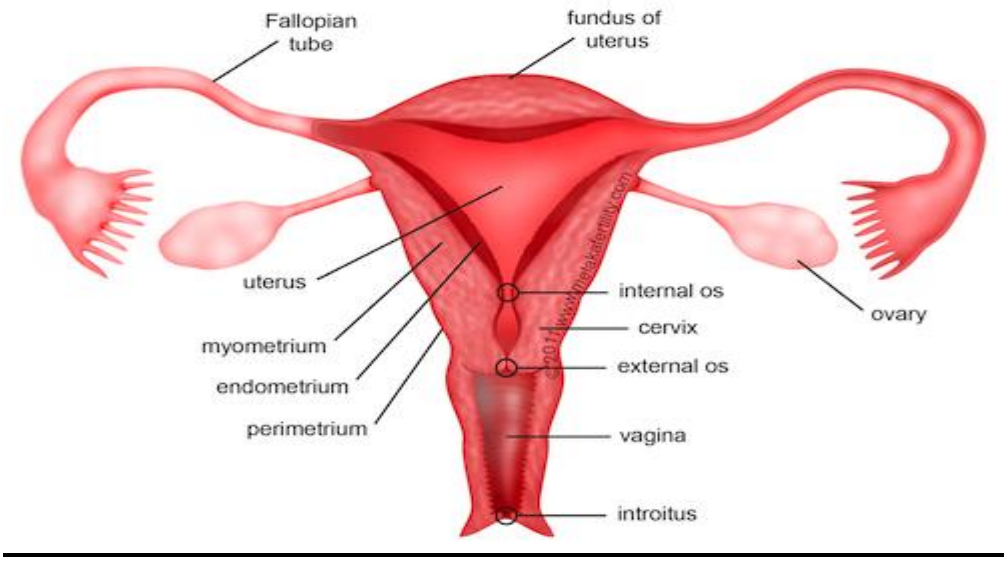
2. Myometrium: It is the middle layer of the uterus. It is composed of smooth muscles.

Function:

- Plays a major role during delivery, when it contracts rhythmically to force the baby out.

3. Epimetrium: The outer layer of the uterus. It protects and supports the uterus. It is a part of the visceral peritoneum.





Physiology

- The ovaries are responsible for storing and nurturing immature egg cells into mature eggs;
- Every month, one of them releases a mature egg into Fallopian tube.
- the ovaries produces two main female sex hormones: the oestrogen and progesterone, which are vital in regulating the menstrual cycles.

Hormones production by ovaries

Hormones production by ovaries becomes very active at puberty.

1. **Estrogen**: Secreted by follicle cells of mature follicle.
   Functions: Causes the appearance of secondary sex characteristics, which includes:
   - Enlargement of the accessory organs (uterine tubes, uterus, vagina, external genitalia)
   - Development of the breast.
   - Appearance of axillary and pubic hair.
   - Increased deposits of fat beneath the skin in the hips and breasts.
   - Widening and lightening of the pelvis.
   - Onset of the menstrual cycle.

2. **Progesterone**: It is produced by corpus luteum (after ovulation occurs, the ruptured follicle is converted to corpus luteum). The corpus luteum stops producing hormones by 10-14 days after ovulation.

Functions:

- Maintains pregnancy
- Prepares the breasts for milk production.

Note: The source of progesterone during pregnancy is the placenta not ovaries.

Female Reproductive System
Ovaries, Oogenesis, and Fertilization

Definitions
Meiosis : It is the process of cell division producing the gametes(sperm or egg cells.
Oogenesis is the process of meiosis for **egg cell** formation; it begins in the ovaries
Spermatogenesis is the process of meiosis for **sperm** production. it begins in the testes
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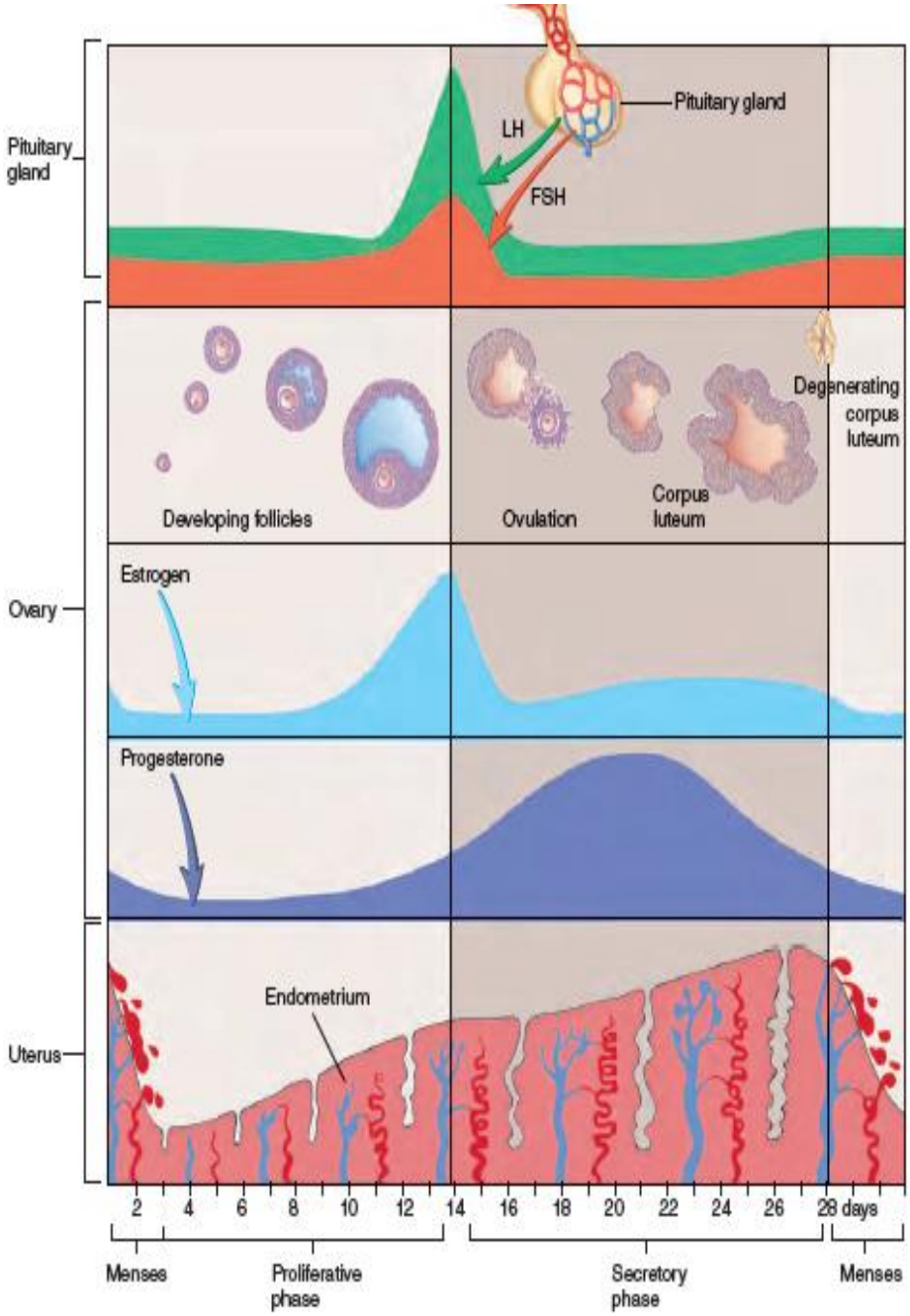


Figure 19.14 AP R

Menstrual Cycle

Over approximately 30 days, fluctuations occur in the levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) secretion from the anterior pituitary gland and in the levels of estrogen and progesterone secretion from the ovary. In addition, changes in the ovary and changes in the endometrium of the uterus are correlated with the changes in hormone secretion throughout the menstrual cycle. Ovulation occurs on about day 14.

Menstrual Cycle

The menstrual cycle is necessary for reproduction.

It begins from menarche (the first menstrual cycle in girl life) and continues until menopause(when the woman's primary ovarian functions stop permanently and no cycle after that) .

The length of a menstrual cycle is calculated from the first day of the menstruation to the day before the next menstruation. The average menstrual cycle length is 28 days, although it can vary from woman to woman.

Menstrual cycle is comprised of 4 phases:

1.Menstruation,

2. Proliferative phase,

3. Ovulation 4.

Luteal phase.

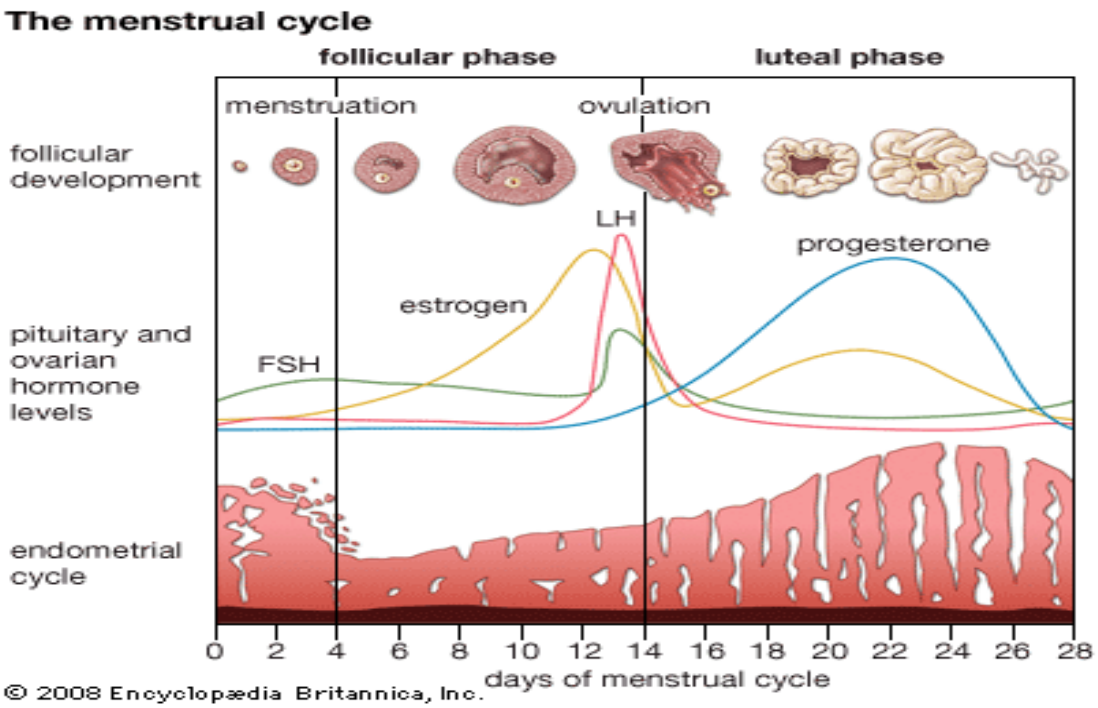
- **Menstruation**

  1. Menstruation or menses refers to the monthly shedding of uterine lining (endometrium), which normally lasts from 3 to 7 days.

  2. Menstruation is triggered by the sudden decline in female sex hormones - oestrogen and progesterone.

- Follicles are fluid-filled sacs that contain an immature egg or oocyte, which can potentially develop into mature ovum

  3. During menstruation, the follicle stimulating hormone (FSH) level rises, which, stimulates the follicles in the ovaries to grow.



a. Follicle – stimulating – hormone (FSH)

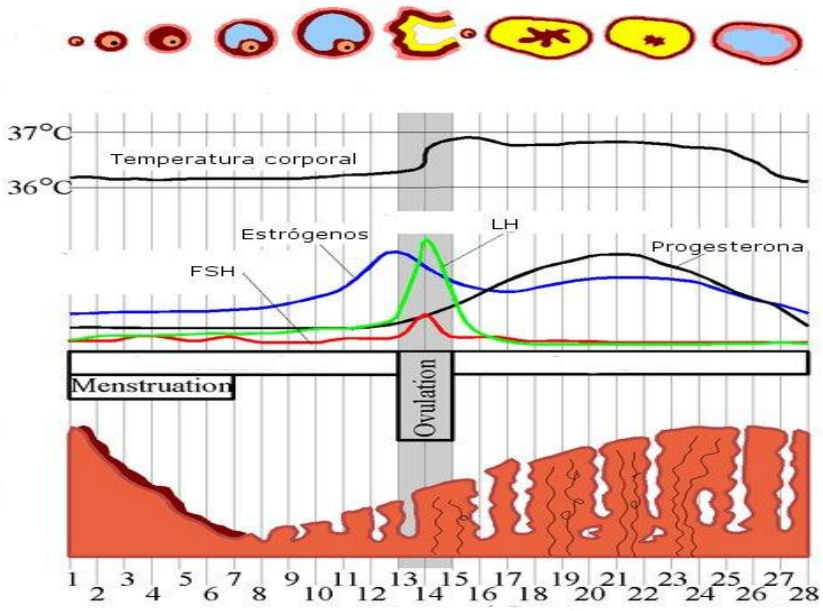
- **Action**:

Female: ovaries : Development of follicles; secretion of estrogen

b. Luteinizing hormone (LH).

- **Action**:

Females: ovaries : - Rupture of follicle and ovulation



- **Proliferative Phase**

  It begins soon after menstruation and ends with ovulation.

- **<u>During this phase :</u>**

- _ 1.The endometrium begins to grow and thicken in preparing for possible pregnancy.

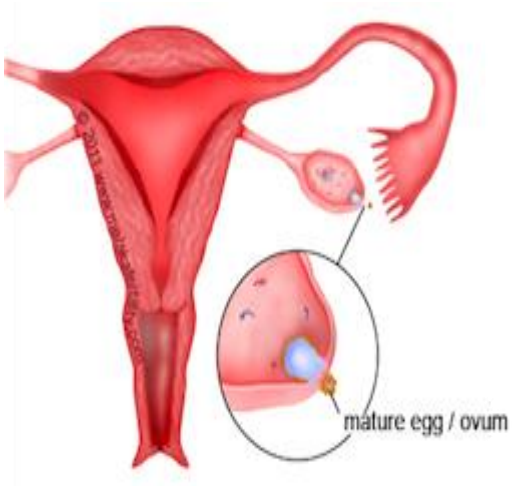
  2. The maturing follicles secrete **increasing amount of oestrogen**, which lead to:

  a. suppression of FSH secretion

  b. increases of LH secretion

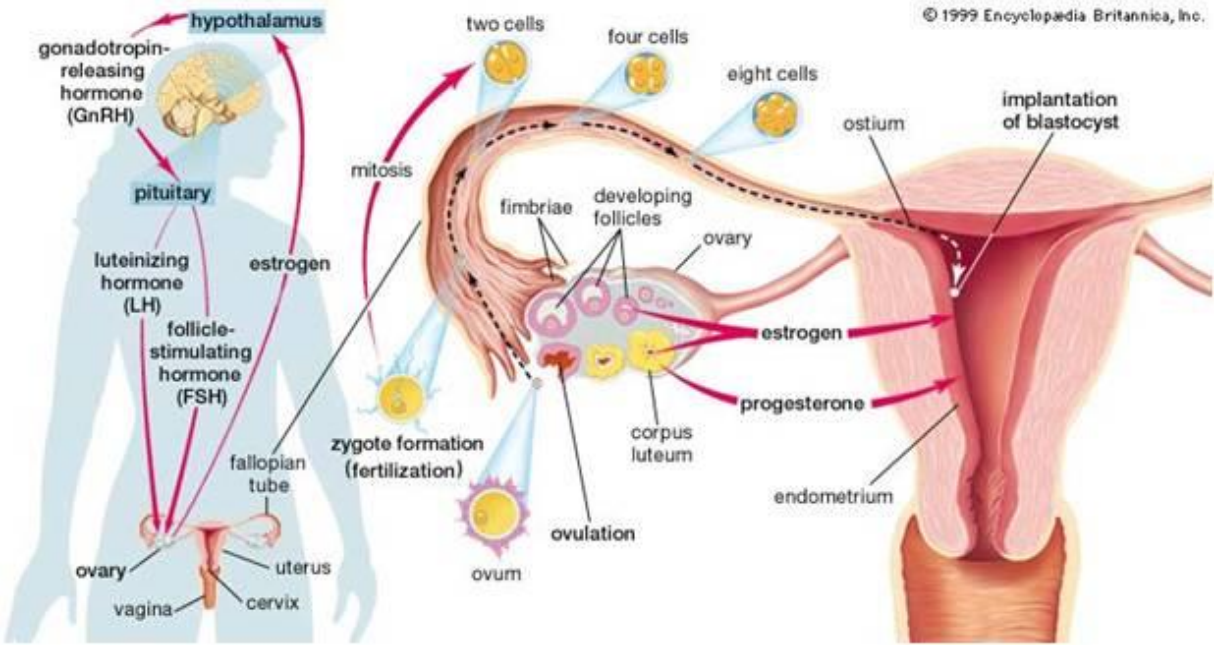
- The changes in both hormones are responsible for degeneration of most maturing follicles. One follicle (sometimes two), however, will become dominant and continue to develop into its tertiary stage, in which it is called Graafian follicle.

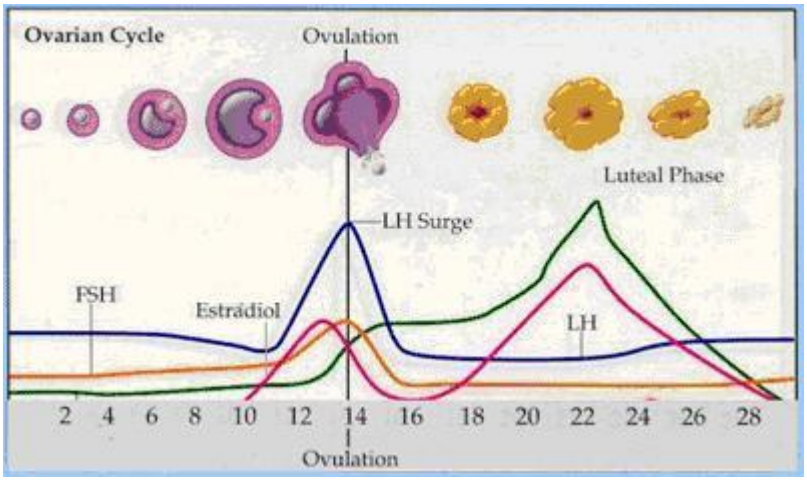
- About 2 to 3 days prior to ovulation, the LH level increases dramatically to facilitate the ovulation.

- 

- **Ovulation** .

  The rapid rise of luteinizing hormone, or more commonly known as the LH surge, causes the Grafian follicle to burst and release the mature egg, which is later caught by the fimbrial end of the fallopian tube. The entire process is called ovulation and usually occurs in the middle of the menstrual cycle, about day 14.

- 

- 

- **Lutueal Phase**

  The occurrence of ovulation also marks the beginning of luteal phase. **<u>During this phase</u>** :

- **1.** the ovum is propelled through the fallopian tube into the uterus. Meanwhile, under the influence of the LH surge, the remaining, ruptured follicle is transformed into a solid glandular structure called corpus luteum.
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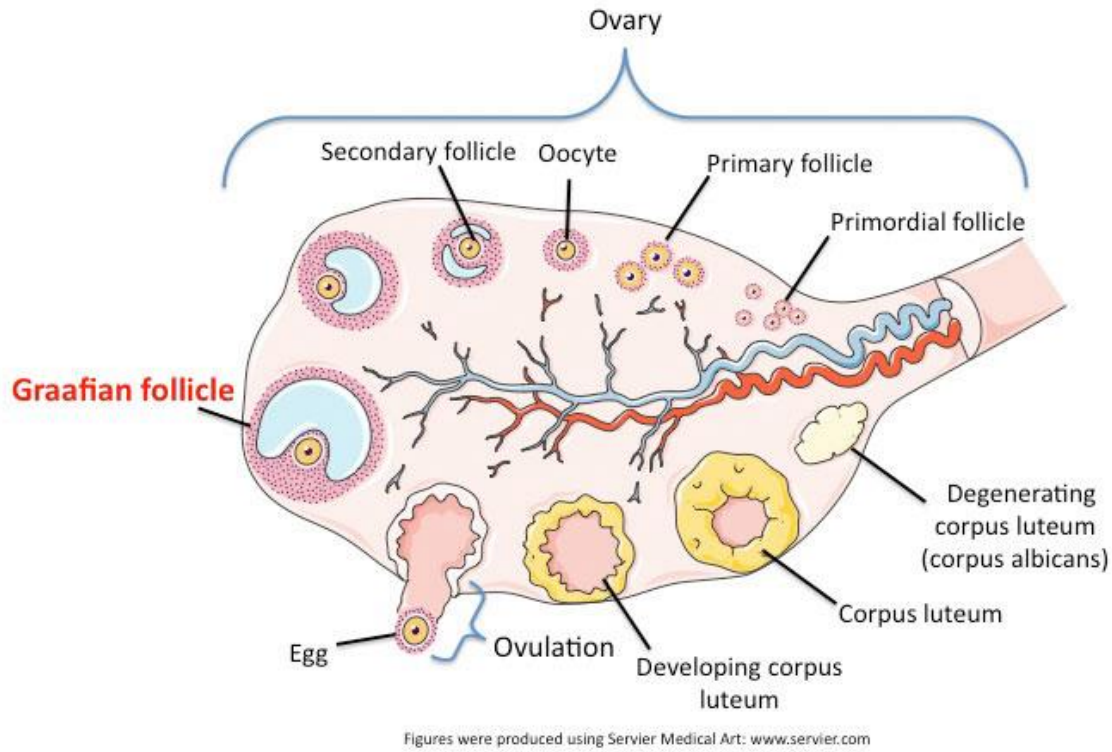
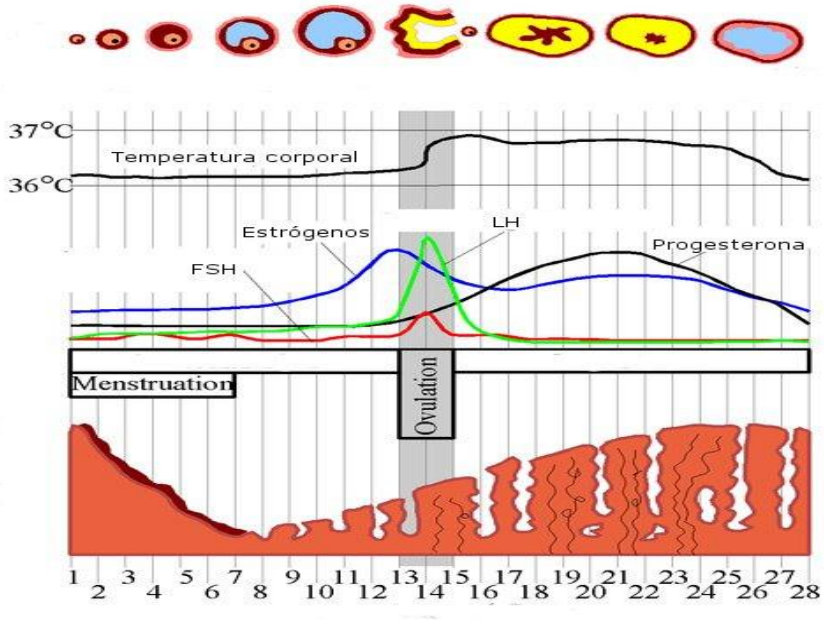
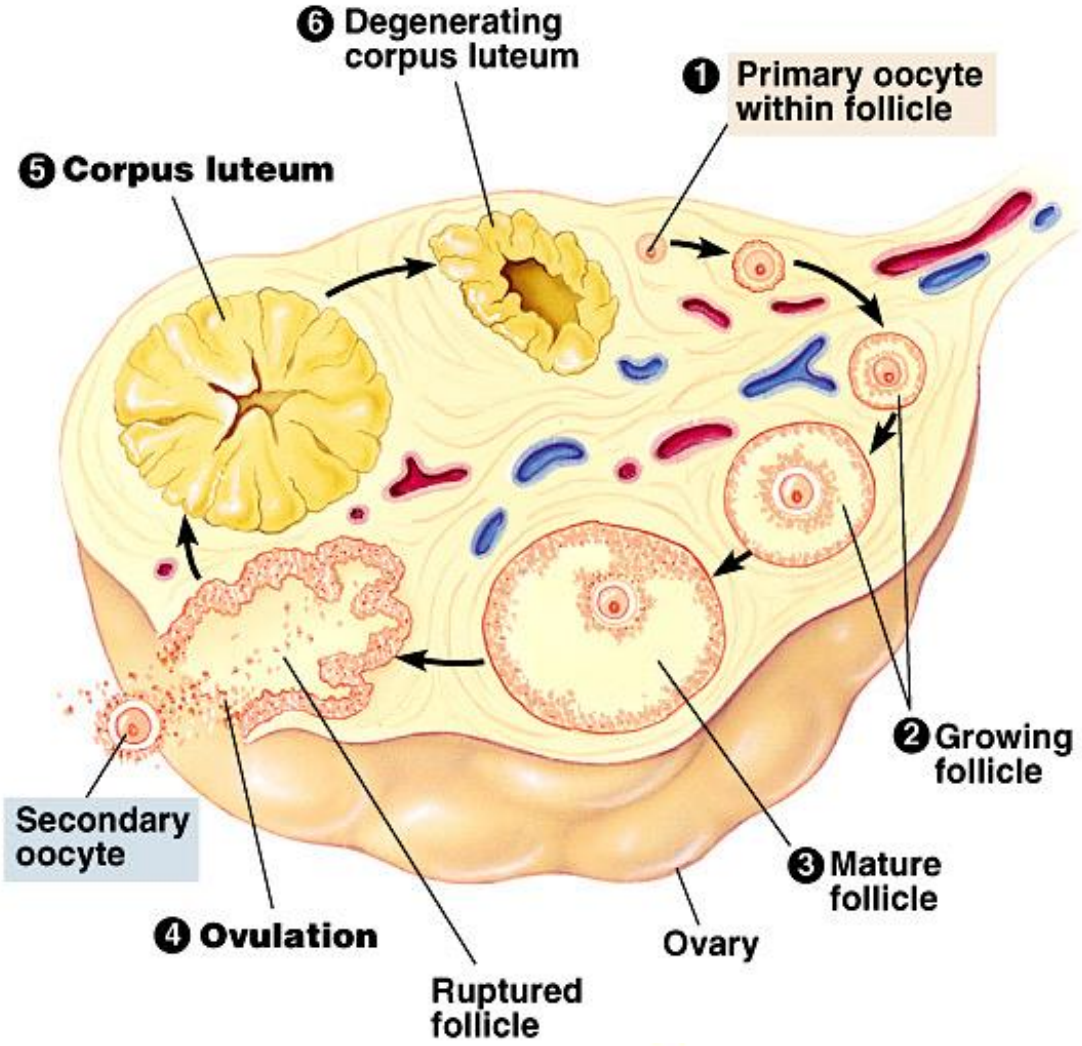


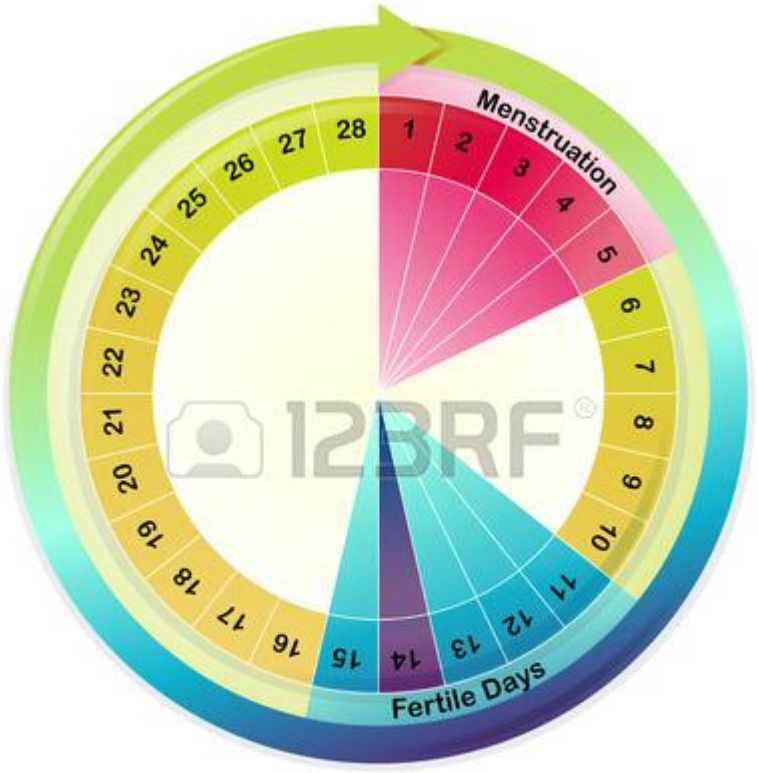
Figures were produced using Servier Medical Art: www.servier.com

- **2.**The corpus luteum produces an increasing amount of progesterone, with some secretion of oestrogen. The progesterone is essential for preparing the endometrium for implantation of embryo if fertilization occurs.
- When the endometrium is stimulated by progesterone it will transform into its secretory phase and attains its full maturity.

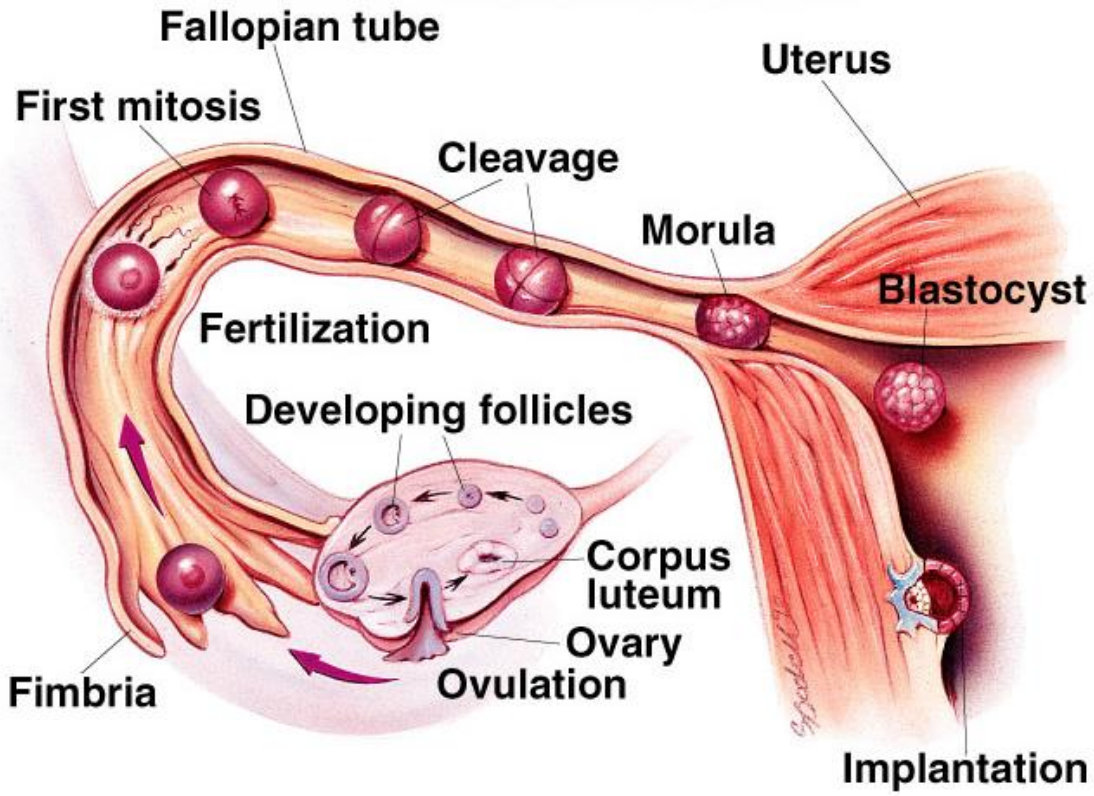


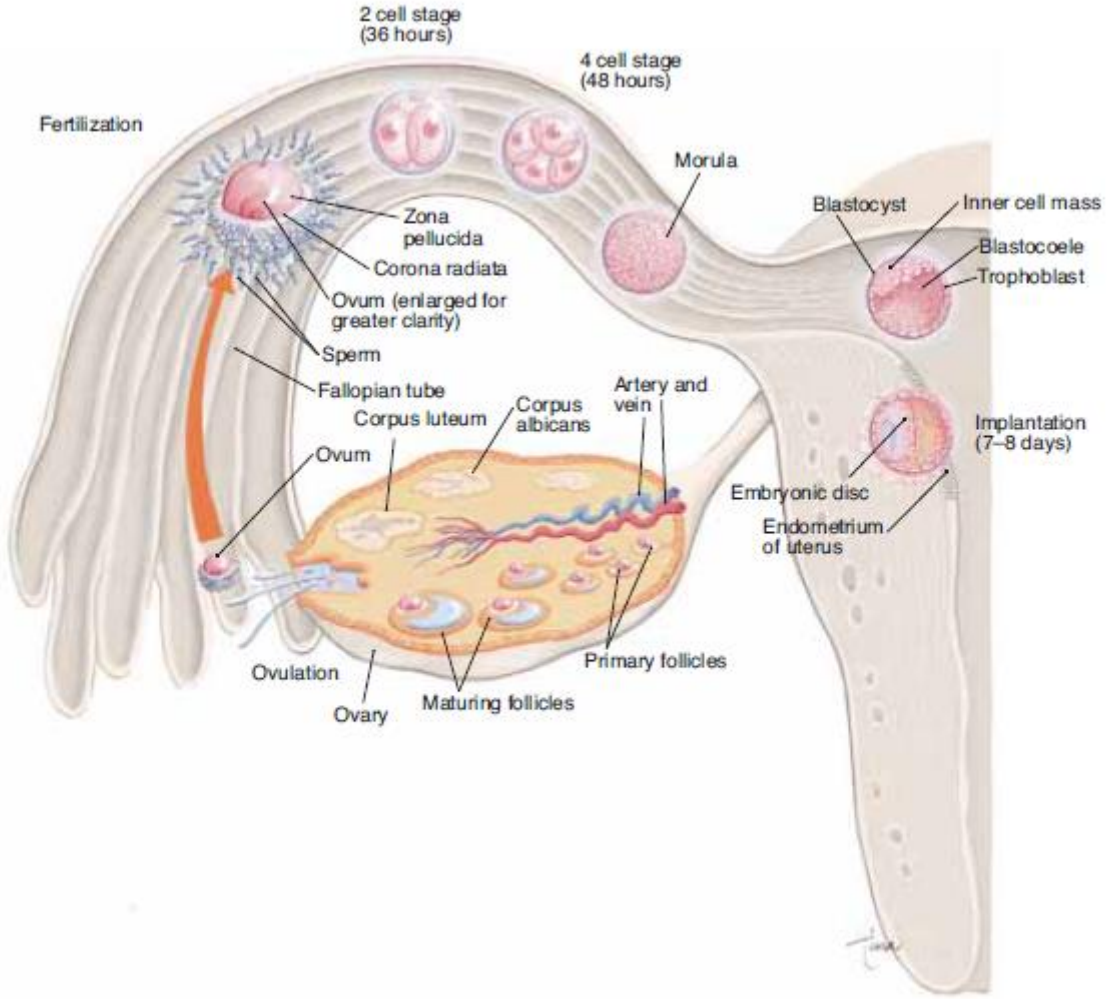
-
- If fertilization does not occur, the corpus luteum will degenerate into a white fibrous scarred tissue called corpus albicans, which leads to a decline in progesterone and oestrogen. The endometrium will then shed and menstruation takes place. The next menstrual cycle begins.





The Menstrual Cycle
About 28 Days


Fallopian tube
Uterus
First mitosis
Cleavage
Morula
Blastocyst
Fertilization
Developing follicles
Corpus luteum
Ovary
Fimbria
Ovulation
Implantation


2 cell stage (36 hours)
4 cell stage (48 hours)
Fertilization
Morula
Blastocyst
Inner cell mass
Blastocoele
Trophoblast
Zona pellucida
Corona radiata
Ovum (enlarged for greater clarity)
Sperm
Fallopian tube
Corpus luteum
Corpus albicans
Artery and vein
Ovum
Implantation (7–8 days)
Embryonic disc
Endometrium of uterus
Ovulation
Ovary
Maturing follicles
Primary follicles

Functions of placenta:

1. By the 3rd week, the placenta delivers nutrients and oxygen to and removes waste from the embryonic blood. All exchange occurs through placenta barrier.
2. By the end of 2nd month of pregnancy, the placenta becomes an endocrine organ and produces estrogen, progesterone and other hormones that help to maintain the pregnancy.

Hormones secreted by placenta.

A. Human chorionic gonadotropin (hcG), secreted during very early pregnancy and produced by the conceptus and then by the fetal part of the placenta.

Function:

- Similar to LH, hcG stimulates the corpus luteum of the ovary to continue producing estrogen and progesterone so that the lining of the uterus is not sloughed off in menses.

B. Estrogen and progesterone: produced by placenta in the third month of pregnancy because the ovaries become inactive in this stage of pregnancy.

Function:

1. Stimulate uterine lining growth.
2. Prepare the breasts for producing milk.

C. Human placental lactogen (hpl):

Works cooperatively with estrogen and progesterone in preparing the breast for lactation.

D. Relaxin: causes the mother's pelvic ligaments and the *pubic symphysis* to relax and become more flexible, which eases birth passage.

Chapter -8

Male Reproductive System

It composed from the following organs :

Testis , **Epididymis**, ductus deferens (vas deference) and urethra

Testis .

The testes (testicles) are the primary male reproductive organs.

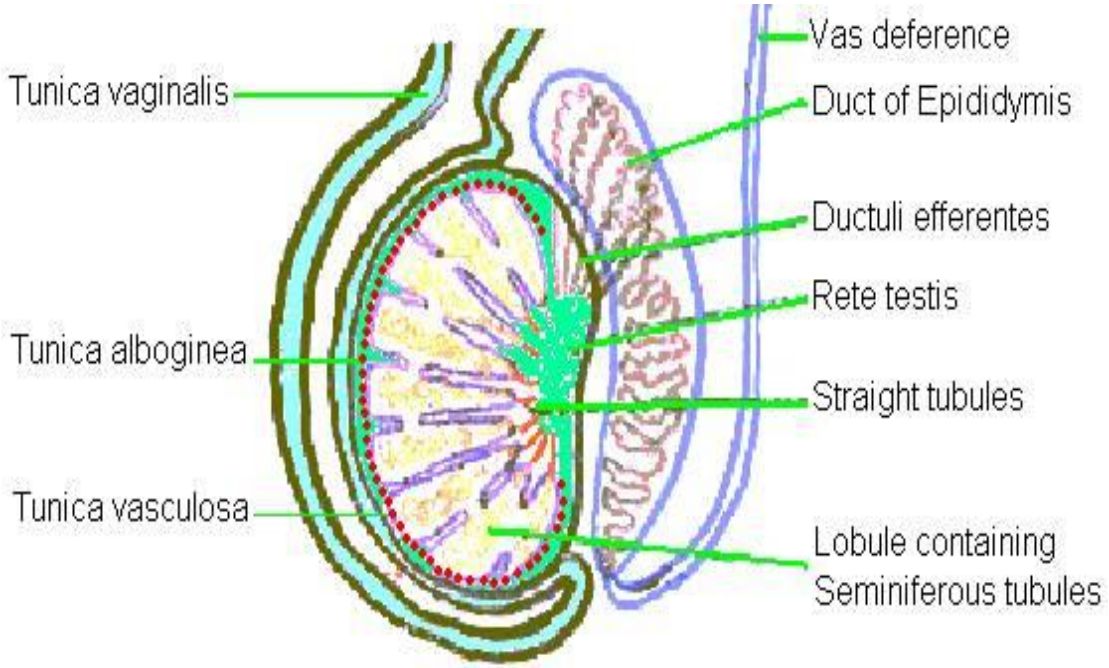
The testes are firm, mobile organs. They are normally two testes approximately

5 cm long, 3 cm wide. Weighing 10–15 g each, the testes are suspended outside the body in a sac called the scrotum.

The testes consist of a series of tubules covered by a multi-layered tunica which covers the testes, It facilitate blood supply to the testes and divide the testis into many parts .

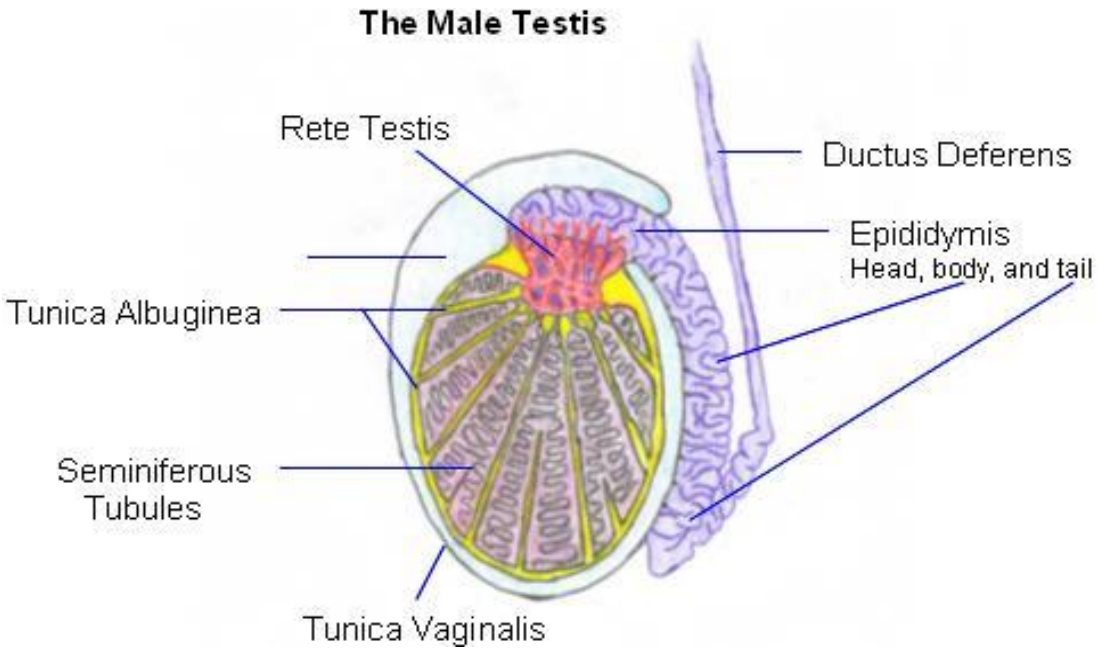
There are three layers to the tunica :

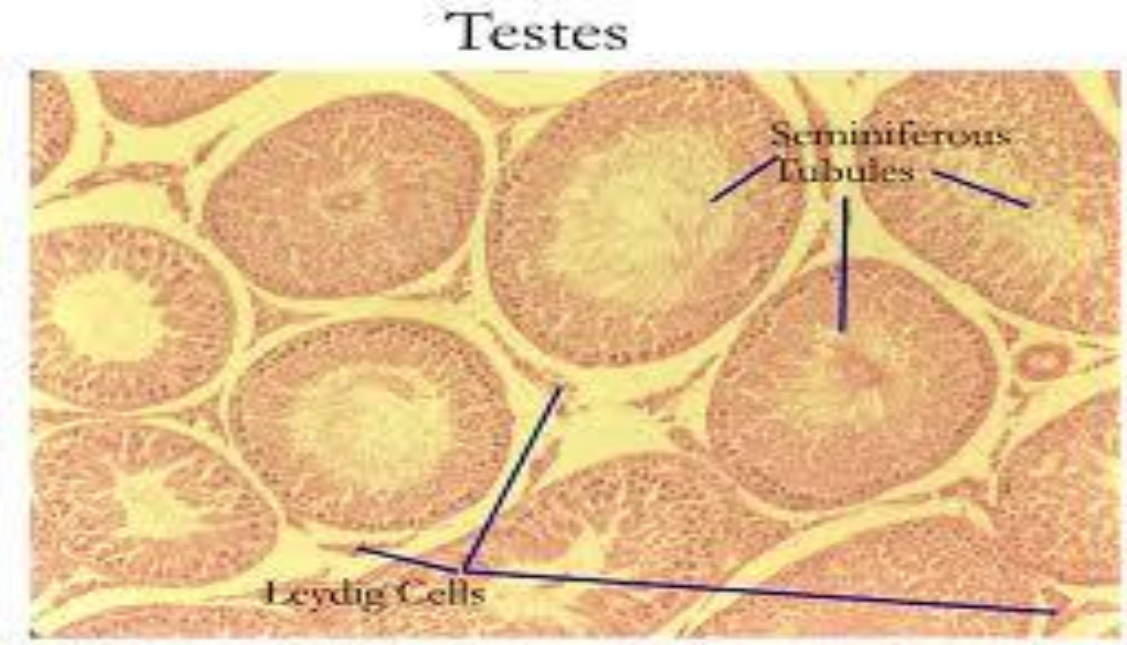
Tunica vasculosa: inner layer
Tunica albuginea : middle layer
Tunica vaginalis. : outer layer



The inside of the testes is divided into small compartments known as lobules. Each lobule contains a section of seminiferous tubule and are separated by partitions, which are extensions of the tunica albuginea, .

---Each lobule contains 1–4 seminiferous tubules and
---Each testis may contain up to 900 of these tubules. which are tightly coiled within the testis.





Functions of testes:

a. Producing the sperms (inside seminiferous tubules by sertoli cells)
b. Producing the testosterone hormone by leydig cell(outside seminiferous tubules)

Duct system

There are a series of ducts and tissues **(duct system)** which play an in transporting sperm from the testes and these are :

a. Epididymis, b. ductus deferens (vas deference) c. urethra.

a. **Epididymis**: It is a highly coiled tube about 6m long that caps the superior part of the testis and then runs down its postero- lateral side.

Epididymis is the first part of the duct system.

Function of epididymis:

1. Provides temporary storage site for the immature sperm until the sperm becomes completely matured. (About 20 days)
2. Expels the sperm into the ductus deferens,

b. Ductus deferens (vas deferens) :

Runs upwards from the epididymis through the inguinal canal into the pelvic cavity and arch over the superior aspect of the bladder.

This tube is enclosed in a connective tissue sheath called the spermatic cord.

The end of the ductus deferens empties into the ejaculatory duct, which passes through the prostate gland to merge with the urethra.

Functions:

Propels sperm from the epididymis into the urethra.

c. Urethra: It is the terminal part of the male duct system

It has three regions:

1. Prostatic urethra
2. Membranous urethra
3. Spongy urethra

Function of male urethra: It carries both urine and sperm to outside of the body

Accessory glands :

The accessory glands of male reproductive system include: -

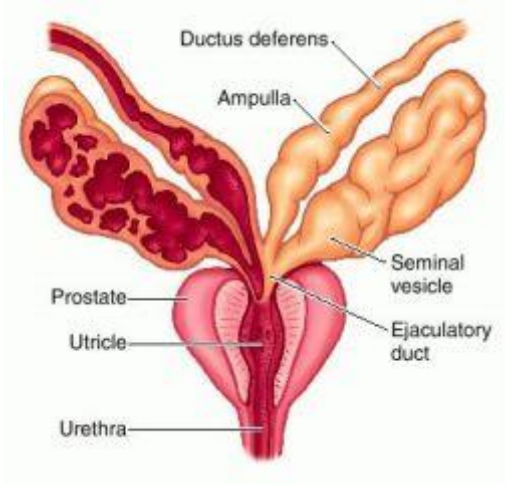
a. Seminal vesicles
b. Prostate gland
c. Bulb urethral glands(cowper's gland

a. Seminal Vesicles

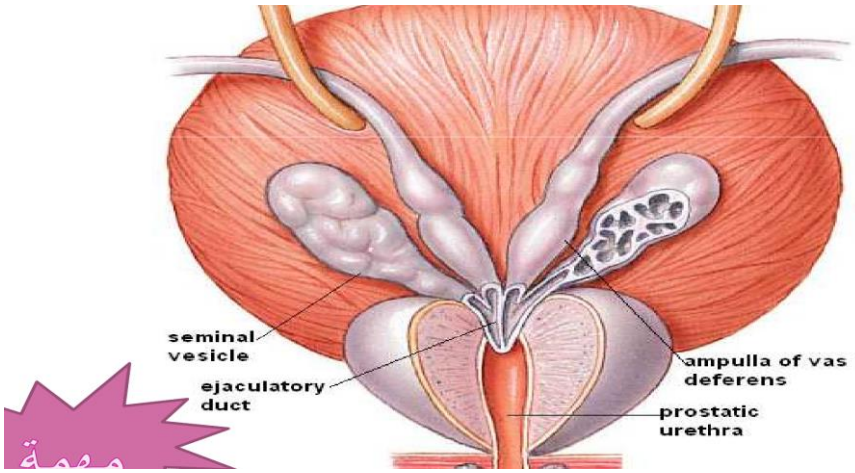
. a. Pair of exocrine glands
. b. About 2 inches in length
, c. Produces about 60% of the fluid volume of semen

It produce thick yellowish fluid rich in sugar (fructose), vitamin C, prostaglandin and other substances, **which nourish and activate the sperm passing through the tract**.

Each seminal vesicle joins the ductus deferens on the same side to form the ejaculatory



duct.



b. Prostate gland: It is a single gland about the size and shape of a chestnut.

It encircles the upper part of the urethra just below the bladder.

Function: Secreting a milky fluid that plays a role in activating sperm, **and contributes with sperm motility**.

c. Bulb urethral glands (**Cowper's Glands**):

are tiny, pea-sized glands inferior to the prostate gland.

Functions:

Produce thick clear mucus that drain into the urethra to clean it from traces of acidic urine.

Spermatogenesis:

Sperm production or spermatogenesis begins during puberty and continues throughout life. **Sperm formation occurs in the seminiferous tubules of the testis.**

Testosterone production:

The interstitial cells (leydig cells) produce **testosterone**, **the most important hormonal product of the testes.**

During puberty, the interstitial cells are being activated by Luteinizing hormone (LH), (which is released by the anterior pituitary gland), to form testosterone.

Functions of testosterone:

1. Develop the reproductive organs to their adult size.
2. Enhance the appearance of secondary sex characteristics, which includes: -
    - Deepening of voice due to enlargement of the larynx.
    - Increase hair growth all over the body .
    - Enlargement of skeletal muscles.
    - Increased heaviness of the skeleton due to thickening of the bone.