PITUITARY GLAND HORMONES

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❖ Pituitary gland:

- **Also it called the *hypophysis,* is a small gland—about 1 centimeter in diameter and 0.5 to 1 gram in weight(lies in the *sella turcica-* a bony cavity at the base of the brain) and is connected to the hypothalamus by the *pituitary stalk.***

- **The pituitary gland is divisible into two distinct portions:**

- ➤ **The *anterior pituitary,* also known as the *adenohypophysis.***

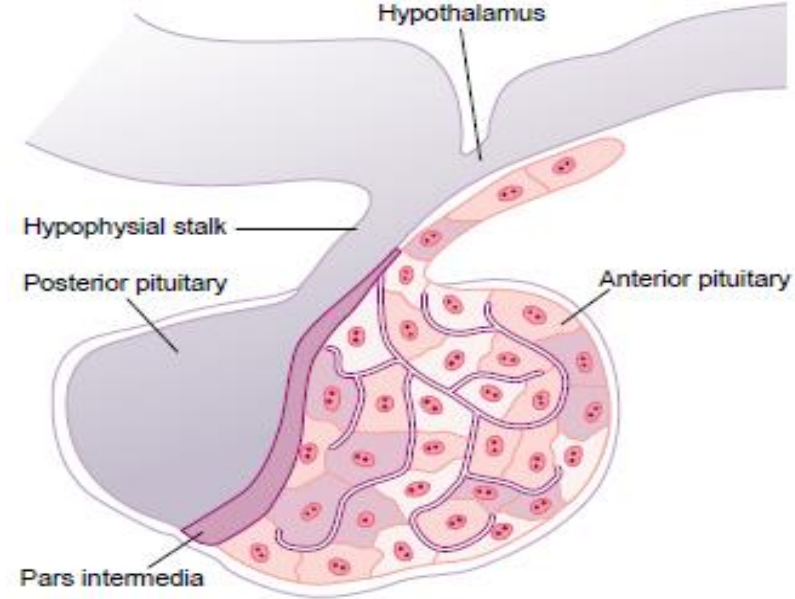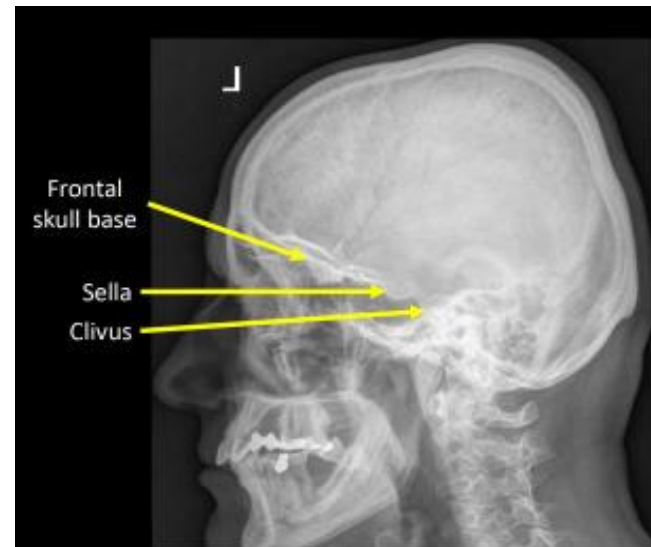- ➤ **The *posterior pituitary,* also known as the *neurohypophysis*.**

Hypothalamus

Hypophysial stalk

Posterior pituitary

Anterior pituitary

Pars intermedia

Figure 75–1

Pituitary gland.

Frontal skull base

Sella

Clivus

❖ **Six important peptide hormones are secreted by the *anterior* pituitary:**

1) *Growth hormone:* promotes growth of the entire body.

2) *Adrenocorticotropin (corticotropin):* controls the secretion of some of the adrenocortical hormones.

3) *Thyroid-stimulating hormone (thyrotropin):* controls the rate of secretion of thyroxine and triiodothyronine by the thyroid gland.

4) *Prolactin:* promotes mammary gland development and milk production.

5) *Follicle - stimulating hormone.*

6) Luteinizing hormone.

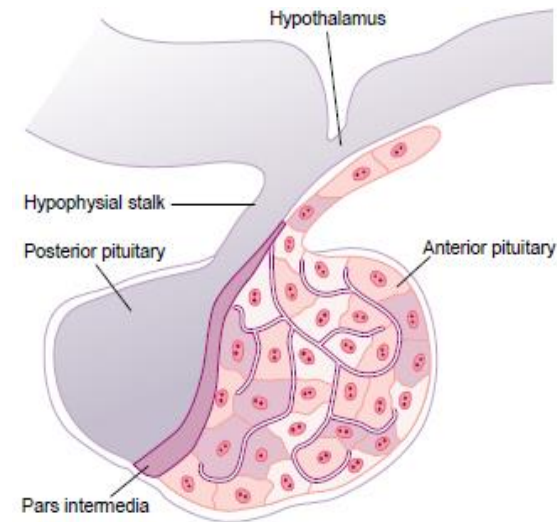▪ Control growth of the ovaries and testes, as well as reproductive activities.

Figure 75–1

Pituitary gland.

❖ **The two hormones secreted by the posterior pituitary:**

1) **Antidiuretic hormone (vasopressin): ADH controls the rate of water excretion into the urine, thus helping to control the concentration of water in the body fluids.**

2) *Oxytocin:* **helps express milk from the glands of the breast to the nipples during suckling; and possibly helps in the delivery of the baby at the end of gestation.**
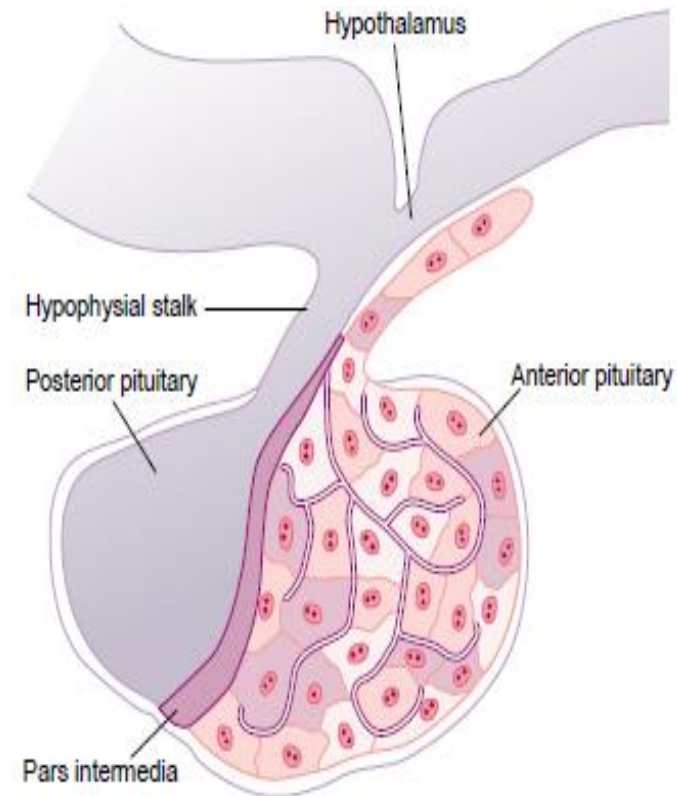

Hypothalamus

Hypophysial stalk

Posterior pituitary

Anterior pituitary

Pars intermedia

Figure 75–1

Pituitary gland.

❖ Growth Hormone:

❑ Physiological functions of growth hormone.

1) **Growth hormone promotes growth of many body tissues**:

- **It causes growth of almost all tissues of the body that are capable of growing.**

- **It promotes increased sizes of the cells and increased mitosis, with development of greater numbers of cells and specific differentiation of certain types of cells such as bone growth cells and early muscle cells.**

2) Growth hormone has several metabolic effects:

A. Increased rate of protein synthesis in most cells of the body.

B. Increased mobilization of fatty acids from adipose tissue, increased free fatty acids in the blood, and increased use of fatty acids for energy.

C. Decreased rate of glucose utilization throughout the body.

3) Growth hormone stimulates cartilage and bone growth:

(A) Increased deposition of protein by the chondrocytic and osteogenic cells that cause bone growth.

(B) Increased rate of reproduction of these cells.

(C) A specific effect of converting chondrocytes into osteogenic cells, thus causing deposition of new bone.

- **Growth hormone also characteristically increases during the first 2 hours of *deep sleep.***

- **The normal concentration of growth hormone in the plasma of an adult is between 1.6 - 3 ng/ml; in a child or adolescent, it is about 6 ng/ml.**

- **These values often increase to as high as 50 ng/ml after depletion of the body stores of proteins or carbohydrates during prolonged starvation.**
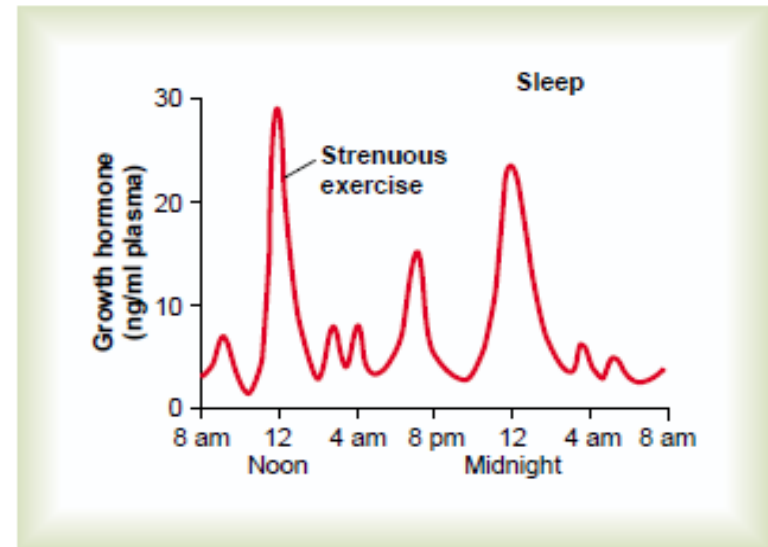

Figure 75–6

Typical variations in growth hormone secretion throughout the day, demonstrating the especially powerful effect of strenuous exercise and also the high rate of growth hormone secretion that occurs during the first few hours of deep sleep.

❖ **Abnormalities of growth hormone secretion panhypopituitarism:**

❑**Dwarfism.**

• **Most instances of dwarfism result from generalized deficiency of anterior pituitary secretion (panhypopituitarism) during childhood.**

❑ Gigantism.

- **Large quantities of growth hormone are produced.**

- **All body tissues grow rapidly, including the bones.**

- **If the condition occurs before adolescence, before the epiphyses of the long bones have become fused with the shafts, height increases so that the person becomes a giant— up to 8 feet tall.**

❑ Acromegaly.

- If an acidophilic tumor occurs after adolescence— that is, after the epiphyses of the long bones have fused with the shafts.

- **The person cannot grow taller, but the bones can become thicker and the soft tissues can continue to grow.**
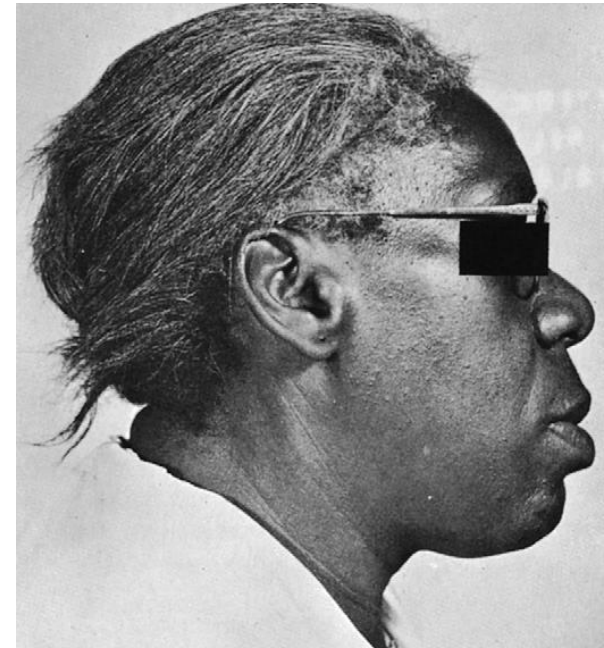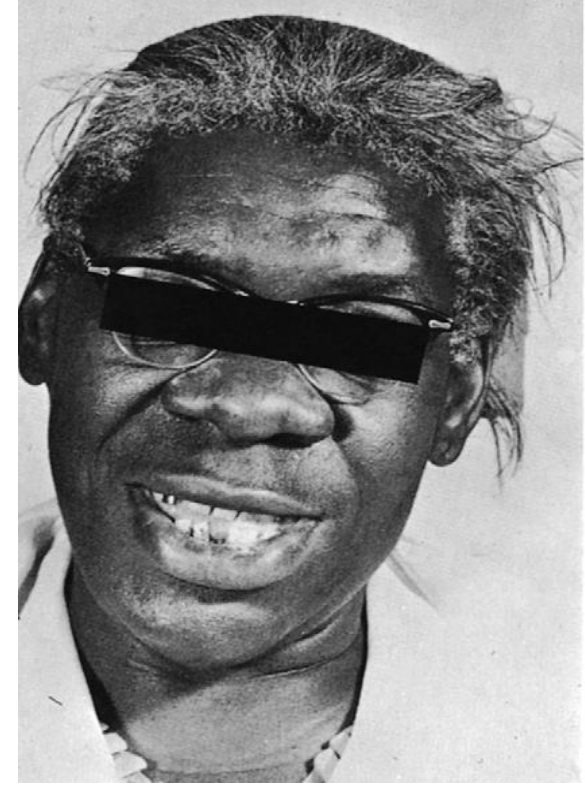
❖**The posterior pituitary hormones are:**

(1) *Antidiuretic hormone* **(ADH),** also called *vasopressin.*

(2) *Oxytocin.*

❖ **Physiological functions of ADH.**

- **ADH can cause decreased excretion of water by the kidneys (antidiuresis).**

- **In the absence of ADH, the collecting tubules and ducts become almost impermeable to water, which prevents significant reabsorption of water and therefore allows extreme loss of water into the urine,(causing dilution of the urine).**
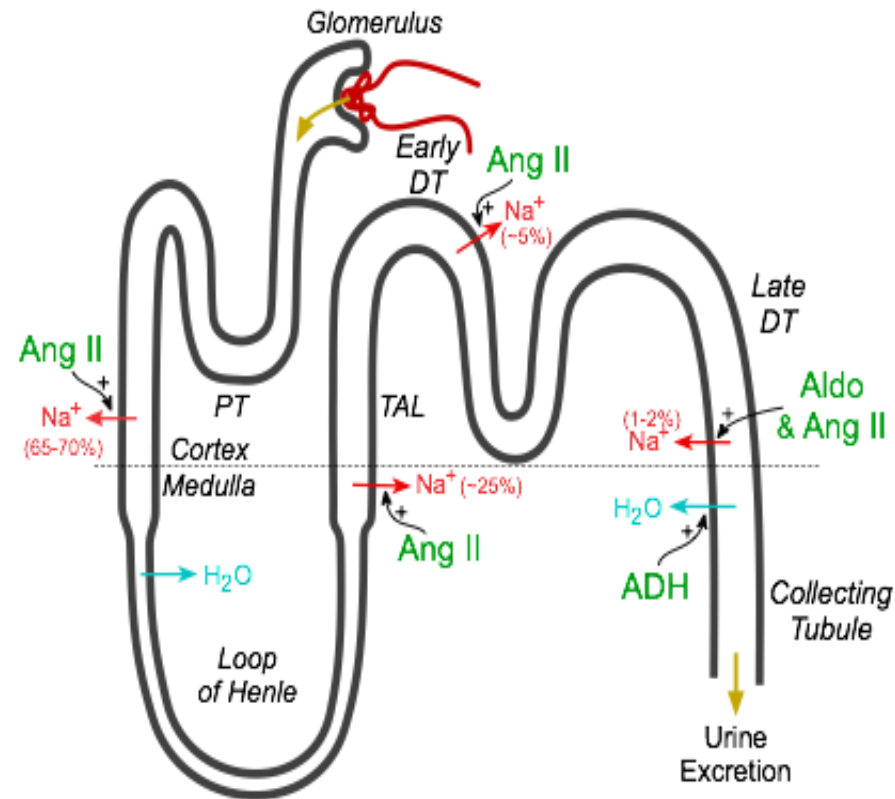
Abbreviations: PT, proximal tubule; TAL, thick ascending limb of loop of Henle; DT, distal tubule; Ang II, angiotensin II; Aldo, aldosterone

- **Conversely, in the presence of ADH, the permeability of the collecting ducts and tubules to water increases greatly and allows most of the water to be reabsorbed as the tubular fluid passes through these ducts, thereby conserving water in the body and producing very concentrated urine.**
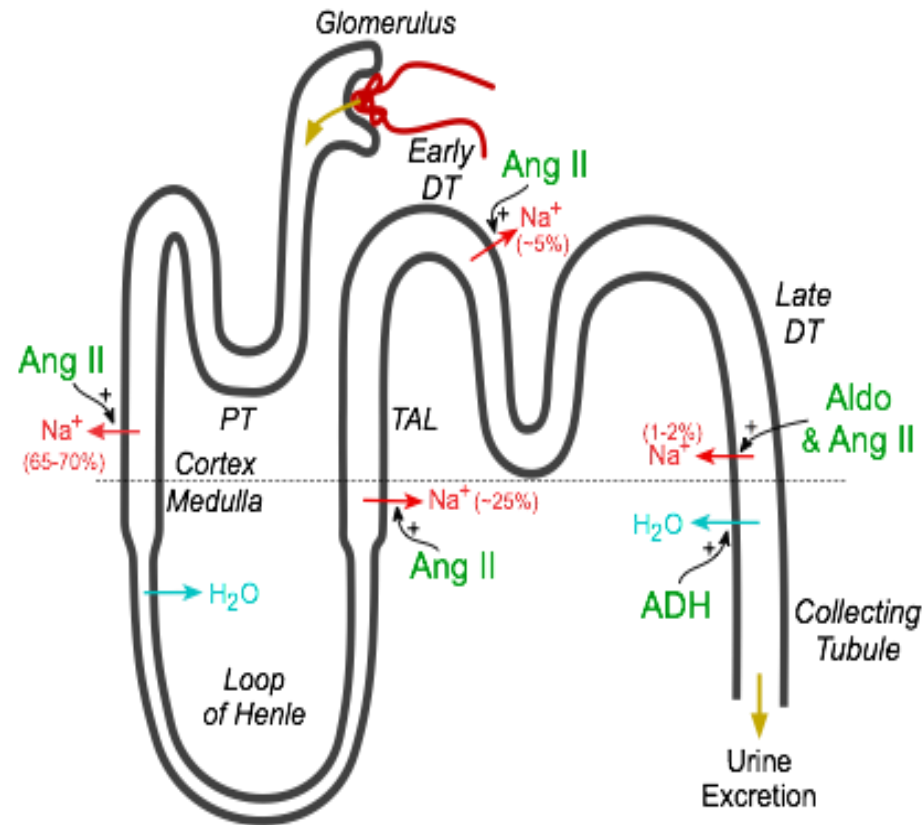
Abbreviations: PT, proximal tubule; TAL, thick ascending limb of loop of Henle; DT, distal tubule; Ang II, angiotensin II; Aldo, aldosterone

❖**Vasoconstrictor and presser effects of ADH, and increased ADH secretion caused by low blood volume**

- **Higher concentrations of ADH have a potent effect of constricting the arterioles throughout the body and therefore increasing the arterial pressure. For this reason, ADH has another name, *vasopressin.***

- **One of the stimuli for causing intense ADH secretion is decreased blood volume.**

- **This occurs strongly when the blood volume decreases 15 -25% or more; the secretory rate then sometimes rises to as high as 50 times normal.**

❖ Oxytocin   hormone:

1) **Powerfully stimulates contraction of the pregnant uterus, especially toward the end of gestation (causing birth of the baby).**

2) **Oxytocin also plays an especially important role in lactation; causing milk expression from the alveoli into the ducts of the breast (so baby can obtain it by suckling).**

THYROID GLAND HORMONES

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❖ The thyroid gland:

- It 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.

PARATHYROID GLAND SYMPTOMS AND TREATMENT

SOUTHLAKE

- **The thyroid secretes two major hormones.**

1. **Thyroxine (T4).**

2. **Tri-iodothyronine (T3).**

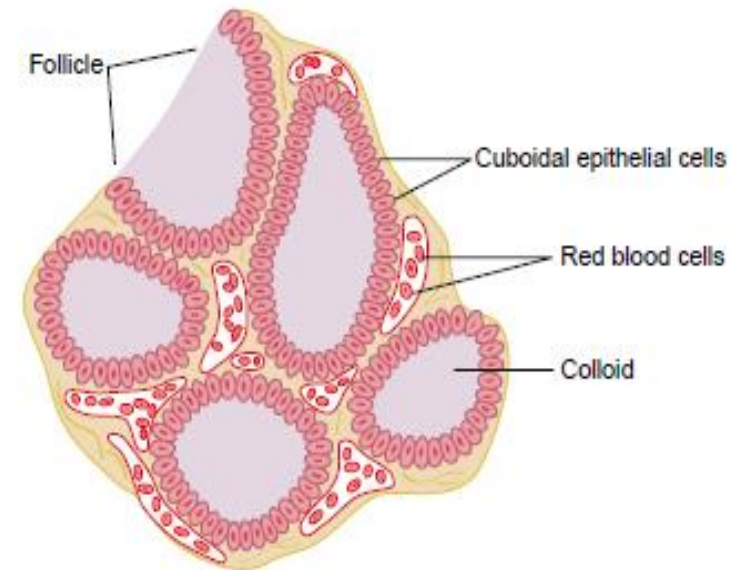Follicle — Cuboidal epithelial cells — Red blood cells — Colloid

Figure 76–1

Microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

- **Both of these hormones profoundly increase the metabolic rate of the body.**

- **Thyroid secretion is controlled primarily by *thyroid stimulating hormone (TSH)* secreted by the anterior pituitary gland.**

- **The thyroid gland also secretes *calcitonin*, an important hormone for calcium metabolism.**
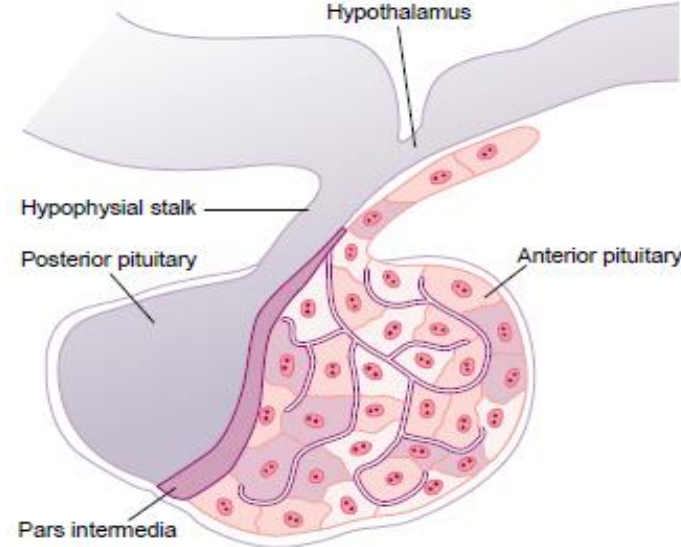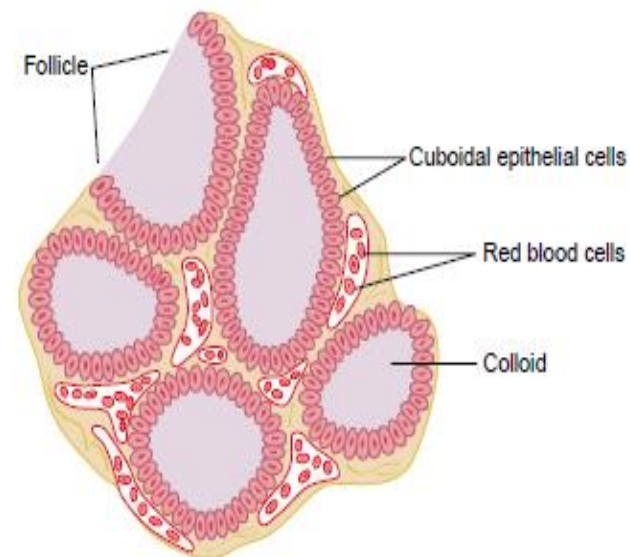

Figure 75–1

Pituitary gland.

Figure 76–1

Microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

❖ **Synthesis and secretion of the thyroid hormones:**

- **About 93% of the metabolically active hormones secreted by the thyroid gland is _thyroxine(T4)_, and 7% _triiodothyronine(T3)._**

- **Almost all the thyroxine is converted to triiodothyronine (T4 ⟶ T3) in the tissues.**

- **Triiodothyronine is about four times as potent as thyroxine, but it is present in the blood in much smaller quantities and persists for a much shorter time than does thyroxine.**
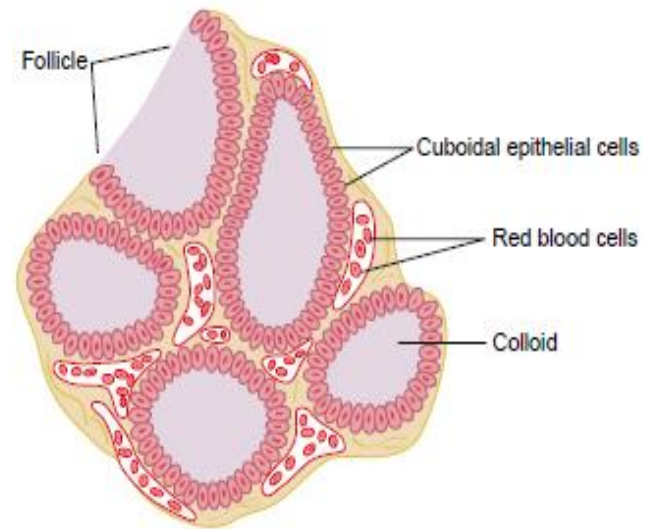

Follicle

Cuboidal epithelial cells

Red blood cells

Colloid

Figure 76–1

Microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

❖ Physiological anatomy of the thyroid gland.

- The thyroid gland is composed of large numbers of closed *follicles* filled with a secretory substance called *colloid* and lined with *cuboidal epithelial cells* that secrete into the interior of the follicles.

- The major constituent of colloid is the large glycoprotein *thyroglobulin,* which contains the thyroid hormones .

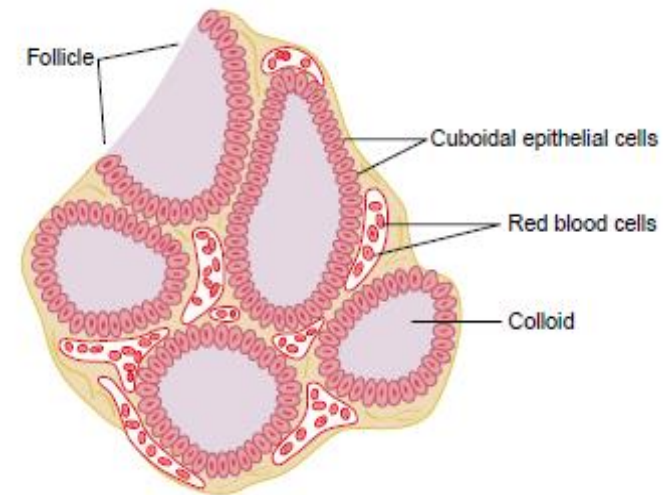- The thyroid gland has a blood flow about five times the weight of the gland each minute.

Figure 76–1

Microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

Labels: Follicle · Cuboidal epithelial cells · Red blood cells · Colloid

❖ **Iodine is required for formation of thyroxin.**

- **To form normal quantities of thyroxine, about 50 mg\year of ingested iodine in the form of iodides are required about *1 mg/week*.**

- **To prevent iodine deficiency, common table salt is iodized with about 1 part sodium iodide to every 100,000 parts sodium chloride.**
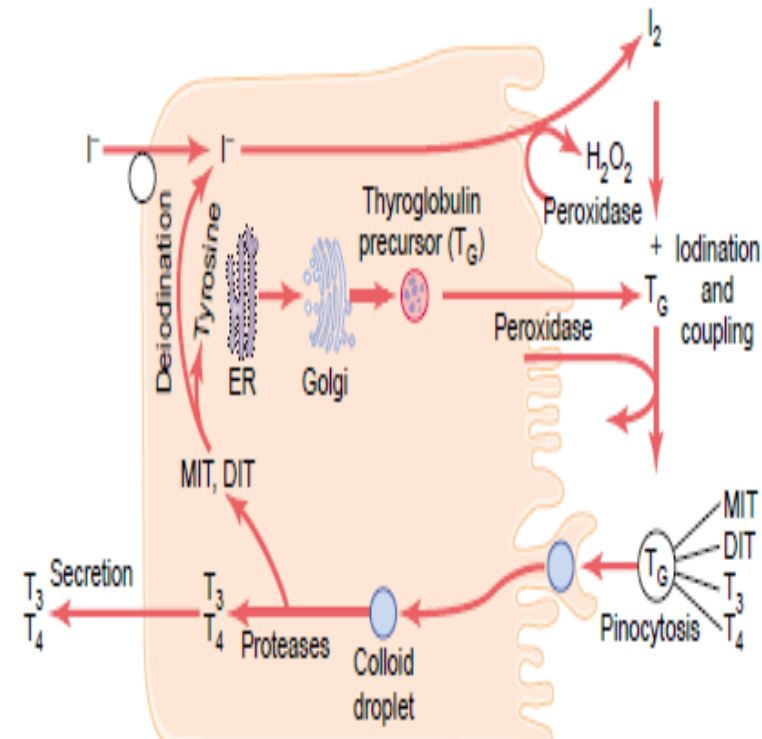
Thyroid cellular mechanisms for iodine transport, thyroxine and triiodothyronine formation, and thyroxine and triiodothyronine release into the blood. MIT, monoiodotyrosine; DIT, diiodotyrosine; T_3, triiodothyronine; T_4, thyroxine; T_G, thyroglobulin.

❖ **Thyroid hormones increase cellular metabolic activity**

- **The thyroid hormones increase the metabolic activities of almost all the tissues of the body.**

- **The basal metabolic rate can increase to 60 to 100% above normal when large quantities of the hormones are secreted.**

- **The rate of utilization of food for energy is greatly accelerated.**

- **Although the rate of protein synthesis is increased, at the same time the rate of protein catabolism is also increased.**

- **The growth rate of young people is greatly accelerated.**

- **The mental processes are excited, and the activities of most of the other endocrine glands are increased.**

❖ Effect of thyroid hormone on growth

- Hyperthyroid, cause excessive skeletal growth, so the child become considerably taller at an earlier age.

- Thyroid hormone promote growth and development of the brain during fetal life and for the first few years of postnatal life.

- The childern who are hypothyroid, the rate of growth is greatly retarded.

- If the fetus does not secrete sufficient quantities of thyroid hormone,the growth and maturation of the brain; before birth and afterward are greatly retarded, and the brain remains smaller than normal.

❖ **Thyroid hormone stimulates almost all aspects of carbohydrate metabolism, including:**

➢ **Rapid uptake of glucose by the cells.**

➢ **Enhanced   glycolysis.**

➢ **Enhanced gluconeogenesis.**

➢ **Increased   rate of absorption from the gastrointestinal tract.**

➢ **Increased insulin secretion with its resultant secondary effects on carbohydrate metabolism.**

❖ **Stimulation of fat metabolism.**

- **Lipids are mobilized rapidly from the fat tissue, which decreases the fat stores of the body.**

- **This also increases the free fatty acid concentration in the plasma and greatly accelerates the oxidation of free fatty acids by the cells.**

❖ Increased basal metabolic rate.

- **Excessive quantities of the thyroid hormone can occasionally increase the basal metabolic rate 60 -100% above normal.**

- **Conversely, when no thyroid hormone is less produced, the basal metabolic rate falls almost to one-half normal.**

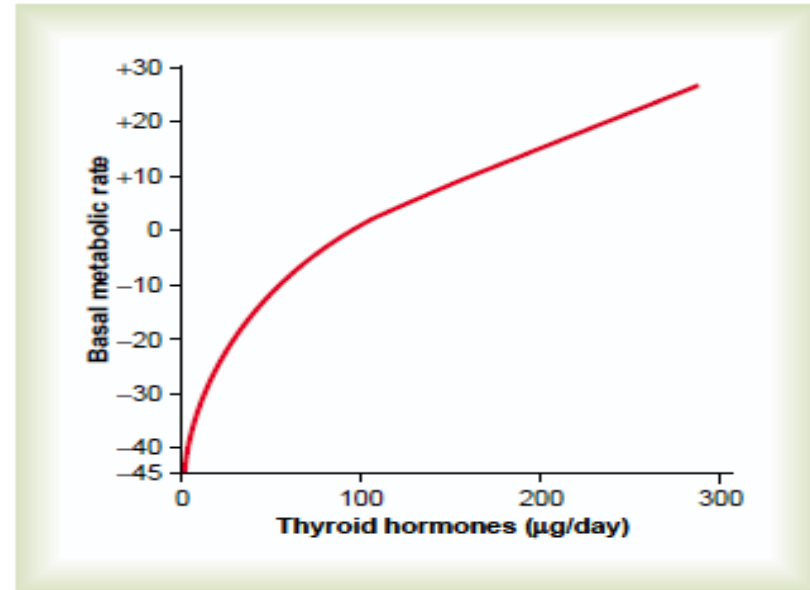

Figure 76–6

Approximate relation of daily rate of thyroid hormone (T$_4$ and T$_3$) secretion to the basal metabolic rate.

❖ **Decreased body weight.**

- **Greatly increased thyroid hormone almost always decreases the body weight.**

- **Greatly decreased hormone almost always increases the body weight.**

- **These effects do not always occur, because thyroid hormone also increases the appetite, and this may counter balance the change in the metabolic rate.**

❖**Effect of thyroid hormones on the cardiovascular system:**

▪ **When there is excessive thyroid hormone is secreted there is:**

1. **Increased heart rate.**

2. **Increased heart strength.**

3. **Normal or slight increase in arterial pressure.**

4. **Increase cardiac output also (60% or more).**

❖ **Increased respiration.**

▪ **The increased rate of metabolism increases the utilization of oxygen and formation of carbon dioxide; these effects activate all the mechanisms that increase the rate and depth of respiration**.

❖ **Increased gastrointestinal motility.**

▪ **Thyroid hormone increase appetite, increase the rates of secretion of the digestive juices and the motility of the gastrointestinal tract.**

❖ **Excitatory effects on the central nervous system.**

▪ **The hyperthyroid individual is likely to have extreme nervousness and many psychoneurotic tendencies, such as anxiety complexes, extreme worry and paranoia.**

❖Muscle tremor.

- One of the most characteristic signs of hyperthyroidism is a fine muscle tremor.

- The tremor can be observed easily by placing a sheet of paper on the extended fingers and noting the degree of vibration of the paper.

❖ **Regulation of thyroid hormone secretion; by TSH (from the anterior pituitary gland).**

1. **Increased proteolysis of the thyroglobulin that stored in the follicles, and release of the thyroid hormones into the circulating blood.**

2. **Increased the rate of "iodide trapping" in the glandular cells.**

3. **Increased iodination of tyrosine to form the thyroid hormones,**

4. **Increased the size, number and secretory activity of thyroid cells plus a change from cuboidal to columnar cells and much infolding of the thyroid epithelium into the follicles.**

Follicle

Cuboidal epithelial cells

Red blood cells

Colloid
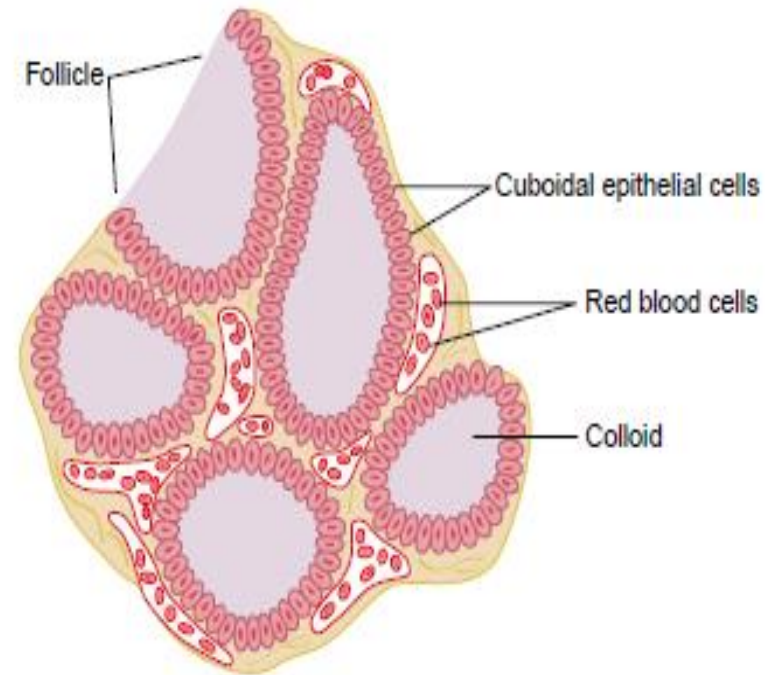
❖ Feedback effect of thyroid hormone to decrease anterior pituitary secretion of TSH

- Increased thyroid hormone in the body fluids decreases secretion of TSH by the anterior pituitary.

- When the rate of thyroid hormone secretion rises to about 1.75 times normal, the rate of TSH secretion falls essentially to zero.

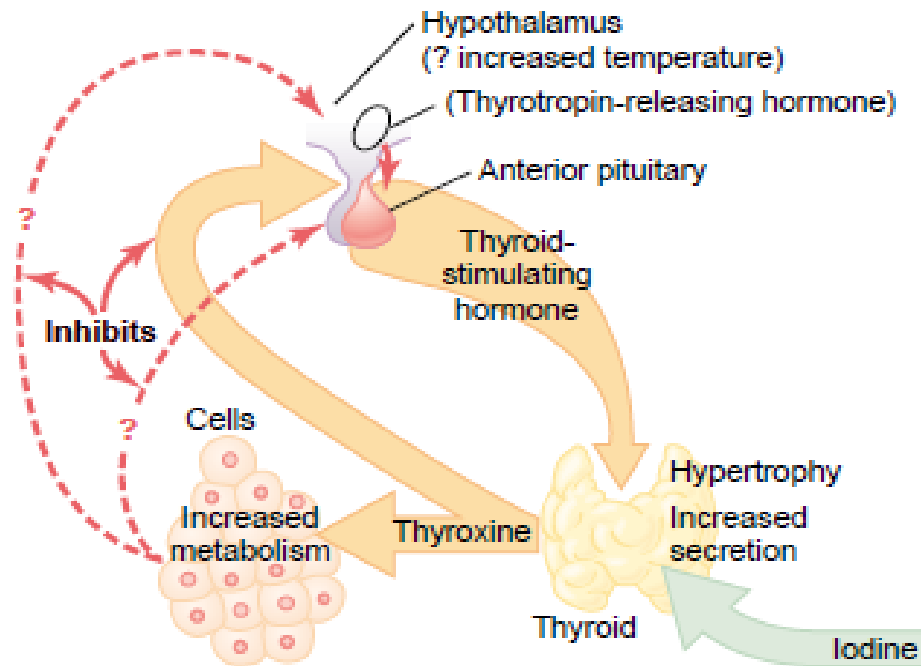- So there is constant concentration of free thyroid hormones in the circulating body fluids.

Hypothalamus (? increased temperature)
(Thyrotropin-releasing hormone)
Anterior pituitary
Thyroid-stimulating hormone
Inhibits
Cells
Increased metabolism
Thyroxine
Hypertrophy
Increased secretion
Thyroid
Iodine

Figure 76–7
Regulation of thyroid secretion.

❖ **Diseases of the thyroid: Hyperthyroidism.**

▪ **In most patients with hyperthyroidism, the thyroid gland is increased to two to three times normal size, with tremendous hyperplasia and infolding of the follicular cell lining into the follicles, so that the number of cells is increased greatly.**
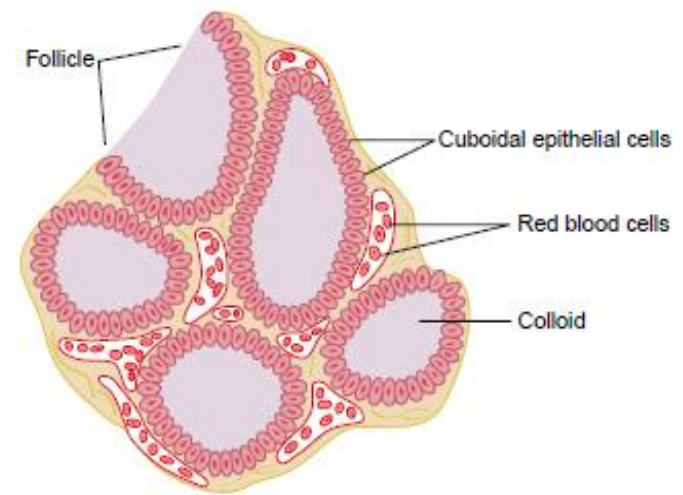

Follicle
Cuboidal epithelial cells
Red blood cells
Colloid

Figure 76-1

Microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

❖Hypothyroidism

- **Hypothyroidism, probably is initiated by autoimmunity against the thyroid gland, that destroyed the gland.**

- **This causes progressive deterioration and finally fibrosis of the gland, with resultant diminished or absent secretion of thyroid hormone.**

- **Several other types of hypothyroidism also occur, often associated with development of enlarged thyroid glands, called *thyroid goiter*, as follows.**
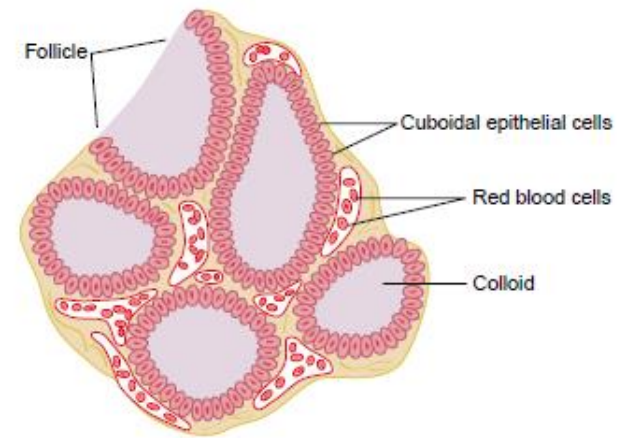

Figure 76-1

Microscopic appearance of the thyroid gland, showing secretion of thyroglobulin into the follicles.

❖ **Endemic colloid goiter caused by dietary iodide deficiency.**

- **The term "goiter" means a greatly enlarged thyroid gland. about 50 mg \year(1mg\week) of iodine are required for the formation of adequate quantities of thyroid hormone.**

- In certain areas of the world, insufficient iodine is present in the soil for the foodstuffs to contain even this minute quantity.

- **Therefore, in the days before iodized table salt, many people who lived in these areas developed extremely large thyroid glands, called *endemic goiters*.**

❖ **The mechanism for development of large endemic goiters is the following:**

- **Lack of iodine prevents production of both thyroxine(T4) and triiodothyronine(T3).**

- **As a result, no hormone is available to inhibit production of TSH by the anterior pituitary; this causes the pituitary to secrete excessively large quantities of TSH.**

- **The TSH then stimulates the thyroid cells to secrete tremendous amounts of thyroglobulin colloid into the follicles, and the gland grows larger and larger.**

- **But because of lack of iodine, thyroxine and triiodothyronine production does not occur in the thyroglobulin molecule and therefore does not cause the normal suppression of TSH production by the anterior pituitary.**

- **The follicles become tremendous in size, and the thyroid gland may increase to 10 to 20 times normal size.**
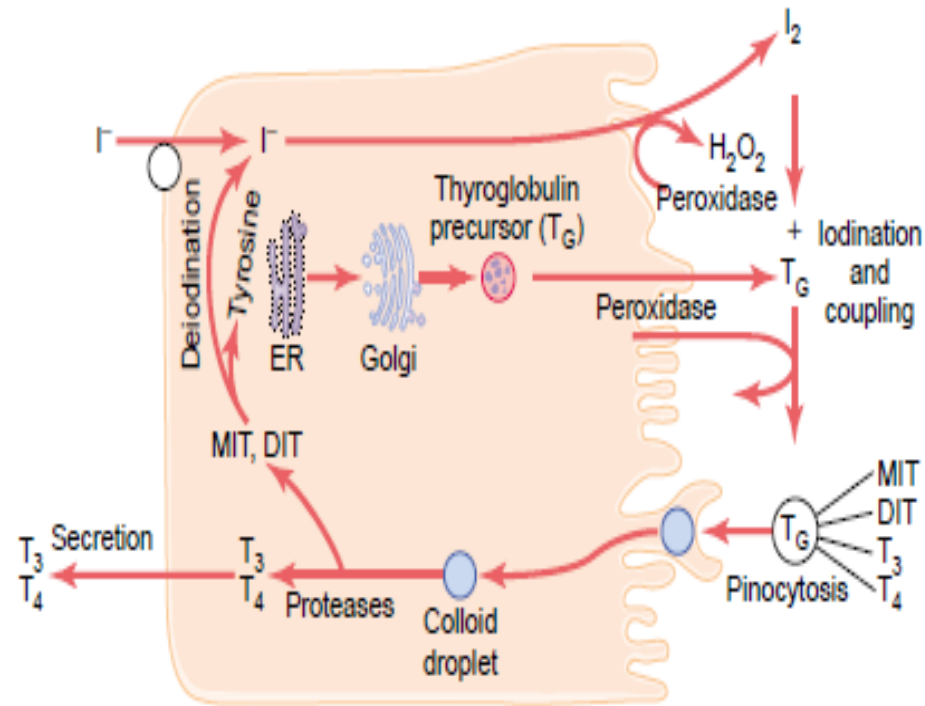

Figure 76-2

Thyroid cellular mechanisms for iodine transport, thyroxine and triiodothyronine formation, and thyroxine and triiodothyronine release into the blood. MIT, monoiodotyrosine; DIT, diiodotyrosine; T_3, triiodothyronine; T_4, thyroxine; T_G, thyroglobulin.

THANK YOU

DIGESTIVE SYSTEM

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ماجستير فسلجة طبية

- **The human digestive system consists of the gastrointestinal tract plus the accessory organs of digestion tongue, salivary glands, pancreas, liver, and gallbladder).**

- **Digestion involves the breakdown of food into smaller and smaller components, until they can be absorbed and assimilated into the body.**
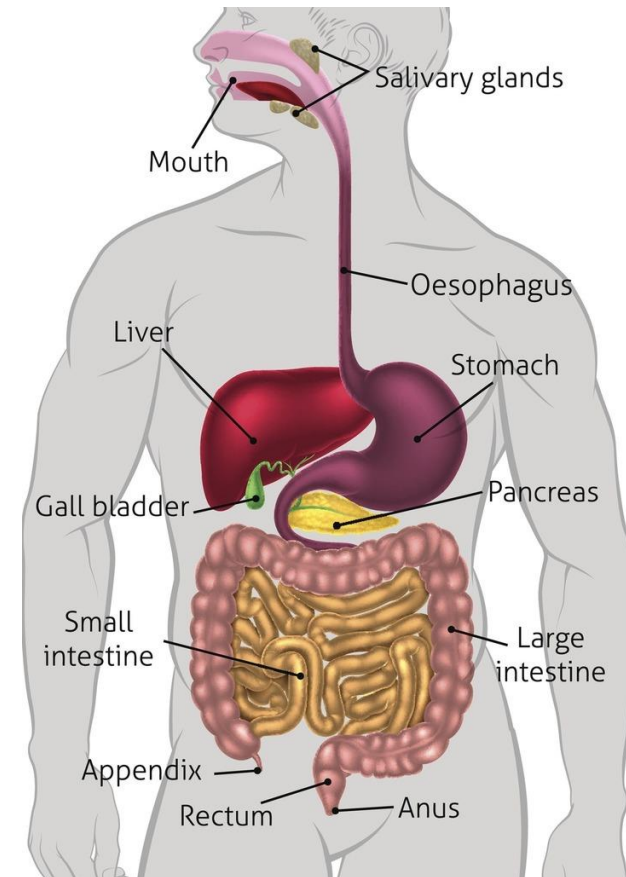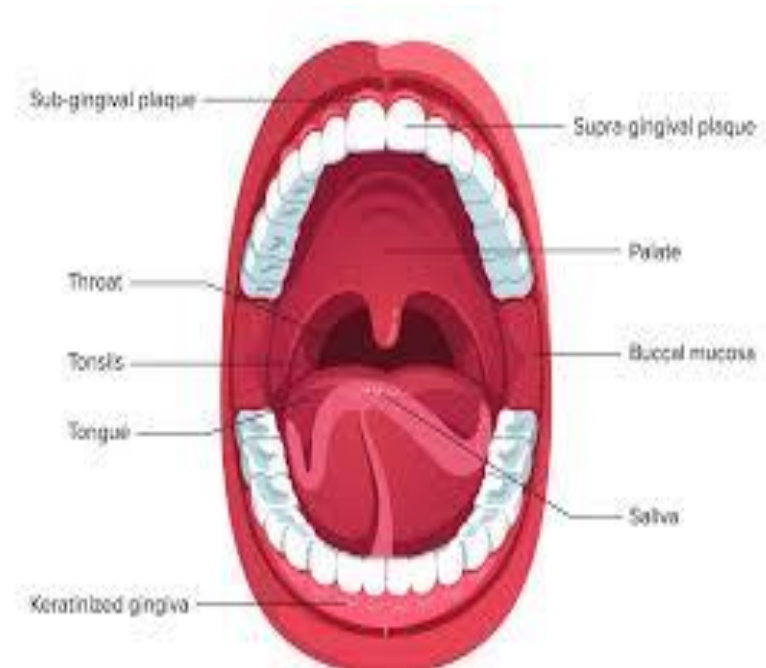
❖ **The process of digestion has three stages.**

1) **The cephalic phase of digestion:**

▪ **which begins with gastric secretions in response to the sight and smell of food.**

▪ **It includes the mechanical breakdown of food by chewing, and the chemical breakdown by digestive enzymes, that takes place in the mouth.**
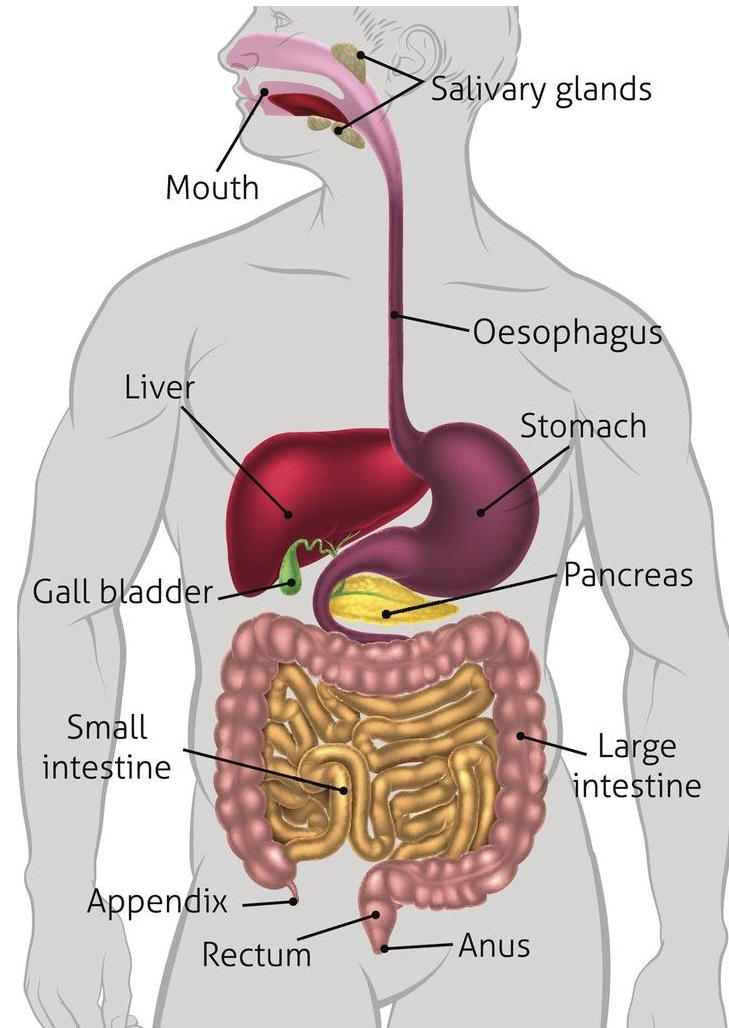
- **The mouth contains digestive enzymes called amylase, and lingual lipase, secreted by the salivary glands and serous glands on the tongue.**

- **The enzymes start to break down the food in the mouth.**

- **Chewing, in which the food is mixed with saliva, begins the mechanical process of digestion.**

- **This produces a bolus which can be swallowed down the esophagus to enter the stomach.**

Sub-gingival plaque

Supra-gingival plaque

Palate

Throat

Tonsils

Buccal mucosa

Tongue

Saliva

Keratinized gingiva

2) Gastric phase of digestion:

- **In the stomach the food is further broken down by mixing with gastric acid until it passes into the duodenum.**

3) Intestinal phase of digestion:

- **In the duodenum; where it is mixed with a number of enzymes produced by the pancreas.**
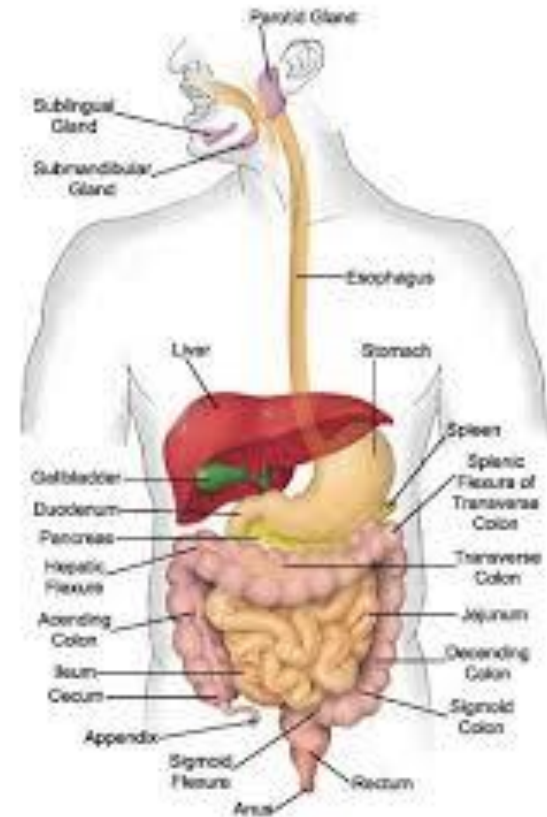
- **Peristalsis is the rhythmic contraction of muscles that begins in the esophagus and continues along the wall of the stomach and the rest of the gastrointestinal tract (GIT).**

- **Most of the digestion of food takes place in the small intestine.**

- **Water and some minerals are reabsorbed back into the blood in the colon of the large intestine.**

- **The waste products of digestion (feces) are defecated from the anus via the rectum.**
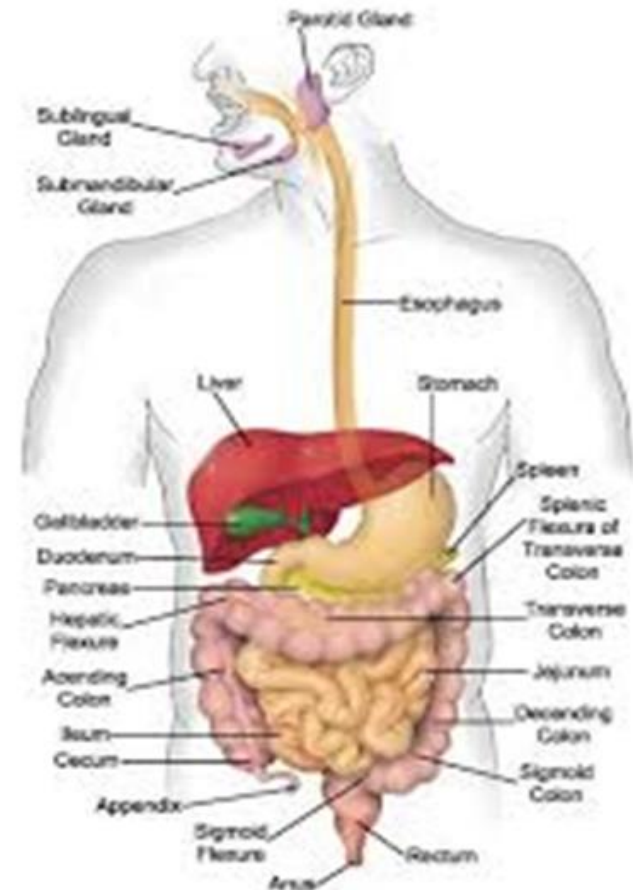
- There are several **organs** and other **components** involved in the digestion of food.

➢ **The organs known as the accessory digestive organs are the:**

- **Liver.**
- **gall bladder.**
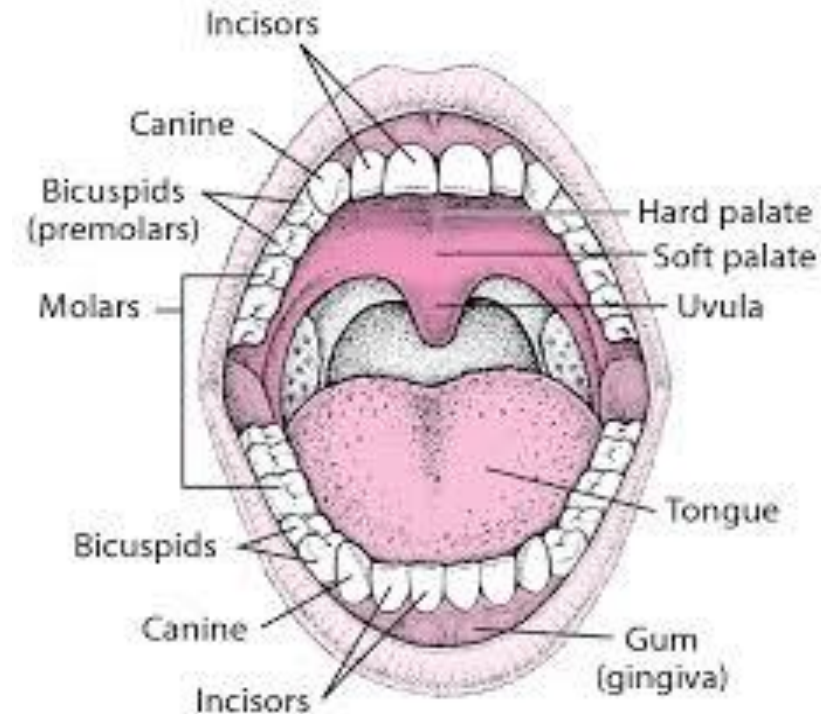- **pancreas.**

➢ **Other components include the:**

- **mouth.**
- **salivary glands.**
- **Tongue.**
- **Teeth.**
- **epiglottis.**

- **The digestive system starts at the mouth and ends at the anus, covering a distance of about nine (9) metres.**

- **The largest part of the gastro-intestinal tract (GIT) is the colon or large intestine; Water is absorbed here and the remaining waste matter is stored prior to defecation.**

- **Most of the digestion of food takes place in the small intestine which is the longest part of the GI tract.**
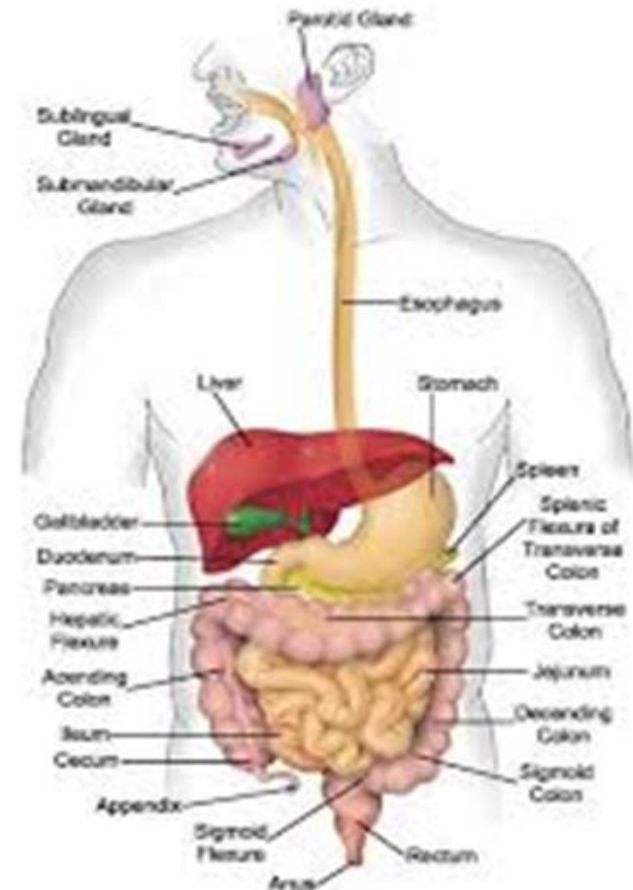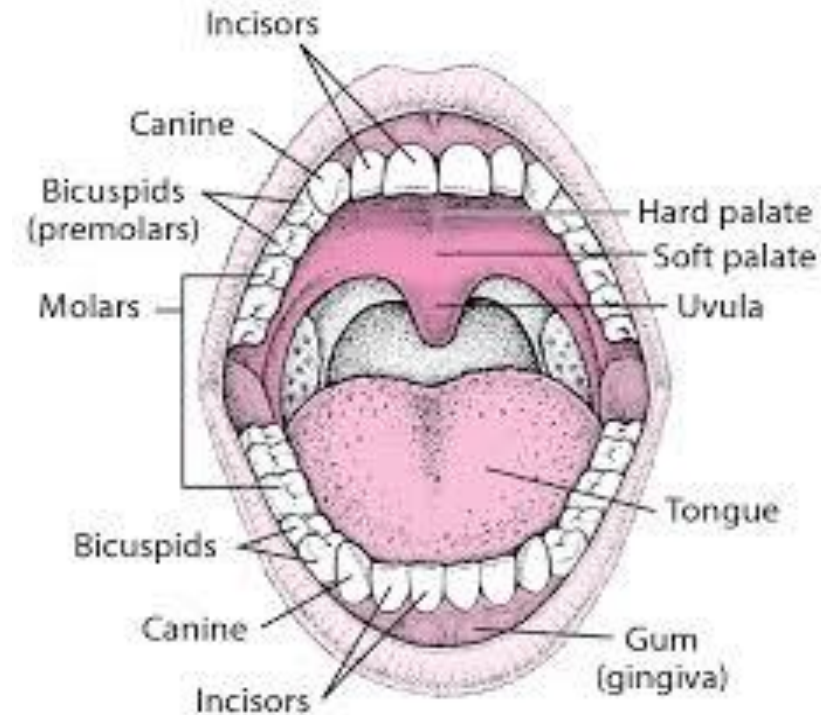
❖ The mouth:

- **Is the first part of the upper gastrointestinal tract and is equipped with several structures that begin the first processes of digestion.**

- **These include salivary glands, teeth and the tongue.**

- **The mouth consists of two regions:**

1) **The vestibule.**

2) **The oral cavity proper.**

- **The vestibule is the area between the teeth, lips and cheeks, and the rest is the oral cavity proper.**

Incisors
Canine
Bicuspids (premolars)
Molars
Bicuspids
Canine
Incisors
Hard palate
Soft palate
Uvula
Tongue
Gum (gingiva)

- **Most of the oral cavity is lined with oral mucosa, a mucous membrane that produces a lubricating mucus.**

- **The mucous membrane in the mouth continues as the thin mucosa which lines the bases of the teeth, cheeks, inner surfaces of the lips, and floor of the mouth,**

Incisors

Canine

Bicuspids (premolars)

Molars

Bicuspids

Canine

Incisors

Hard palate

Soft palate

Uvula

Tongue

Gum (gingiva)

- The main component of mucus is a **glycoprotein** called **mucin** and the type secreted varies according to the region involved.

- **Mucin is:** a viscous, clear, and clinging; the mucin produced is highly protective against tooth decay.

- Mucus helps in the mastication of food in its ability to **soften** and **collect** the food in the formation of the **bolus**.

Salivary gland ducts
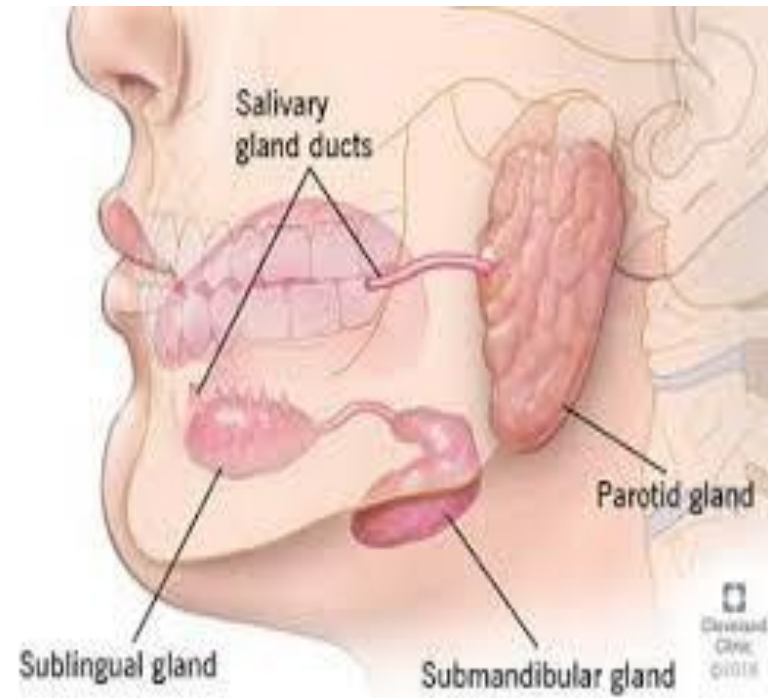
Parotid gland

Sublingual gland

Submandibular gland
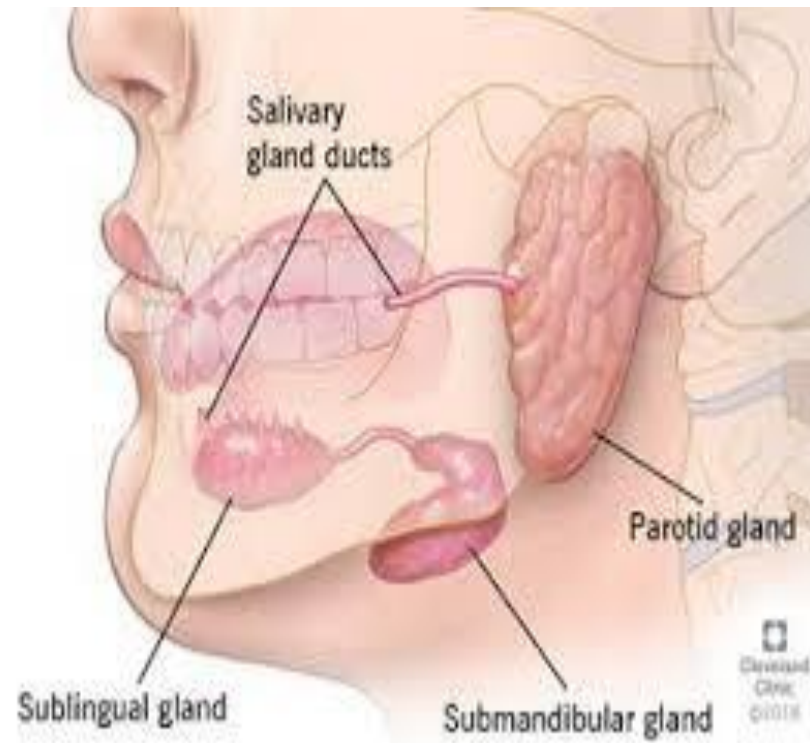
- The roof of the mouth is termed the **palate** and it separates the oral cavity from the nasal cavity.

- Hard palate: at the front of the mouth.

- Soft palate: Is more pliable at the back being made of **muscle** and **connective tissue**, and it can move to swallow food and liquids; it ends at the **uvula.**

- The surface of the **hard palate** allows for the pressure needed in eating food, to leave the nasal passage clear.

uvula

Hard palate   Soft palate

Nasal cavity

Oral cavity
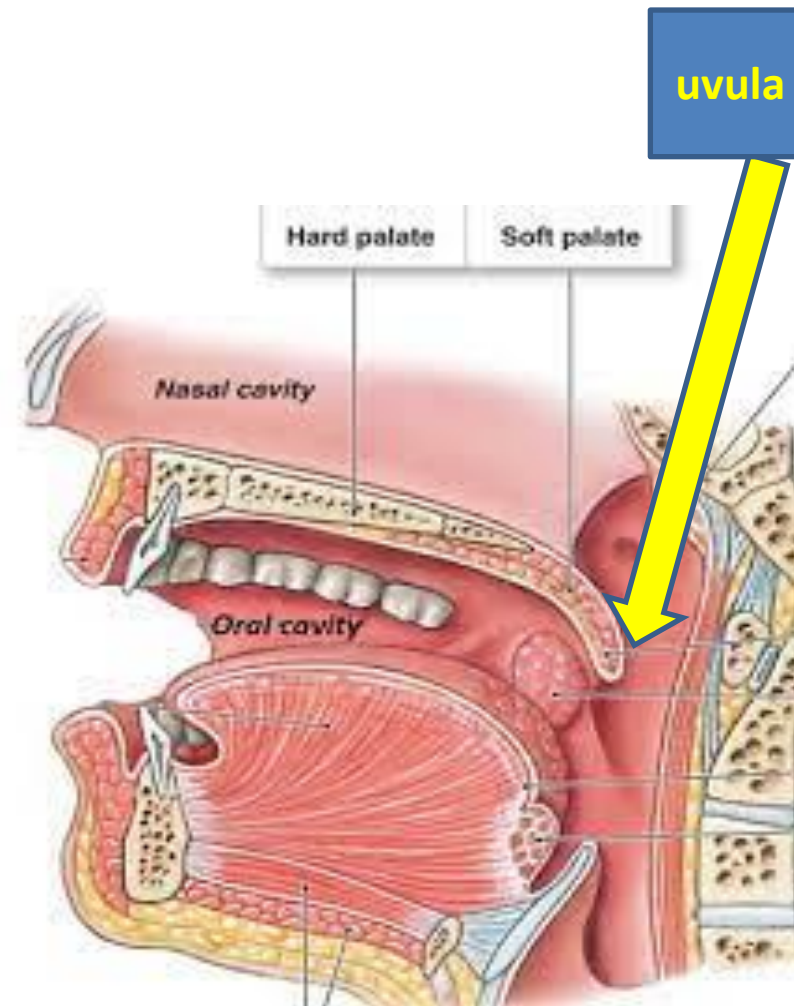
❖ Salivary glands:

❖ Parotid glands:

- **The two parotid glands are major salivary glands; located posterior to the mandibular ramus and anterior to the mastoid process of the temporal bone.**

- **They secreting saliva to facilitate mastication and swallowing.**

- **It is the serous type of gland which secretes alpha-amylase (*ptyalin*); to begin the digestion of starches; It enters the oral cavity via the parotid duct.**

- **They produce 20% of the total salivary content in the oral cavity.**
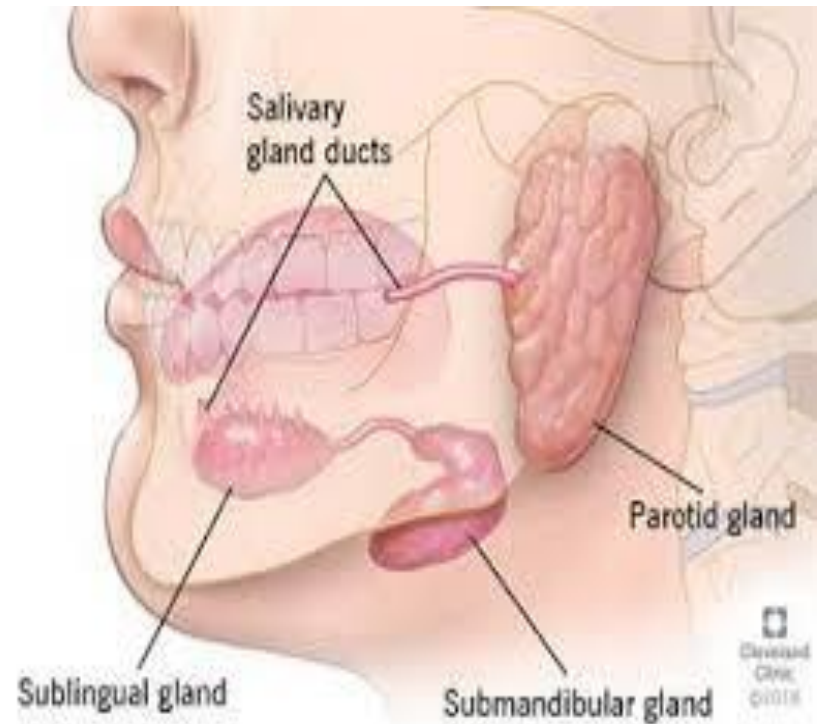
❖ **Submandibular glands:**

- **They are a pair of major salivary glands located beneath the lower jaw.**

- **The secretion produced is a mixture of both serous fluid and mucus, and enters the oral cavity via the submandibular duct or ''Wharton duct''.**

Salivary gland ducts

Parotid gland

Sublingual gland

Submandibular gland
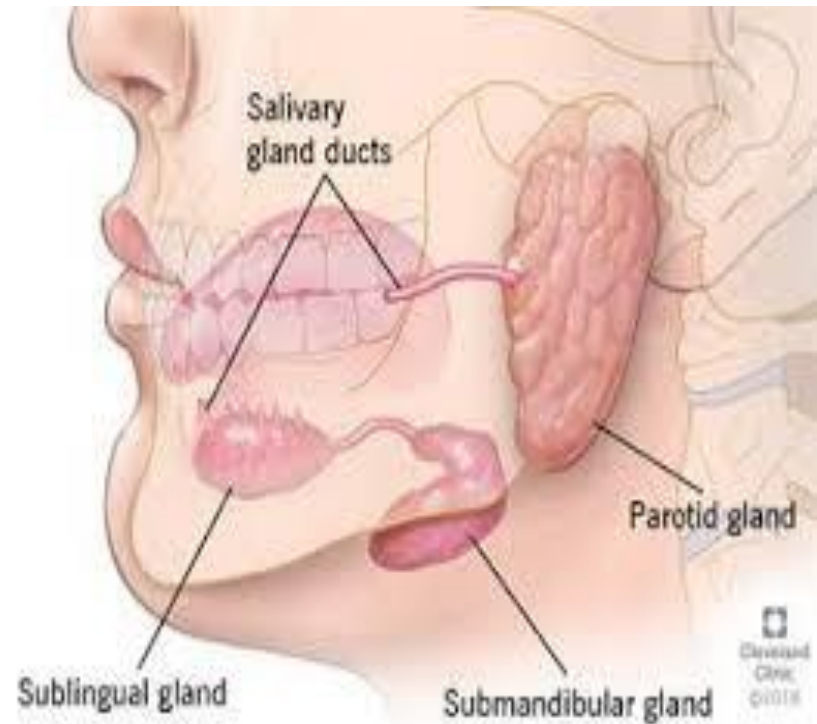
- **A boute 65-70% of saliva in the oral cavity is produced by the submandibular glands, even though they are much smaller than the parotid glands.**

Salivary gland ducts

Sublingual gland

Parotid gland

Submandibular gland
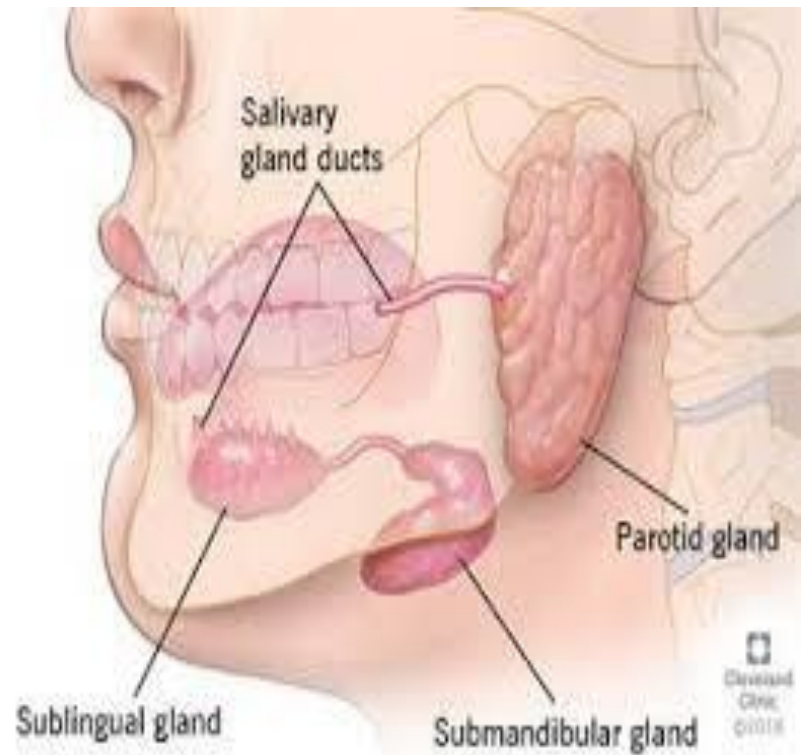
❖Sublingual glands:

- **They are a pair of major salivary glands located inferior to the tongue, anterior to the submandibular glands.**

- **The secretion produced is mainly mucous in nature.**

- **Approximately 5% of saliva entering the oral cavity comes from these glands.**
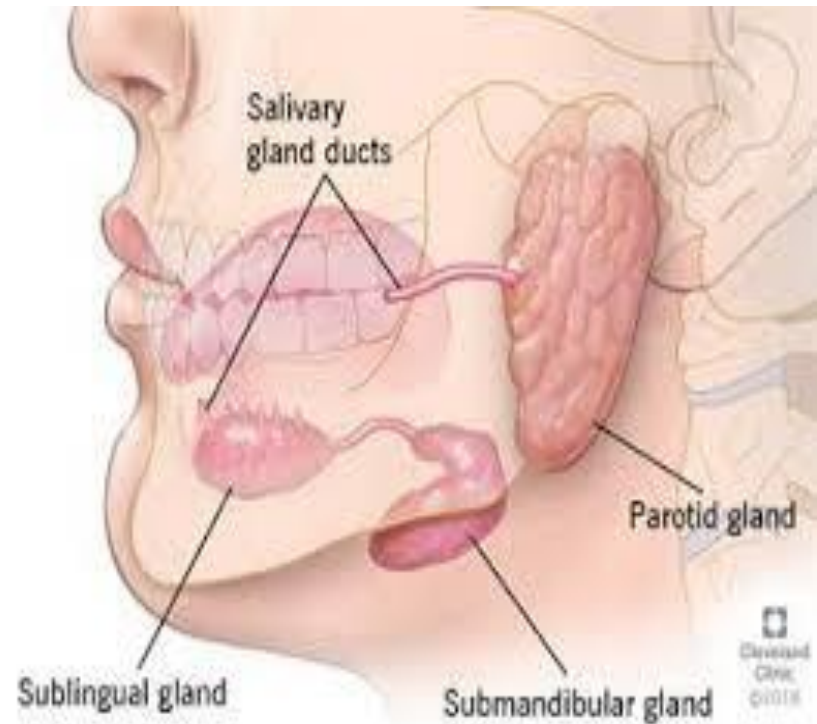
❖ Minor salivary glands:

- There are **800 to 1,000** minor salivary glands located throughout the oral cavity within the submucosa of the oral mucosa in the tissue of the buccal, labial, lingual mucosa, the soft palate, the lateral parts of the hard palate, and the floor of the mouth.

- Their secretion is mainly **mucous** in nature and have many functions such as coating the oral cavity with saliva.
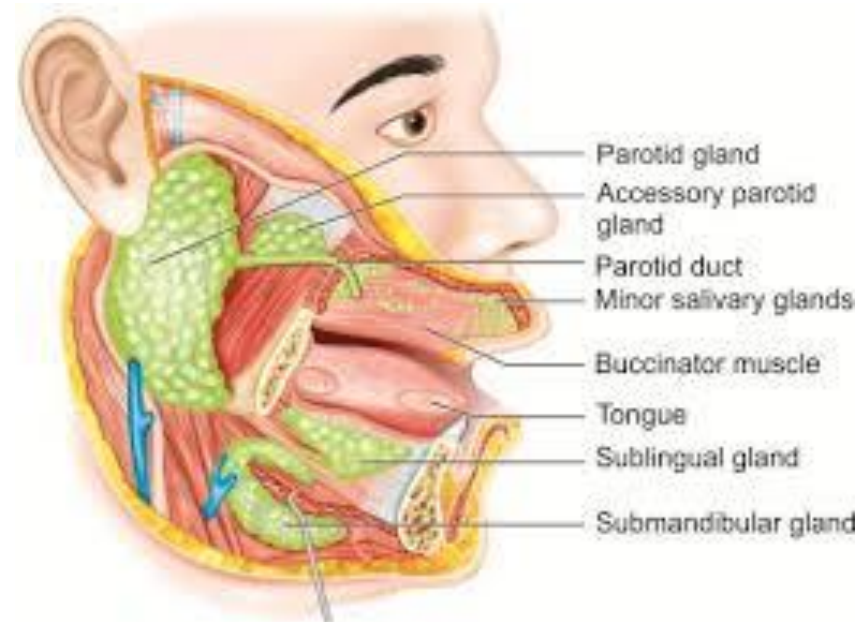
- **Daily secretion of saliva normally ranges between 800 and 1500 milliliters, during un stimulated flow.**

- **20% Parotid gland.**

- **65% from submandibular.**

- **5% from sublingual.**

- **10% from numerous minor glands.**

- **The unstimulated saliva must be above > 0.1 mL/min.**

- **For stimulated saliva, it must increases to 0.2 mL/min.**

Salivary gland ducts

Sublingual gland

Parotid gland

Submandibular gland
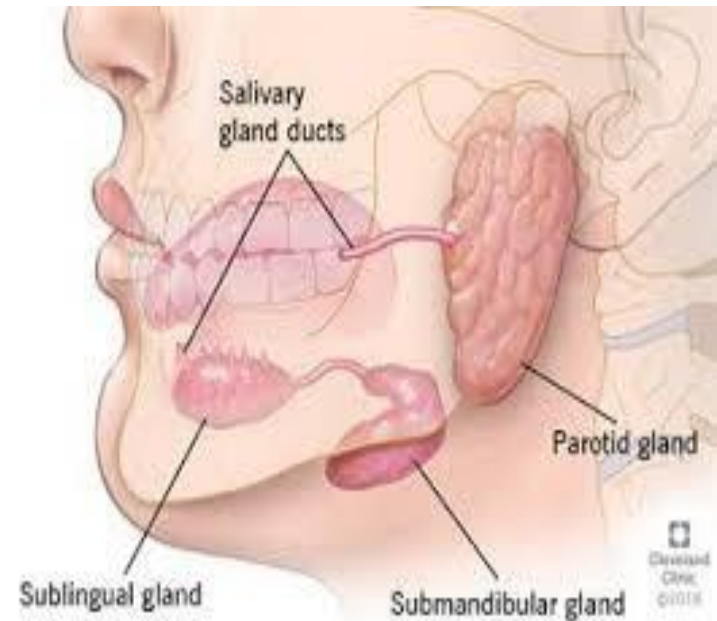
- **Any unstimulated flow rate below < 0.1 mL/min is considered hypofunction.**

- **The flow of saliva diminishes considerably during sleep, is nearly zero, allow populations of bacteria to build up in the mouth – the result is dragon breath in the morning.**

- **Circannual (yearly) low flow occurs during the summer, whereas peak flow is during the winter.**

Salivary gland ducts

Parotid gland

Sublingual gland

Submandibular gland

Cleveland Clinic ©2018
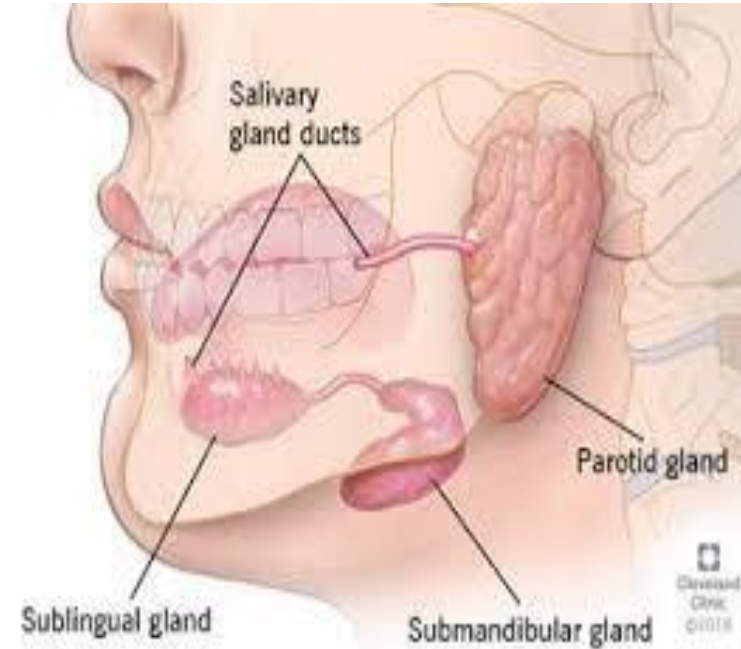
- **The women exhibit low unstimulated and stimulated salivary flow compared to males as a result of a smaller size of the salivary glands and the influence of female sex hormones.**

- **Nutritional deficiencies can influence salivary function; severe caloric restrictions tend to reduce salivary flow, cell numbers, and salivary composition.**

- **Head and neck radiotherapy has serious side effects on the oral cavity including the loss of salivary gland function and a persistent complaint of a dry mouth (xerostomia).**

❖ **Saliva contains two major types of protein secretion:**

(1) **A serous secretion that contains ptyalin (an-amylase), which is an enzyme for digesting starches.**

(2) **Mucus secretion that contains mucin for lubricating and surface protective.**

- **The parotid glands secrete almost entirely the serous type of secretion.**

- **The submandibular and sublingual glands secrete both serous secretion and mucus.**

- **The buccal glands secrete only mucus.**

Salivary gland ducts

Parotid gland

Sublingual gland

Submandibular gland
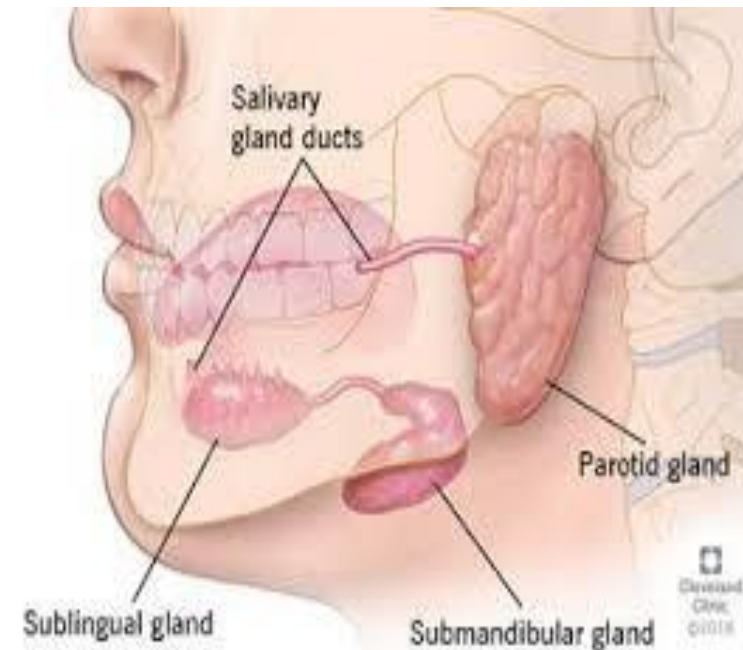
- **Saliva has a pH between (6.0 - 7.0) a favorable range for the digestive action of ptyalin.**

- **Saliva contains large quantities of potassium and bicarbonate ions.**

- **Conversely, the concentrations of both sodium and chloride ions are several times less in saliva than in plasma.**

THANK YOU

DIGESTIVE SYSTEM

د.محمد عيسى السبعاوي
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❖Function of Saliva:

- **Salivary function can be organized into *five* major categories that serve to maintain oral health and create an appropriate ecologic balance:**
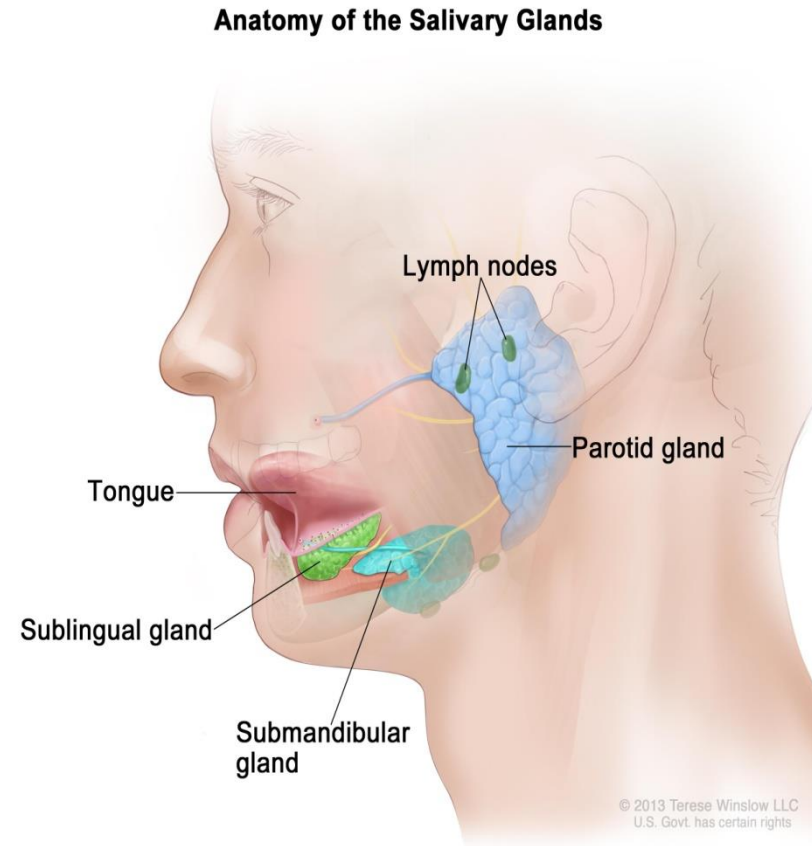
(1) Lubrication and protection.

(2) Buffering action and clearance.

(3) Maintenance of tooth integrity.
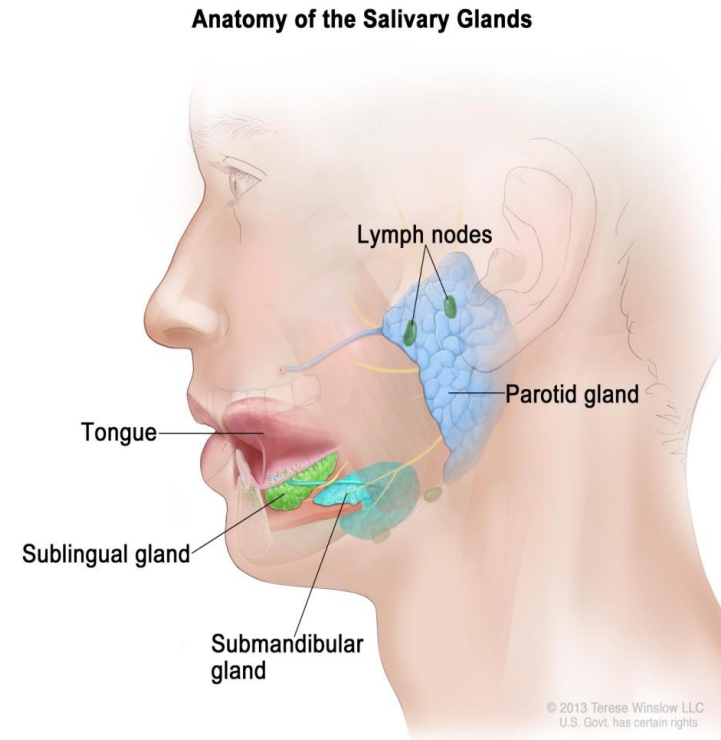
(4) Antibacterial activity.

(5) Taste and digestion.

Anatomy of the Salivary Glands

Lymph nodes

Parotid gland

Tongue

Sublingual gland

Submandibular gland

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(1) lubrication and protection:

o As a seromucous coating, saliva lubricates and protects oral tissues, acting as a barrier against irritants.

o The best lubricating components of saliva are mucins that are excreted from minor salivary glands.

o These mucins have the properties of:

➢ **Low solubility.**

➢ **High viscosity.**

➢ **High elasticity.**

➢ **Strong adhesiveness.**

o **Mastication*.**

o **Speech**.**

o **Swallowing***.**

o All are aided by the lubricating effects of mucins.

Anatomy of the Salivary Glands

Lymph nodes

Parotid gland

Tongue

Sublingual gland

Submandibular gland

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- Mucins also perform an antibacterial function by selectively modulating the adhesion of microorganisms to oral tissue surfaces, which contributes to the control of bacterial and fungal colonization.

- Salivary mucins also preserving mucosal integrity through regulate intercellular calcium levels.

- Mucins forming a protective barrier and lubrication against excessive wear and limiting mineral egress from the tooth surface.

Anatomy of the Salivary Glands

Lymph nodes

Parotid gland

Tongue

Sublingual gland

Submandibular gland

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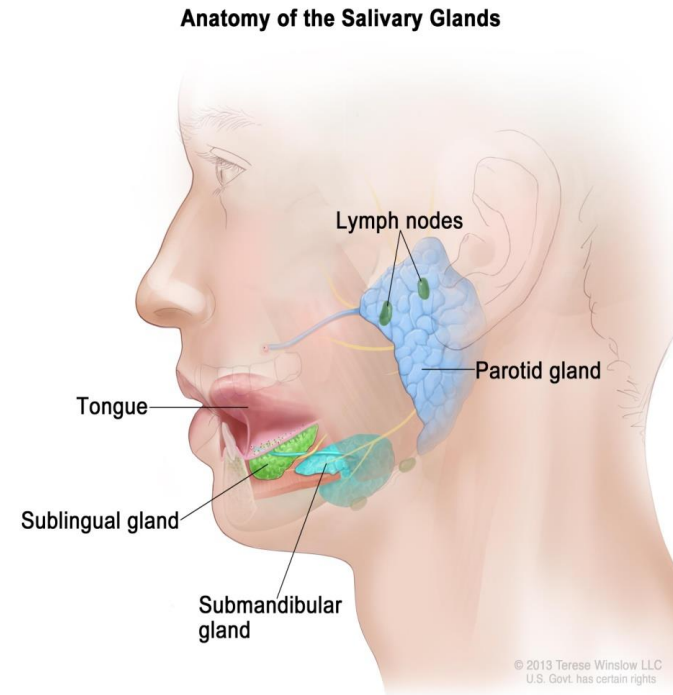
2) Buffering action and clearance:

- **Bicarbonate , phosphate, urea, and amphoteric proteins and enzymes are the important components for the buffering function.**

- ❑ **Bicarbonate is the most important buffering system.**

- ➢ **It diffuses into plaque and acts as a buffer by neutralizing acids.**

- ➢ **it generates ammonia to form amines, which also serve as a buffer by neutralizing acids.**

Salivary gland ducts

Parotid gland

Sublingual gland

Submandibular gland
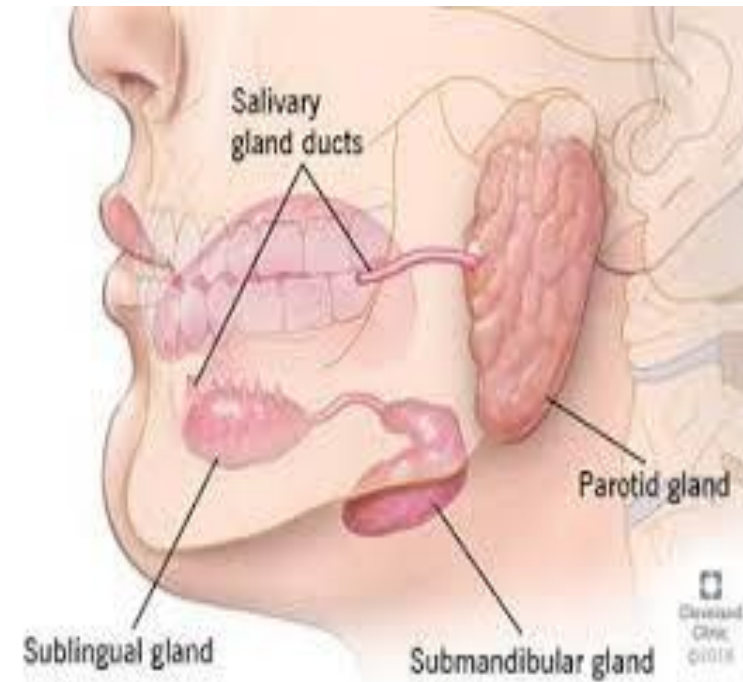
3) Maintaining tooth integrity:

- **Saliva facilitates the demineralization and remineralization process.**

4) Antibacterial activity:

❑ **Salivary glands secrete fluid containing:**

- **Immunologic agents (IgA, IgG, and IgM.)**

- **Non immunologic agents (Proteins, mucins, Peptide and enzymes (lactoferrin, lysozyme).**

For the protection of teeth and mucosal surfaces.

5) Enhance taste and digestive process:

- The hypotonicity of saliva enhances the tasting capacity of salty foods and nutrient sources.

- Saliva has an early role in igestion by beginning the breakdown of starch with amylase, a major component of parotid saliva that initially dissolves sugar.

- Salivary enzymes also initiate fat digestion.

- Saliva serves to lubricate the food bolus, which aids in swallowing.

❖ Tongue:

- **The tongue is a fleshy and muscular sensory organ, and the very first sensory information is received via the taste buds in the papillae on its surface.**

- **If the taste is agreeable, the tongue will go into action, manipulating the food in the mouth which stimulates the secretion of saliva from the salivary glands.**

Anatomy of the Mouth and Throat
(Tongue Extended)
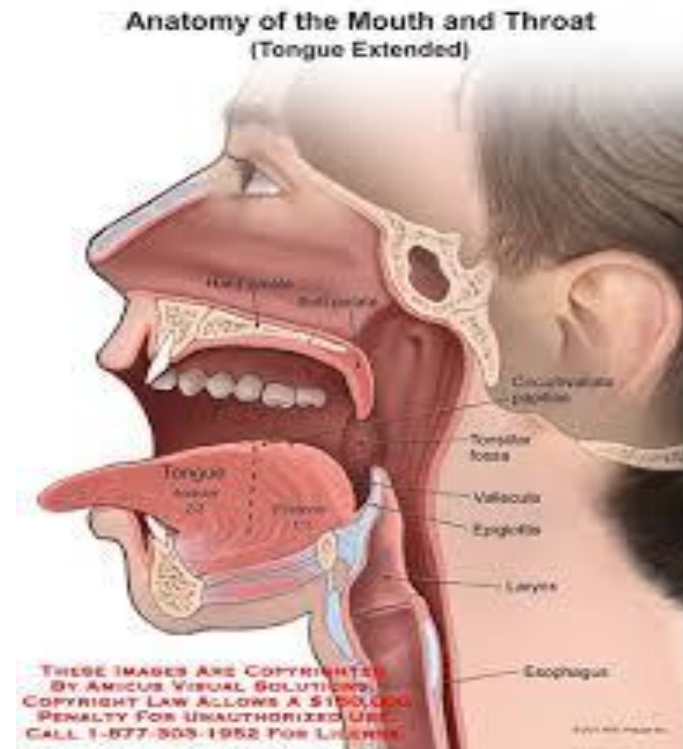
- **The tongue is attached to the floor of the mouth by a ligamentous band called the frenum and this gives it great mobility for the manipulation of food (and speech).**

➤ **The tongue's two sets of muscles:**

1) **Four intrinsic muscles that originate in the tongue and are involved with its** **shaping**.

2) **Four extrinsic muscles originating in bone that are involved with its** **movement**.


FRENULUM

SUBMANDIBULAR
SALIVARY DUCTS
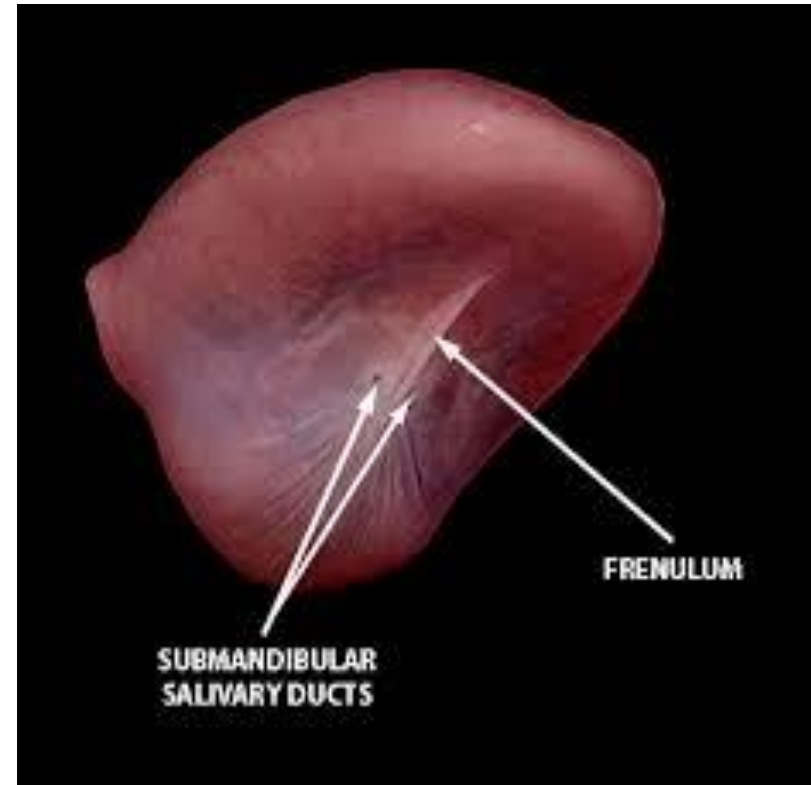
- **Taste:** is a form of chemoreception that takes place in the specialised taste receptors, contained in structures called taste buds in the mouth.

- Taste buds are mainly on the upper surface (dorsum) of the tongue.

- The function of taste perception is vital to help prevent harmful or rotten foods from being consumed.

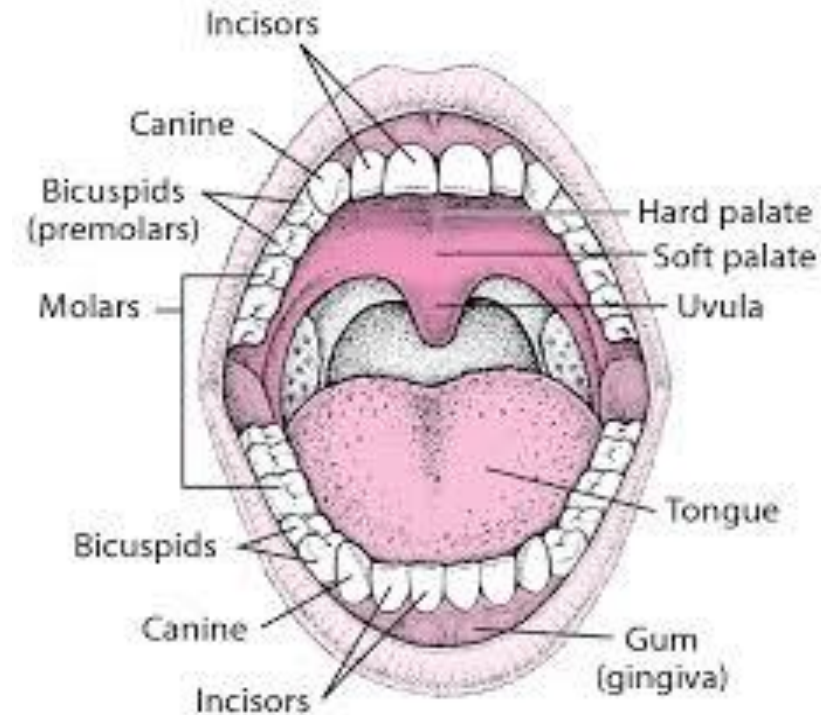- The five basic tastes are referred to as those of saltiness, sourness, bitterness, sweetness, and umami.

Taste Buds

- Epiglottis
- Palatine Tonsil
- Lingul Tonsil
- Villate Papillae
- Fungiform Papillae
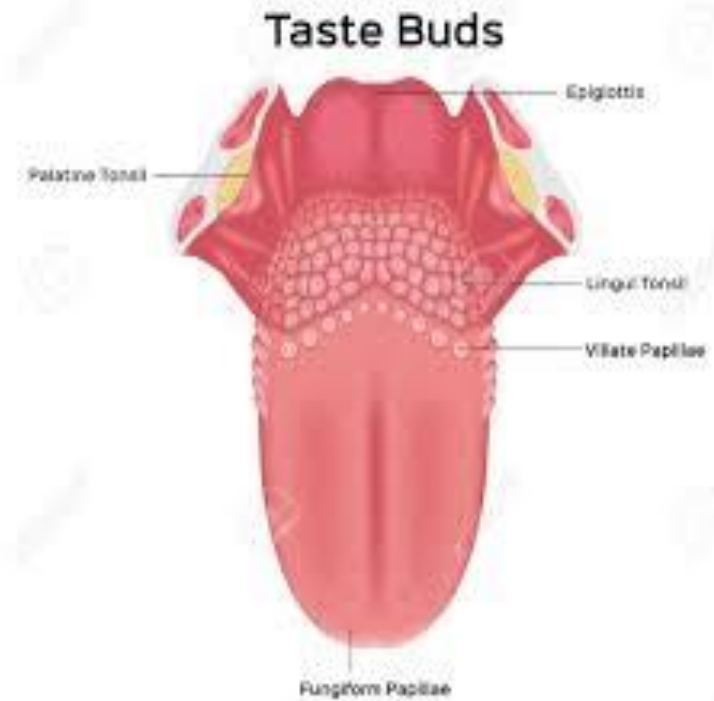
❖ Teeth

- **Teeth are complex structures made of materials specific to them.**

- **They are made of a bone-like material called dentin, which is covered by the hardest tissue in the body— enamel.**

- **Teeth have different shapes to deal with different aspects of mastication employed in tearing and chewing pieces of food into smaller and smaller pieces.**

- **This results in a much larger surface area for the action of digestive enzymes.**
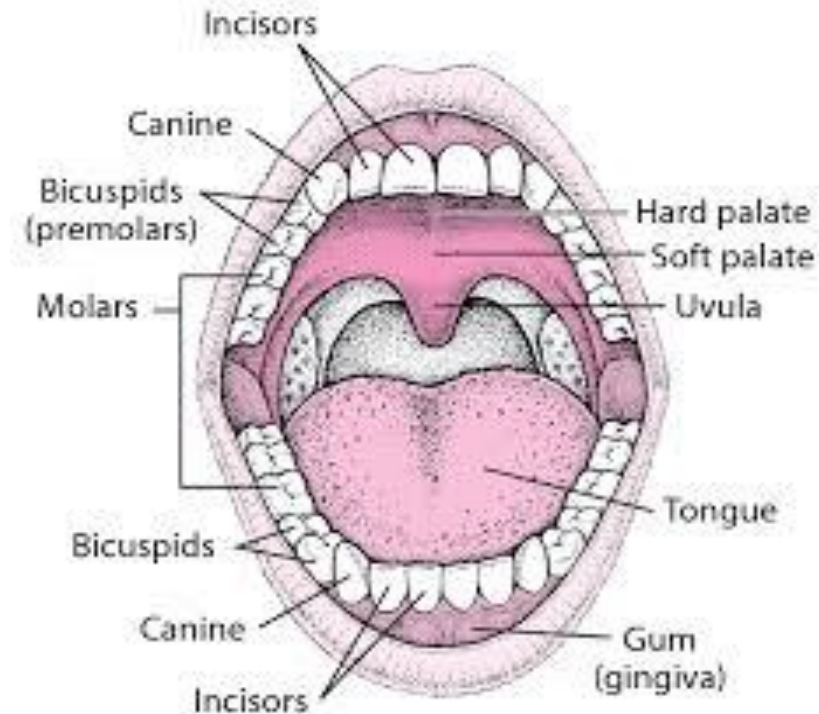
❑ **The teeth are named after their particular roles in the process of mastication:**

➢ **Incisors: are used for cutting or biting off pieces of food.**

➢ **Canines: are used for tearing.**

➢ **Premolars and molars: are used for chewing and grinding.**

• **Mastication of the food with the help of saliva and mucus results in the formation of a soft bolus which can then be swallowed to make its way down the upper gastrointestinal tract to the stomach.**


Incisors
Canine
Bicuspids (premolars)
Molars
Bicuspids
Canine
Incisors
Hard palate
Soft palate
Uvula
Tongue
Gum (gingiva)

❖ Epiglottis

- **The epiglottis is a flap of elastic cartilage attached to the entrance of the larynx.**

- **It is covered with a mucous membrane**

- **The epiglottis functions to guard the entrance of the glottis, the opening between the vocal folds.**

- **It is normally pointed upward during breathing with its underside functioning as part of the pharynx, but during swallowing, the epiglottis folds down to a more horizontal position, with its upper side functioning as part of the pharynx.**

Normal larynx

Epiglottis | Vocal cords | Tongue | Epiglottis | Esophagus | Larynx (voice box) | Trachea

- **In this manner it prevents food from going into the trachea and instead directs it to the esophagus, which is behind.**

- **Stimulation of the larynx by ingested matter produces a strong cough reflex in order to protect the lungs.**
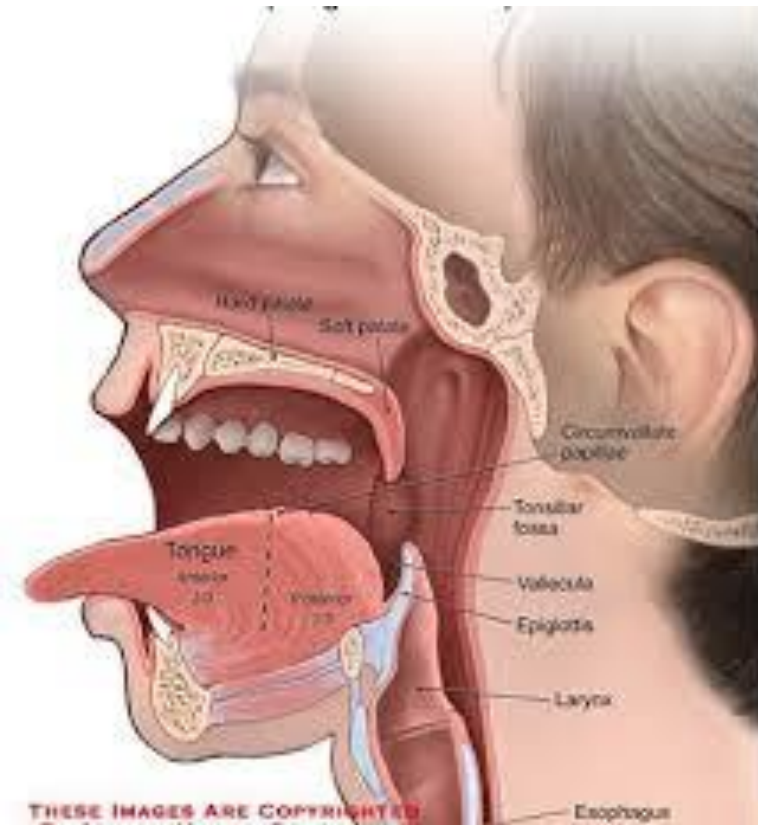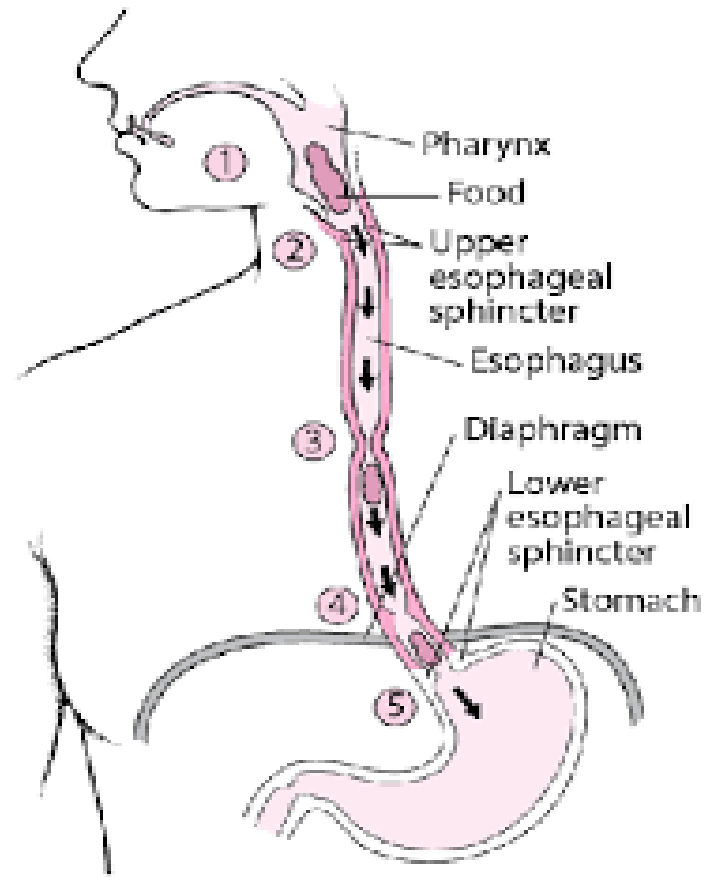
❖ Esophagus:

- **The esophagus, commonly known as the foodpipe or gullet, consists of a muscular tube through which food passes from the pharynx to the stomach.**

- **It passes through the posterior mediastinum in the thorax and enters the stomach through a hole in the thoracic diaphragm—the esophageal hiatus, at the level of the tenth thoracic vertebra (T10).**

- **Its length averages 25 cm, varying with an individual's height.**

- **It is divided into cervical, thoracic and abdominal parts.**
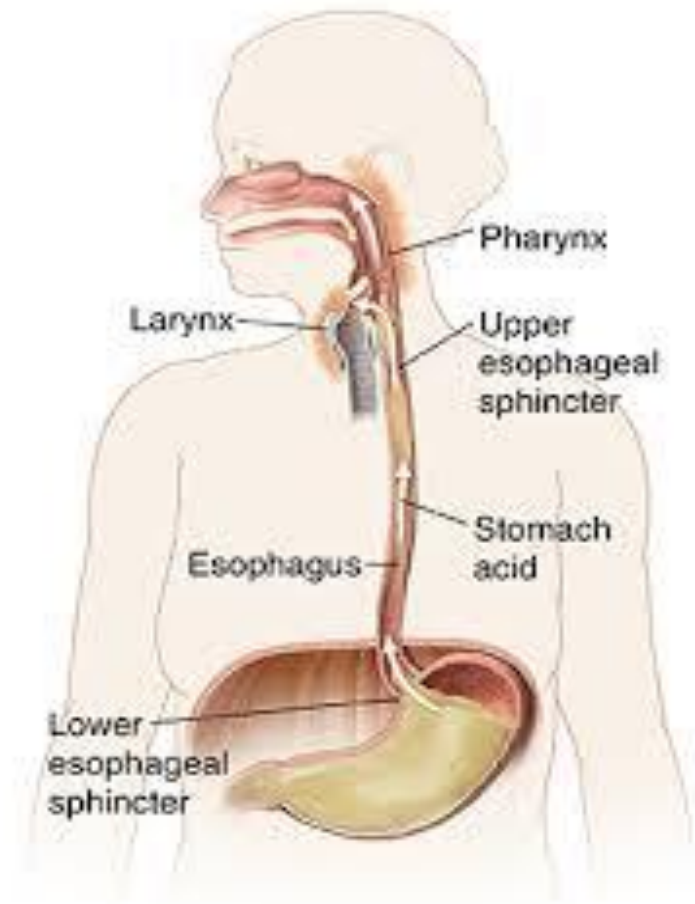
- **At rest the esophagus is closed at both ends, by the upper and lower esophageal sphincters.**

- **The opening of the upper sphincter is triggered by the swallowing reflex so that food is allowed through.**

- **The sphincter also serves to prevent back flow from the esophagus into the pharynx.**

- **The esophagus has a mucous membrane and the epithelium which has a protective function is continuously replaced due to the volume of food that passes inside the esophagus.**

- **During swallowing, food passes from the mouth through the pharynx into the esophagus.**

- **The epiglottis folds down to a more horizontal position to direct the food into the esophagus, and away from the trachea.**
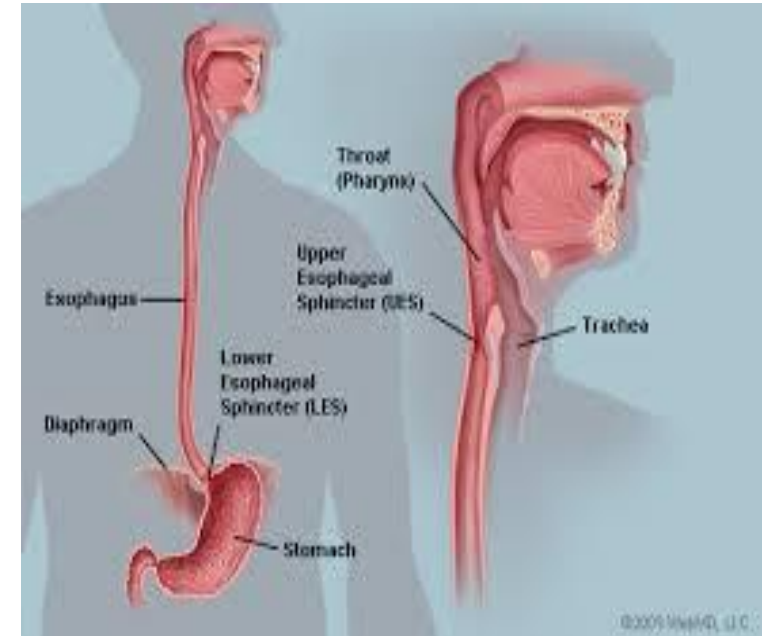
- Once in the esophagus, the bolus travels down to the stomach via rhythmic contraction and relaxation of muscles known as peristalsis.
- The lower esophageal sphincter is a muscular sphincter surrounding the lower part of the esophagus.
- Gastroesophageal junction between the esophagus and the stomach is controlled by the lower esophageal sphincter, which remains constricted at all times other than during swallowing and vomiting to prevent the contents of the stomach from entering the esophagus.
- As the esophagus does not have the same protection from acid as the stomach, any failure of this sphincter can lead to heartburn.

Pharynx
Food
Upper esophageal sphincter
Esophagus
Diaphragm
Lower esophageal sphincter
Stomach
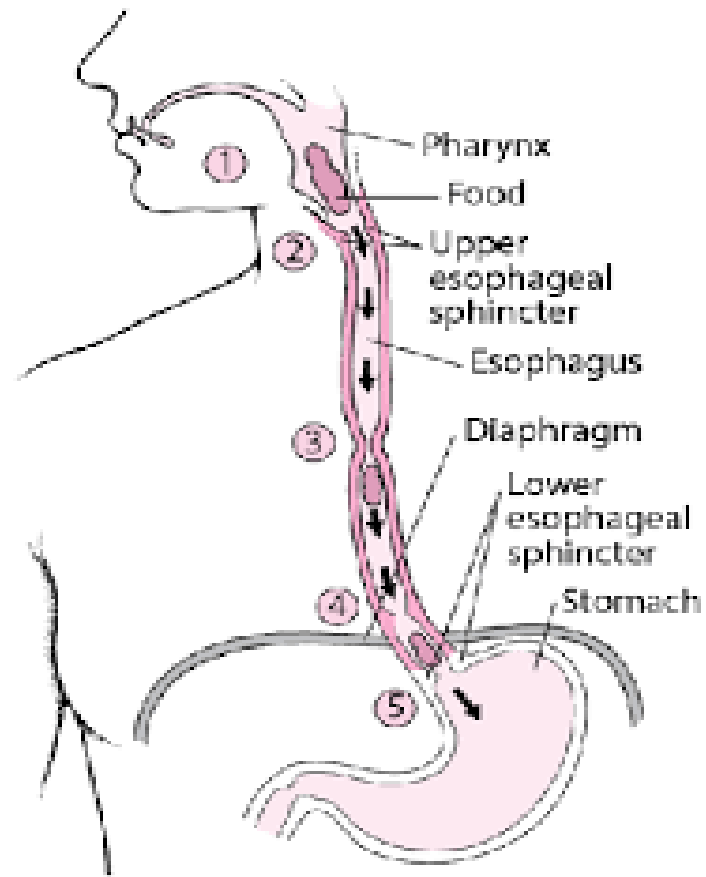
❖ Stomach:

- **The stomach is a major organ of the gastrointestinal tract and digestive system.**

- **It is a consistently J-shaped organ joined to the esophagus at its upper end and to the duodenum at its lower end.**

- **Gastric acid (*gastric juice*), produced in the stomach plays a vital role in the digestive process, and mainly contains hydrochloric acid and sodium chloride.**

esophagus

stomach

small intestine
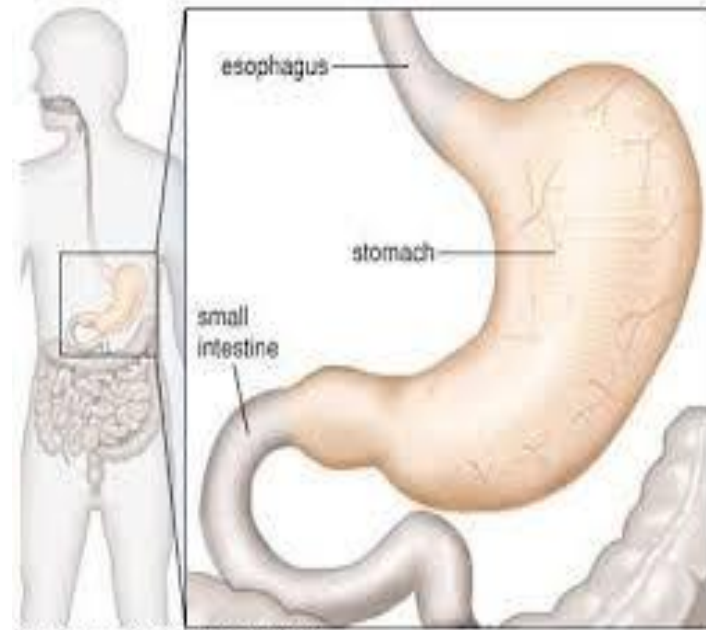
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- **The parietal cells in the fundus of the stomach, produce a glycoprotein called intrinsic factor which is essential for the absorption of vitamin B12.**
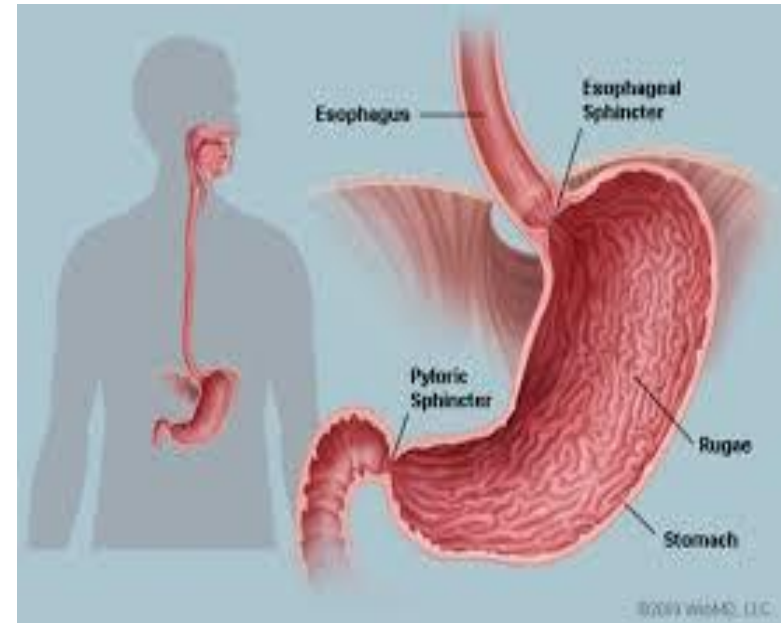
- The stomach is a distensible organ and can normally expand to hold about one litre of food.

- This expansion is enabled by a series of gastric folds in the inner walls of the stomach.

- The stomach of a newborn baby will only be able to expand to retain about 30 ml.
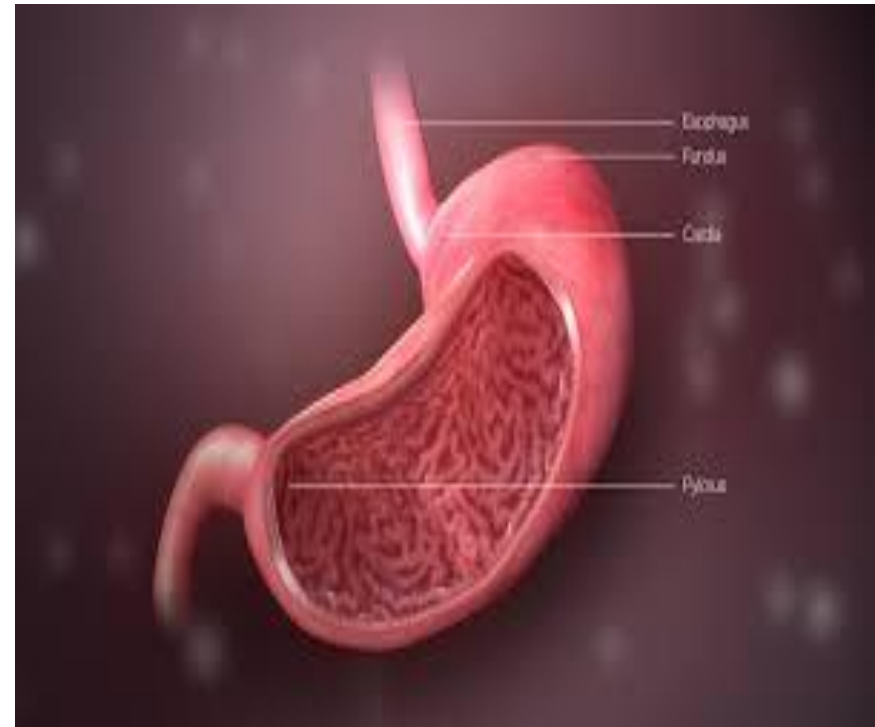
- **The pylorus:** the lowest section of the stomach which attaches to the duodenum via the pyloric canal, contains countless glands which secrete digestive enzymes including gastrin.

- After an hour or two, a thick semi-liquid called chyme is produced.

- When the pyloric sphincter, or valve opened, the chyme enters the duodenum where it mixes further with digestive enzymes from the pancreas, and then passes through the small intestine, where digestion continues.

esophagus

stomach

small intestine

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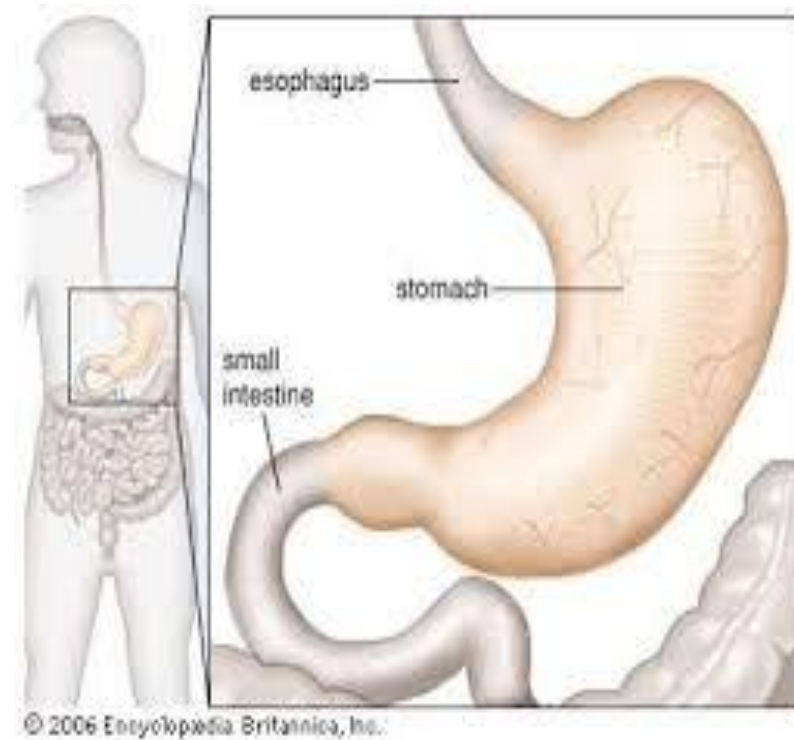
- When the chyme is fully digested, it is absorbed into the blood.
- **95% of absorption of nutrients occurs in the small intestine.**
- Water and minerals are reabsorbed back into the blood in the colon of the large intestine, where the environment is slightly acidic.
- Some vitamins, such as biotin and vitamin K produced by bacteria in the gut flora of the colon are also absorbed.

esophagus

stomach

small intestine

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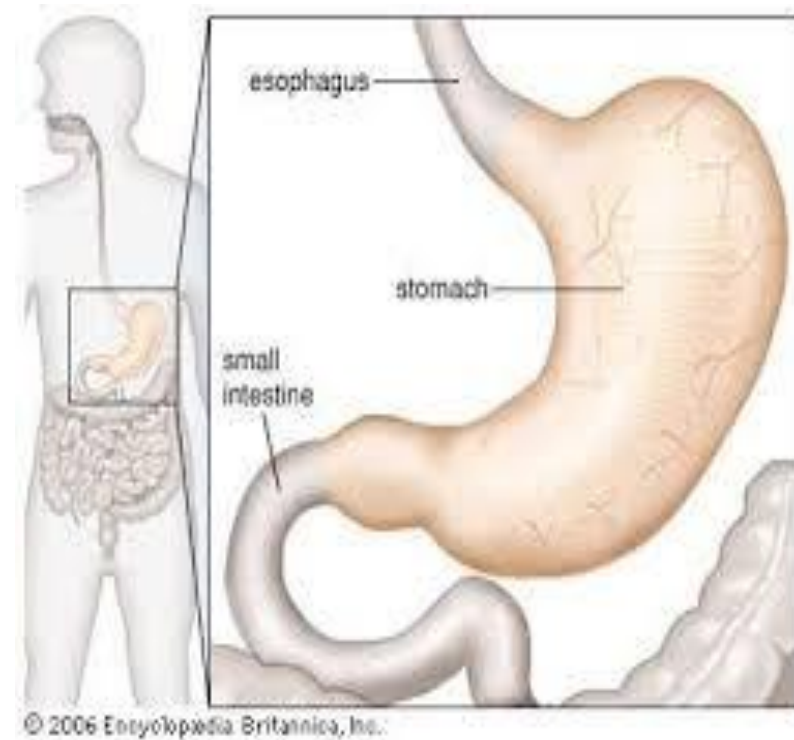
DIGESTIVE SYSTEM

د.محمد عيسى السبعاوي
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❖Spleen

- **The spleen is the largest lymphoid organ in the body but has other functions.**

- **It breaks down both red and white blood cells that are *spent*.**

- **This is why it is sometimes known as the 'graveyard of red blood cells.**

- **A product of this *digestion* is the:**

1) **Pigment bilirubin, which is sent to the liver and secreted in the bile.**

2) **Iron, which is used in the formation of new blood cells in the bone marrow.**

Stomach

Spleen

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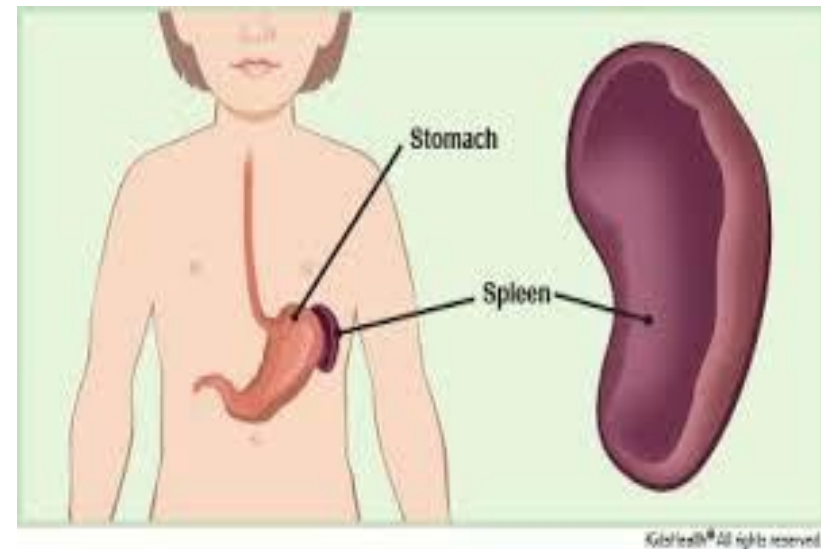
❖ **Liver:**

- **The liver is located in the upper right quadrant of the abdomen and below the diaphragm.**

- **To the right of the stomach and it overlies the gall bladder.**

- **The liver is the second largest organ (after the skin) and is an accessory digestive gland which plays a role in the body's metabolism.**

Lungs
Stomach
Liver
Large Intestine
Gall Bladder
Small Intestine

THE MEDICAL STRUCTURE OF THE LIVER

Right Hepatic Duct
Left lobe of liver
Right Liver of liver
Gallbladder
Left Hepatic Duct
Cystic Duct
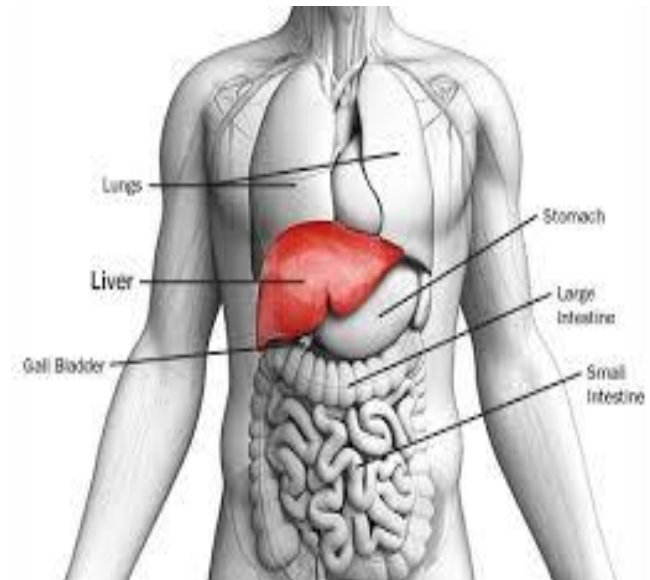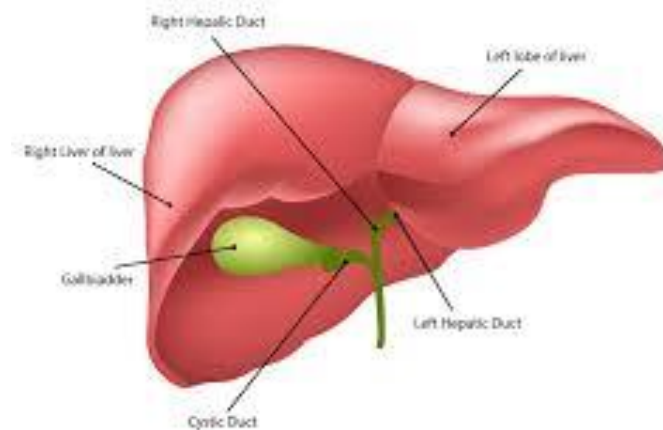
❖ The liver has many functions are:

1) Detoxify various metabolites.

2) Synthesise and degradation of Proteins.

3) Synthesise glucose from certain amino acids.

4) Storage of glycogen which it can form from glucose (glycogenesis).

5) Breaking down of carbohydrates(digestive function).

6) Synthesises of cholesterol.

7) Fat production.

8) Synthesises of lipoproteins.

9) Synthesises bile acids and lecithin to promote the digestion of fat.

❖ Bile

- Bile produced by the liver is made up of **water (97%), bile salts, mucus** and **pigments**, **1% fats** and **inorganic salts**.

- **Bilirubin is, its major pigment.**

- **Food fat is dispersed by the action of bile into smaller units called micelles.**

- **The breaking down into micelles creates a much larger surface area for the pancreatic enzyme, lipase to work on.**

- **Lipase digests the triglycerides which are broken down into two fatty acids and a monoglyceride.**

THE MEDICAL STRUCTURE OF THE LIVER

Right Hepatic Duct

Left lobe of liver

Right Liver of liver

Gallbladder

Left Hepatic Duct
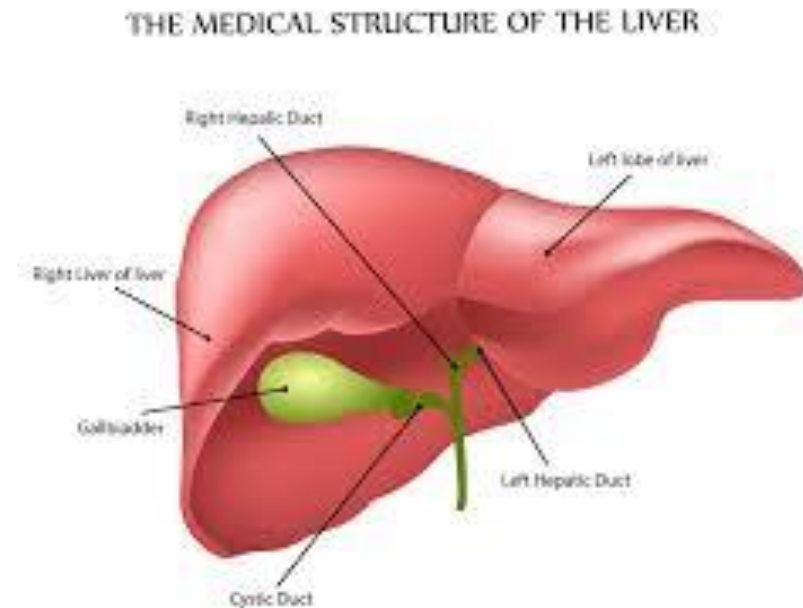
Cystic Duct

- **These are then absorbed by villi on the intestinal wall.**

- **Bile also helps in the absorption of vitamin K from the diet.**

- **Bile is collected and delivered through the common hepatic duct.**

- **This duct joins with the cystic duct to connect in a common bile duct with the gallbladder.**

- **Bile is stored in the gallbladder for release when food is discharged into the duodenum, after a few hours.**

Bile ducts
Liver
Pancreas
Small intestine
Gallbladder
Liver
Common hepatic duct
Cystic duct
Pancreas
Common bile duct
Small intestine

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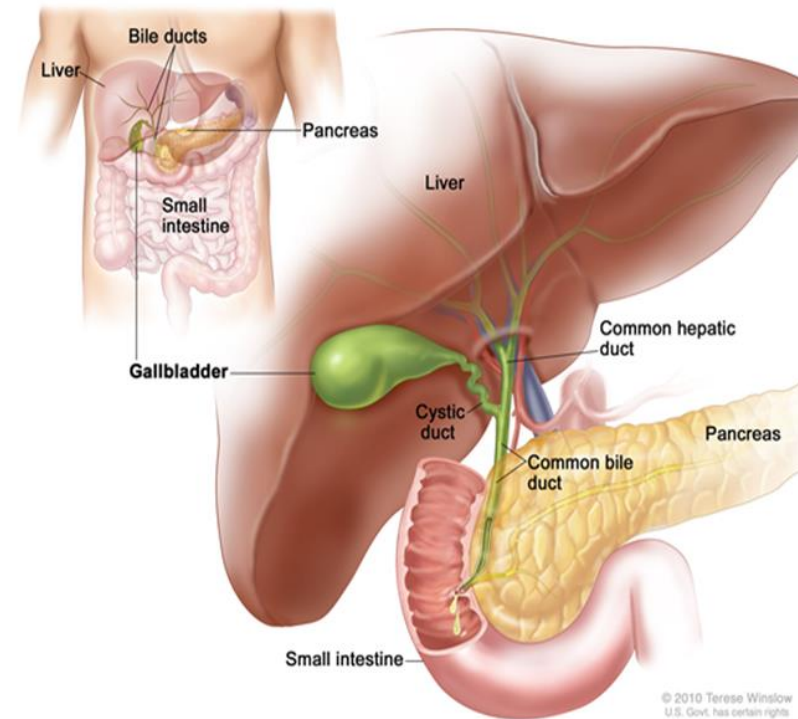
❖ Gallbladder.

- **The gallbladder is a hollow part of the biliary tract that sits just beneath the liver, with the gallbladder body resting in a small depression.**

- **It is a small organ where the bile produced by the liver is stored, before being released into the small intestine.**

- **Bile flows from the liver through the bile ducts and into the gall bladder for storage.**

- **The bile is released in response to cholecystokinin (CCK) a peptide hormone released from the duodenum.**

- **The production of CCK (by endocrine cells of the duodenum) is stimulated by the presence of fat in the duodenum.**

Bile ducts
Liver
Pancreas
Small intestine
Liver
Common hepatic duct
Gallbladder
Cystic duct
Pancreas
Common bile duct
Small intestine
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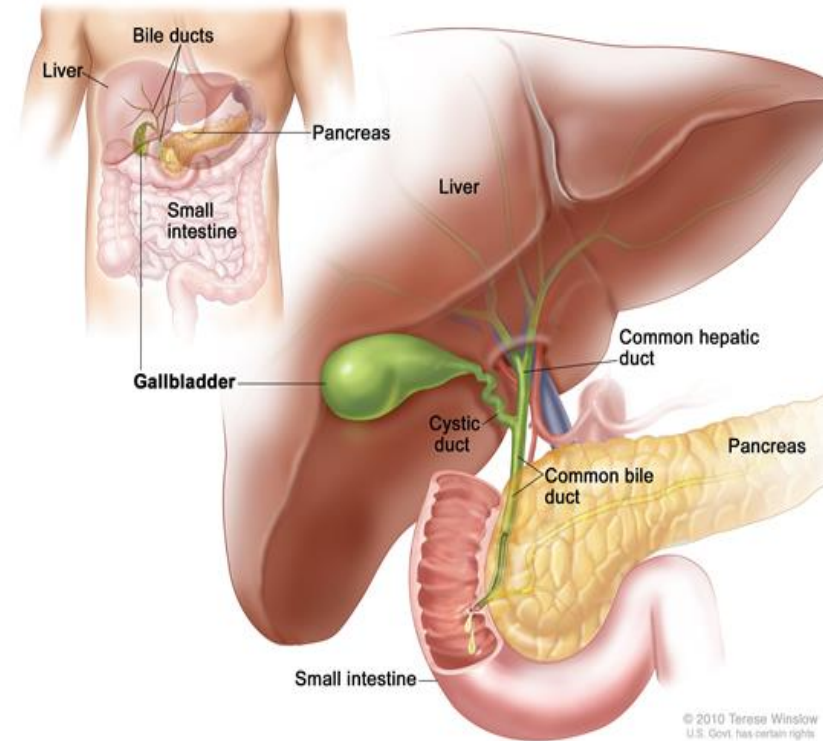
- **Gall bladder is divided into three sections, a fundus, body and neck.**

- **The neck tapers and connects to the biliary tract via the cystic duct, which then joins the common hepatic duct to form the common bile duct.**

- **At this junction is a mucosal fold called *Hartmann's pouch*, where gallstones commonly get stuck.**

- **The muscular layer of the body is of smooth muscle tissue that helps the gallbladder contract, so that it can discharge its bile into the bile duct.**

- **The gallbladder needs to store bile in a natural, semi-liquid form at all times.**

THE MEDICAL STRUCTURE OF THE LIVER

Right Hepatic Duct

Left lobe of liver

Right Liver of liver

Gallbladder

Left Hepatic Duct

Cystic Duct
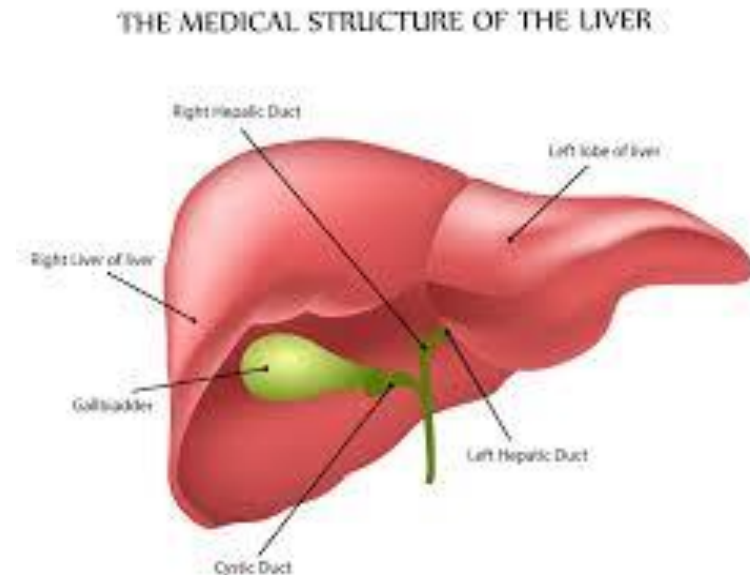
- **Hydrogen ions secreted from the inner lining of the gallbladder keep the bile acidic enough to prevent hardening.**

- **To dilute the bile, water and electrolytes from the digestion system are added.**

- **Also, salts attach themselves to cholesterol molecules in the bile to keep them from crystallising.**

- **If there is too much cholesterol or bilirubin in the bile, or if the gallbladder doesn't empty properly the systems can fail.**

Hepatic duct

Liver

Left hepatic duct

Right hepatic duct

Gallbladder

Cystic duct

Common bile duct

Duodenum

Pancreatic duct

Portal vein

Pancreas

Stomach

Jejunum
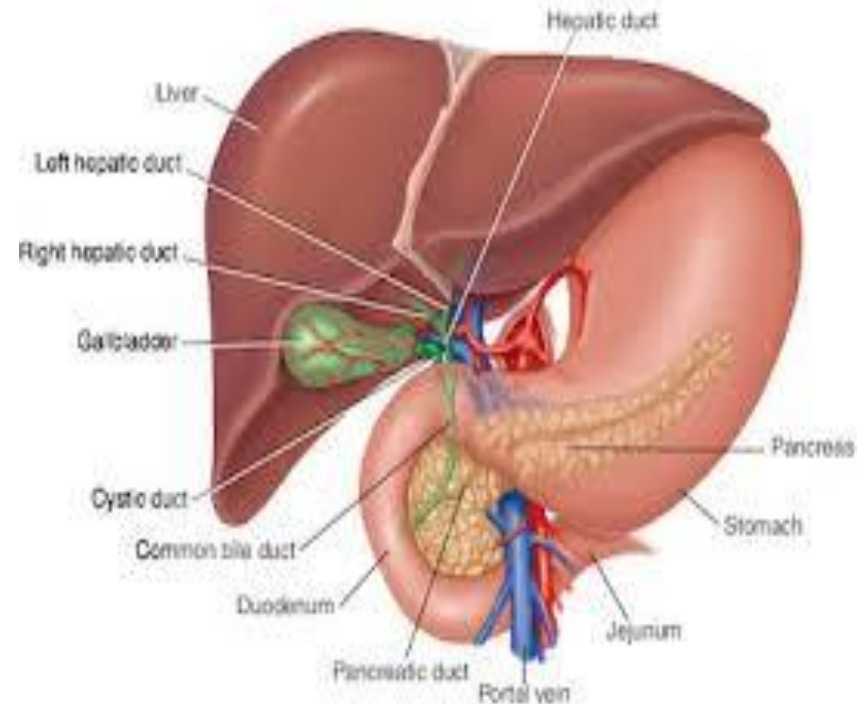
- This is how gallstones form when a small piece of **calcium** gets coated with either **cholesterol** or **bilirubin** and the bile crystallises and forms a gallstone.

- The main purpose of the gallbladder is to store and release bile, or *gall*.

- Bile is released into the small intestine in order to help in the digestion of **fats** by breaking down larger molecules into smaller ones.

- After the fat is absorbed, the bile is also absorbed and transported back to the liver for reuse.
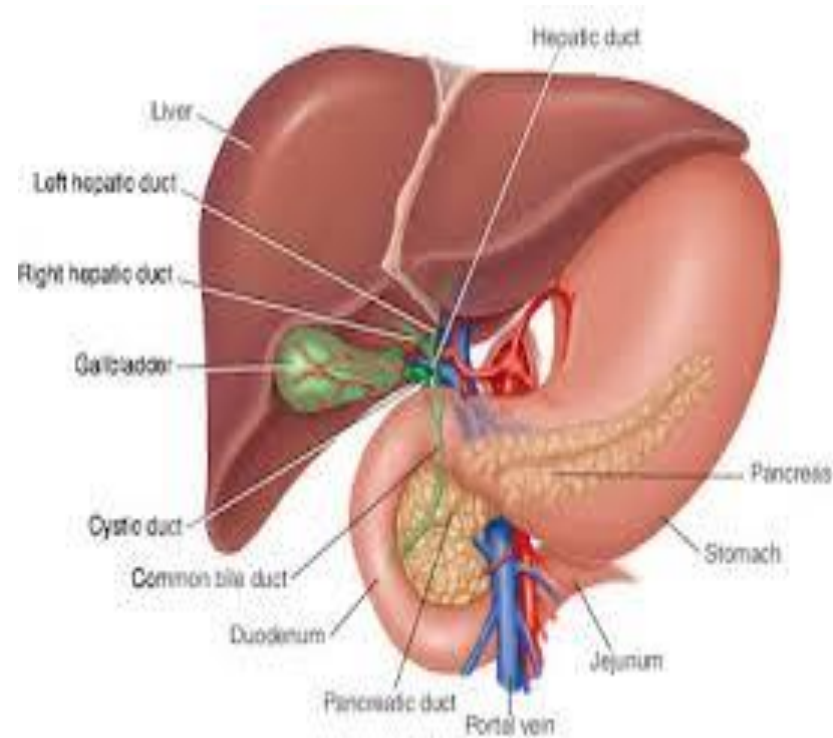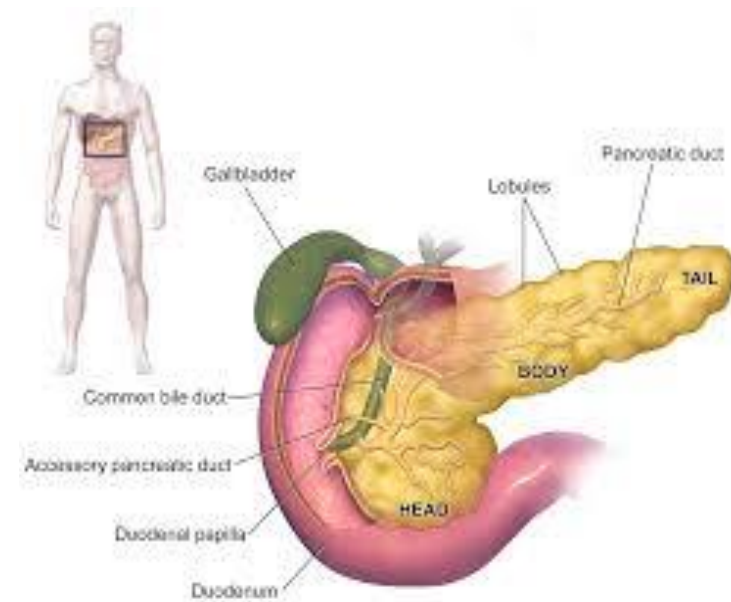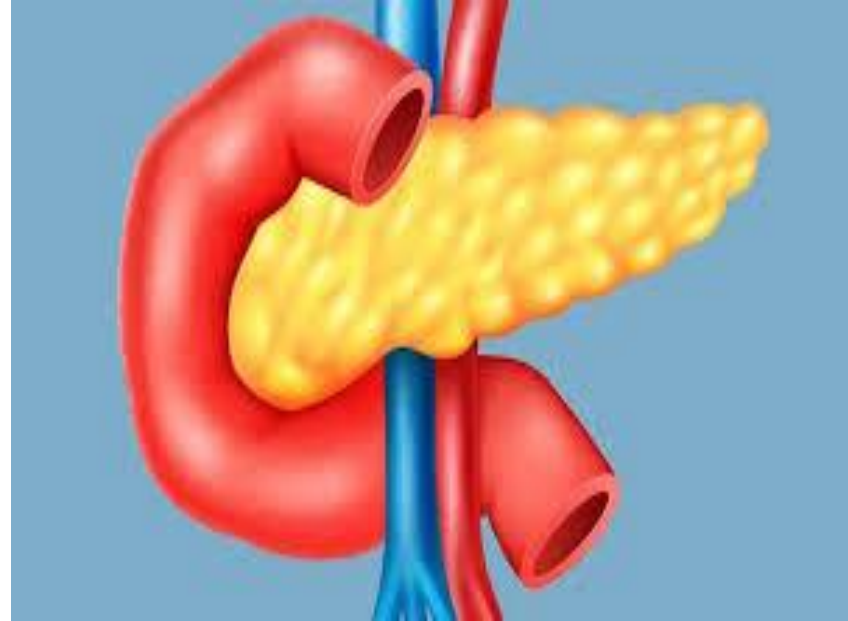
❖ The pancreas:

- The pancreas is a major organ functioning as an accessory digestive gland in the digestive system.

- The pancreas lies below and at the back of the stomach.

- It is both an **endocrine** gland and an **exocrine** gland.

❑ **The endocrine part secretes:**

1) **Insulin** when the blood sugar becomes high; insulin moves glucose from the blood into the muscles and other tissues for use as energy.

2) **Glucagon** when the blood sugar is low; **glucagon** allows stored sugar to be broken down into glucose by the liver in order to re-balance the sugar levels.

Gallbladder
Pancreatic duct
Lobules
TAIL
Common bile duct
BODY
Accessory pancreatic duct
Duodenal papilla
HEAD
Duodenum

- The exocrine glands of pancreas produces and releases important **digestive enzymes** in the pancreatic juice that it delivers to the duodenum.

- It connects to the duodenum via the pancreatic duct which it joins near to the bile duct's connection where both the bile and pancreatic juice can act on the chyme that is released from the stomach into the duodenum.

- **The pancreas is also the main source of enzymes for the digestion of fats and proteins.**
- **Some of these are released in response to the production of CKK in the duodenum.**
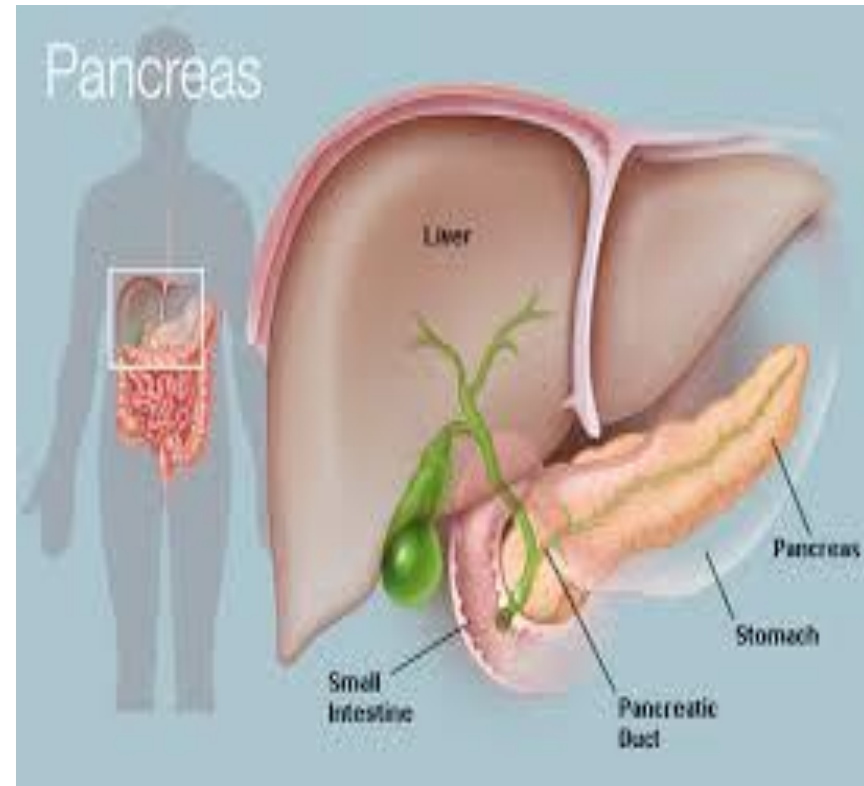
❑**The pancreas also secrete other enzymes:**

➢**Protease.**

➢**Trypsinogen.**

➢**Chymotrypsinogen.**

➢**Elastase.**

➢**Lipase.**

➢**Amylase.**

➢**Phospholipase A2.**

➢**Lysophospholipase.**

➢**Cholesterol esterase.**

Liver
Celiac axis
Esophagus
Gallbladder
Spleen
Portal vein
Pancreas
Duodenum
Superior mesenteric vein
Superior mesenteric artery

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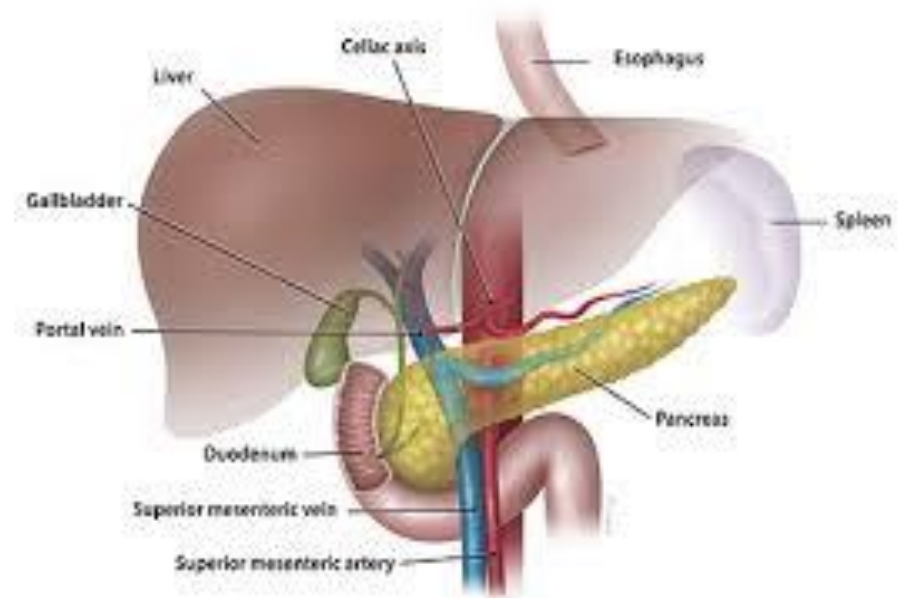
❖ Lower gastrointestinal tract

- The lower gastrointestinal tract (GI), includes the small intestine and all of the large intestine.

- The intestine is also called the bowel or the gut.

- The lower GI starts at the pyloric sphincter of the stomach and finishes at the anus.

- The small intestine is subdivided into the duodenum, the jejunum and the ileum.

- The cecum marks the division between the small and large intestine.

- The large intestine includes the rectum and anal canal.

LOWER GASTROINTESTINAL
DISORDERS

Stomach

Duodenum

Jejunum

Presented by-MSc nsg 1st yr.
Neha Maurya

Ileum

Caecum
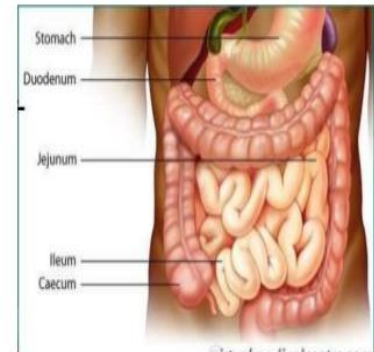
❖ Duodenum

- **The duodenum is the first and shortest section of the small intestine.**

- **It is a hollow, jointed C-shaped tube connecting the stomach to the jejunum.**

- **Partially digested food starts to arrive in the small intestine as semi-liquid chyme, one hour after it is eaten.**

Superior region — Pyloric sphincter
Duodenal bulb —
Stomach
Ascending region
Circular fold —
Duodenojejunal flexure
Descending region —
Major duodenal papilla —
Jejunum
Sphincter of Oddi —
Horizontal region
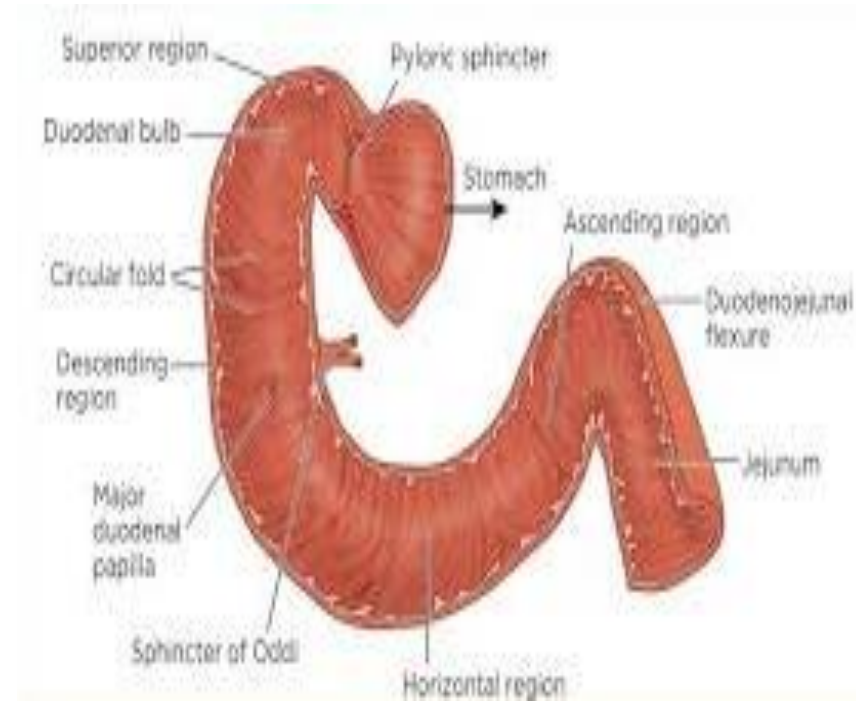
- The stomach is half empty after an average of **1.2 hours.**
- After 4-5 hours the stomach has emptied.
- In the small intestine, the pH becomes crucial; it needs to be finely balanced in order to activate digestive enzymes.
- The chyme is **very acidic**, with a **low pH**, having been released from the stomach and needs to be made much more alkaline.
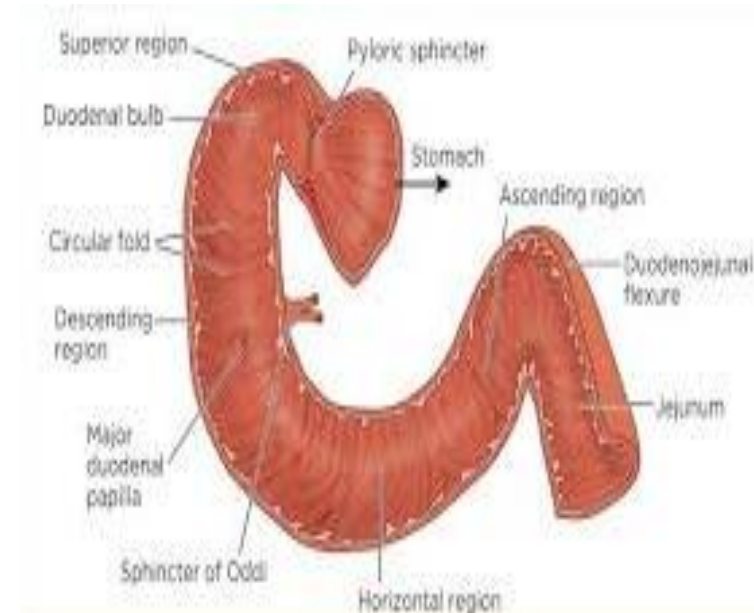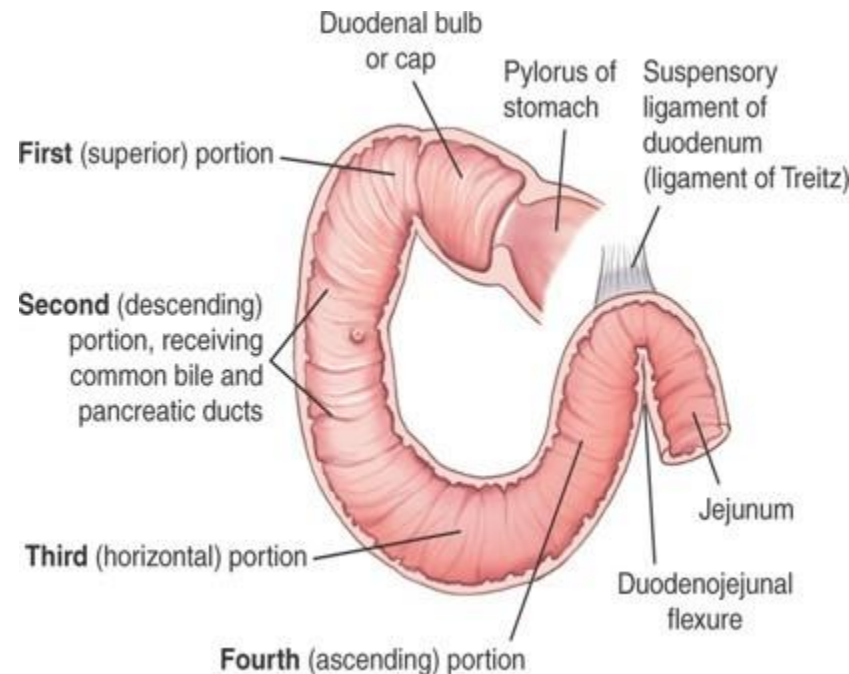
❖ **This is achieved in the duodenum by the addition of:**

1) **Bile from the gall bladder.**

2) **Bicarbonate secretions from the pancreatic duct.**

3) **Bicarbonate – rich mucus from duodenal glands (Brunner's glands).**

• **The chyme arrives in the intestines having been released from the stomach through the opening of the pyloric sphincter.**

• **The resulting alkaline fluid mix neutralises the gastric.**

Duodenal bulb or cap
Pylorus of stomach
Suspensory ligament of duodenum (ligament of Treitz)
First (superior) portion
Second (descending) portion, receiving common bile and pancreatic ducts
Third (horizontal) portion
Jejunum
Duodenojejunal flexure
Fourth (ascending) portion

- **Most food digestion takes place in the small intestine.**

- **When the digested food particles are reduced enough in size and composition, they can be absorbed by the intestinal wall and carried to the blood stream.**

- **Segmentation contractions act to mix and move the chyme more slowly in the small intestine allowing more time for absorption (and these continue in the large intestine).**

Liver
Gallbladder
Pylorus
Duodenum
Right colic flexure
Duodeno-jejunal junction
Ascending colon
Ileocecal junction
Ileum
Cecum
Appendix
Stomach
Pancreas
Left colic flexure
Transverse colon
Jejunum
Descending colon
Sigmoid colon
Rectum
Anal canal
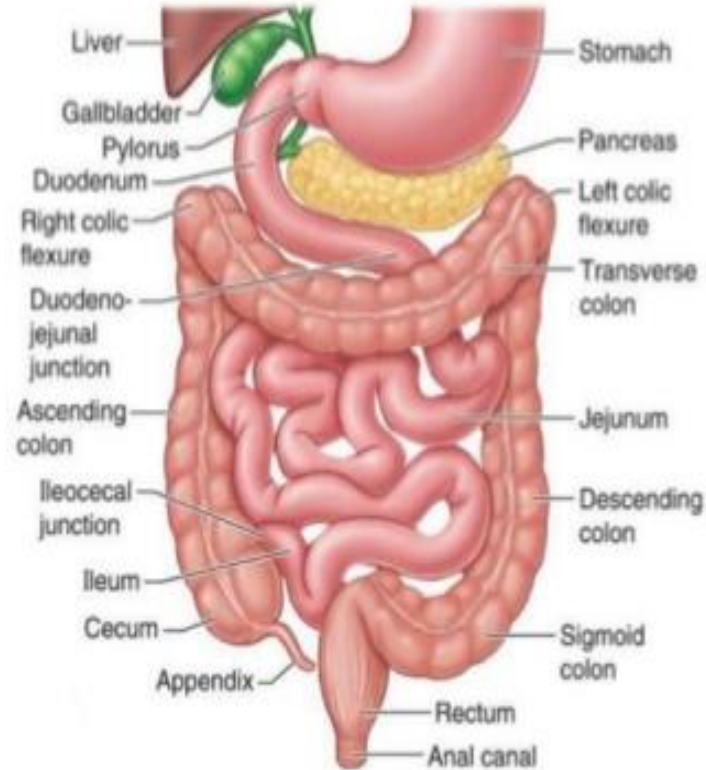
- **There are a digestive cells called enterocytes lining the intestines (the majority being in the small intestine).**
- **They are unusual cells in that they have villi on their surface which in turn have innumerable microvilli on their surface.**
- **All these villi make for a greater surface area, not only for the absorption of chyme but also for its further digestion by large numbers of digestive enzymes present on the microvilli.**

ENTEROCYTE

Microvilli

Golgi apparatus

Smooth endoplasmic reticulum

Nucleus

Mitochondrion
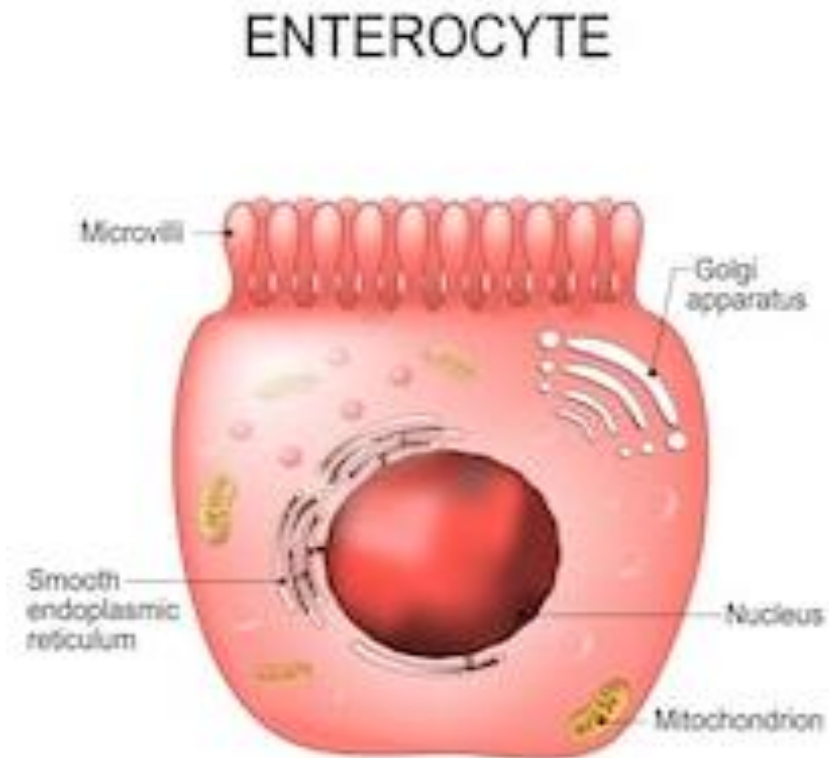
❖ **The jejunum:**

▪ **The midsection of the small intestine contains circular folds, flaps of doubled mucosal membrane which partially encircle and sometimes completely encircle the lumen of the intestine.**

• **These folds together with villi serve to increase the surface area of the jejunum enabling an increased absorption of digested sugars, amino acids and fatty acids into the bloodstream.**

• **The circular folds also slow the passage of food giving more time for nutrients to be absorbed.**
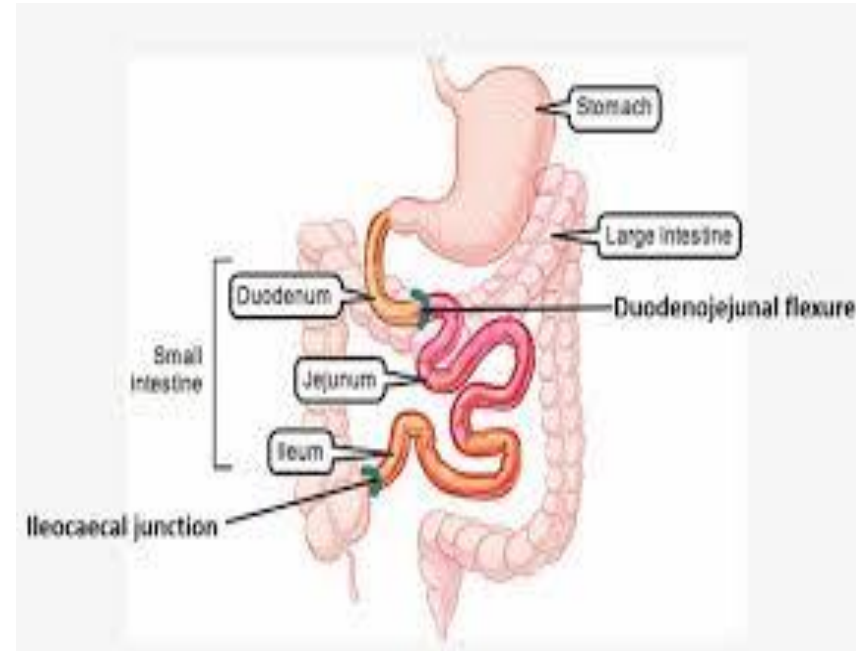
❖ The ileum:

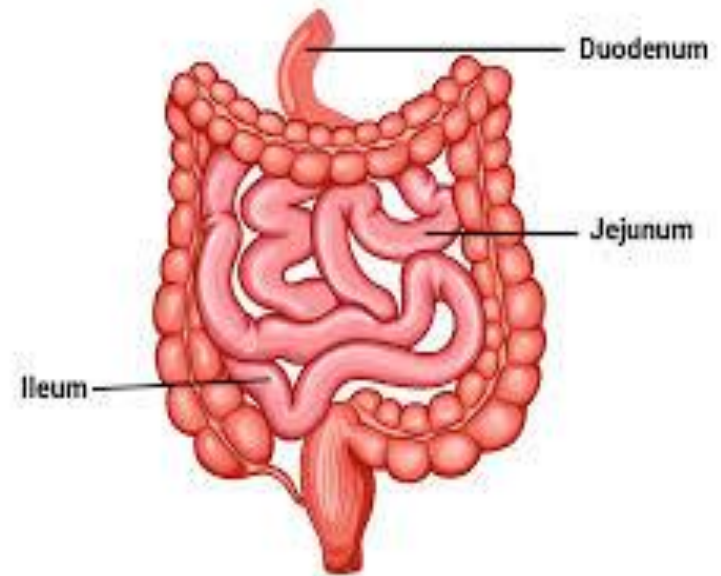- The last part of the small intestine.

- It contains villi;the vitamin B12; bile acids and any residue nutrients are absorbed here.

- When the chyme is exhausted of its nutrients the remaining waste material changes into the semi-solids called feces, which pass to the large intestine, where bacteria in the gut flora further break down residual proteins and starches.


Duodenum

Jejunum

Ileum
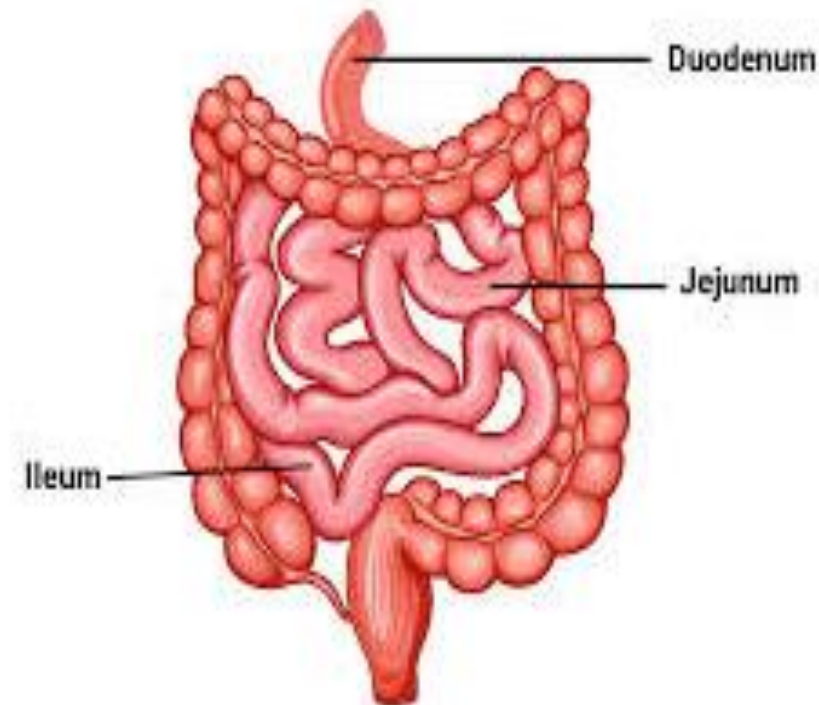
- **Transit time through the small intestine is an average of 4 hours.**

- **Half of the food residues of a meal have emptied from the small intestine by an average of 5.4 hours after ingestion.**

- **Emptying of the small intestine is complete after an average of 8.6 hours.**

❖ Cecum

- **The cecum is a pouch marking the division between the small intestine and the large intestine.**

- **It lies below the ileocecal valve in the lower right quadrant of the abdomen.**

- **The cecum receives chyme from the last part of the small intestine (the ileum) and connects to the ascending colon of the large intestine.**

- **At this junction there is a sphincter or valve, the ileocecal valve which slows the passage of chyme from the ileum, allowing further digestion.**

- **It is also the site of the appendix attachment.**

transverse colon

ascending colon

descending colon

cecum

appendix

sigmoid colon

rectum
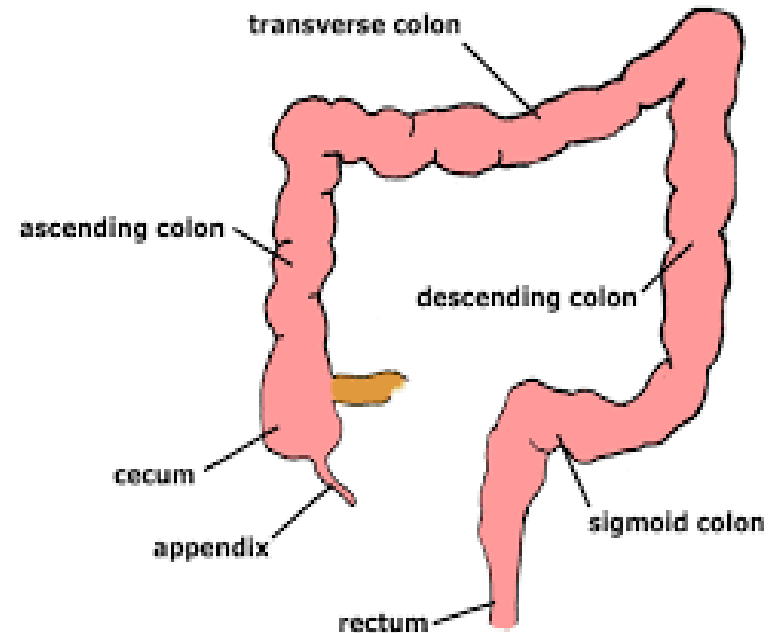
❖ Large intestine

- **In the large intestine, the passage of the digesting food in the colon is a lot slower, taking from 30 to 40 hours until it is removed by defecation.**

- **The colon mainly serves as a site for the fermentation of digestible matter by the gut flora.**

- **The time taken varies considerably between individuals.**
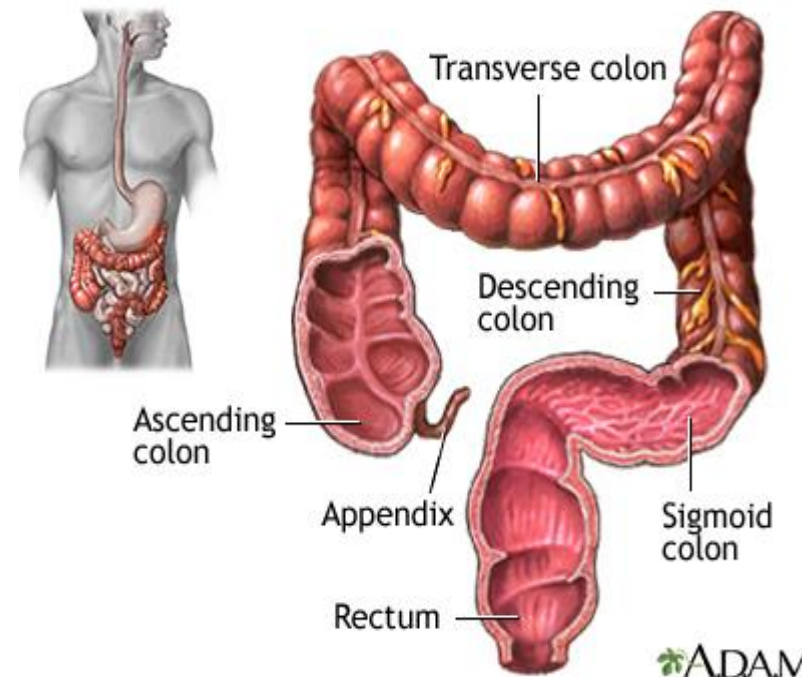
- **The remaining semi-solid waste is termed feces and is removed by the coordinated contractions of the intestinal walls, termed peristalsis, which propels the excreta forward to reach the rectum and exit via defecation from the anus.**

Transverse colon

Descending colon

Ascending colon

Appendix

Sigmoid colon

Rectum

THANK YOU
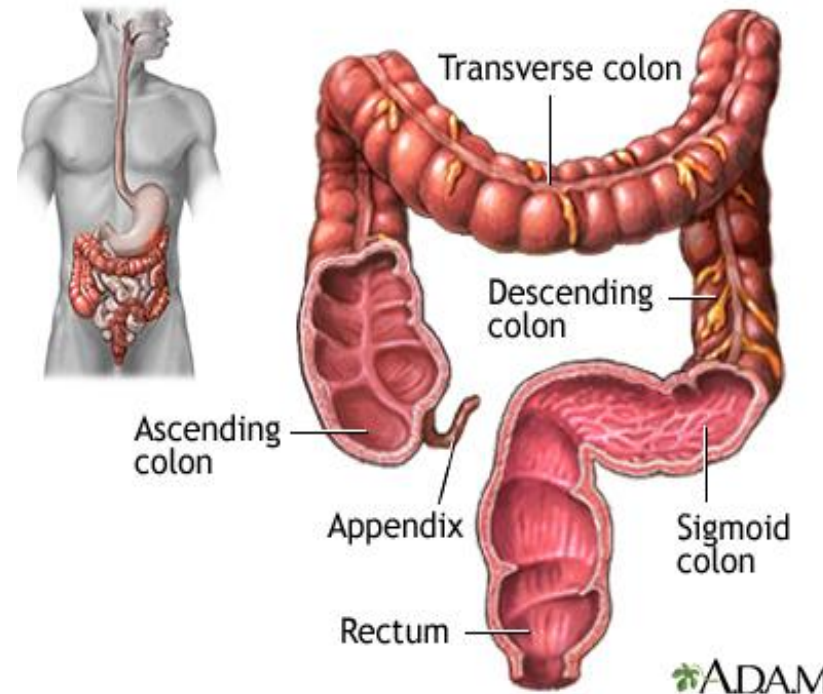
THE URINARY SYSTEM

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

❖**Multiple functions of the kidneys in homeostasis**

1) **Excretion of metabolic waste products and foreign chemicals**

2) **Regulation of water and electrolyte balances**

3) **Regulation of body fluid osmolality and electrolyte concentrations**

4) **Regulation of arterial pressure**

5) **Regulation of acid-base balance**

6) **Secretion, metabolism, and excretion of hormones**

7) **Gluconeogenesis**

❖ **General organization of the kidneys and urinary tract:**

▪ **The two kidneys lie on the posterior wall of the abdomen, outside the peritoneal cavity.**

▪ **Each kidney of the adult human weights about 150 grams and is about the size of a clenched fist.**

Cut-away of kidney

Cortex

Major calyx

Medulla

Renal pelvis

Ureter

Minor calyx
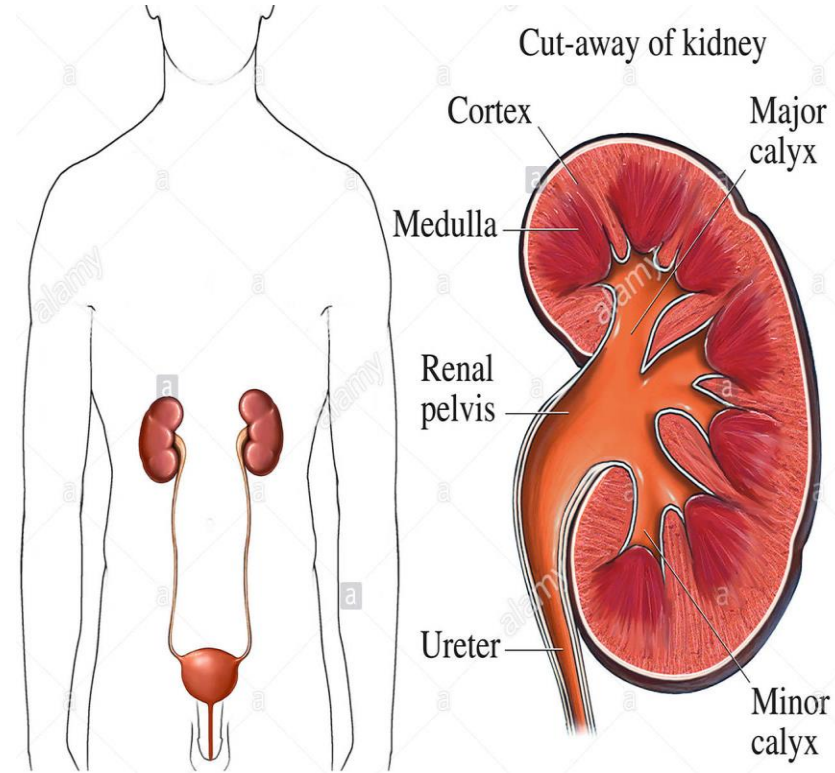
▪ **The medial side of each kidney contains an indented region called the hilum through which pass the renal artery and vein, lymphatics, nerve supply, and ureter.**

▪ **Ureters carries the final urine from the kidney to the bladder, where it is stored until emptied.**

▪ **The kidney is surrounded by a tough, fibrous capsule that protects its delicate inner structures.**

Cut-away of kidney

Cortex

Medulla

Renal pelvis

Ureter

Major calyx

Minor calyx
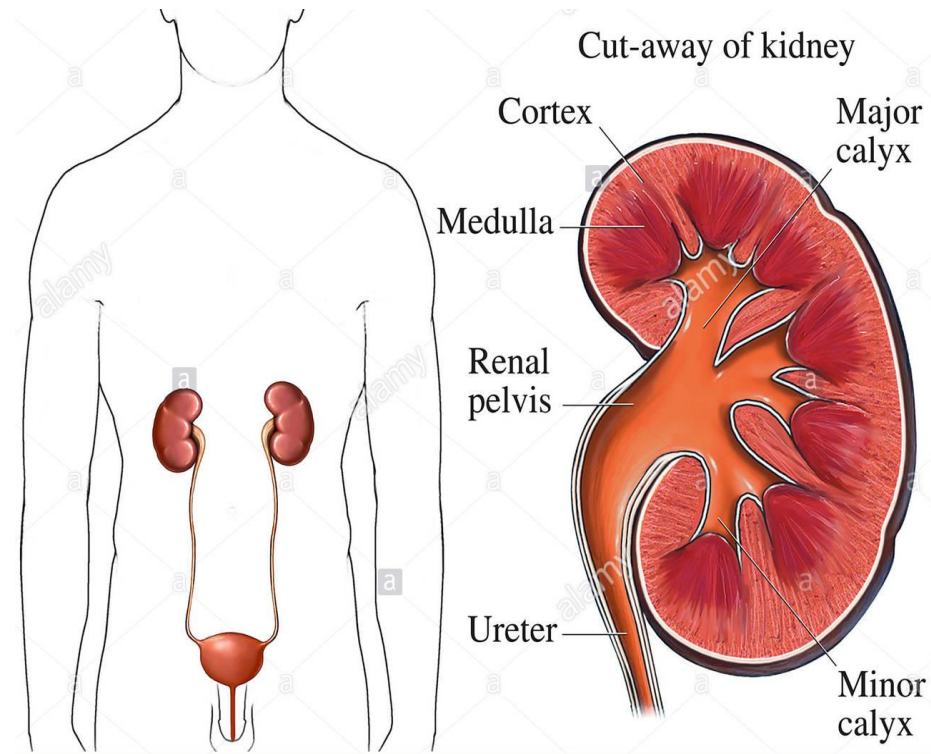
- If the kidney is bisected from top to bottom, the two major regions that can be visualized are the outer cortex and the inner region referred to as the medulla.

- The medulla is divided into multiple cone-shaped masses of tissue called renal pyramids.

- The base of each pyramid originates at the border between the cortex and medulla and terminates in the papilla, which projects into the space of the renal pelvis, a funnel-shaped continuation of the upper end of the ureter.

Cortex
Major calyx
Medulla
Renal pelvis
Ureter
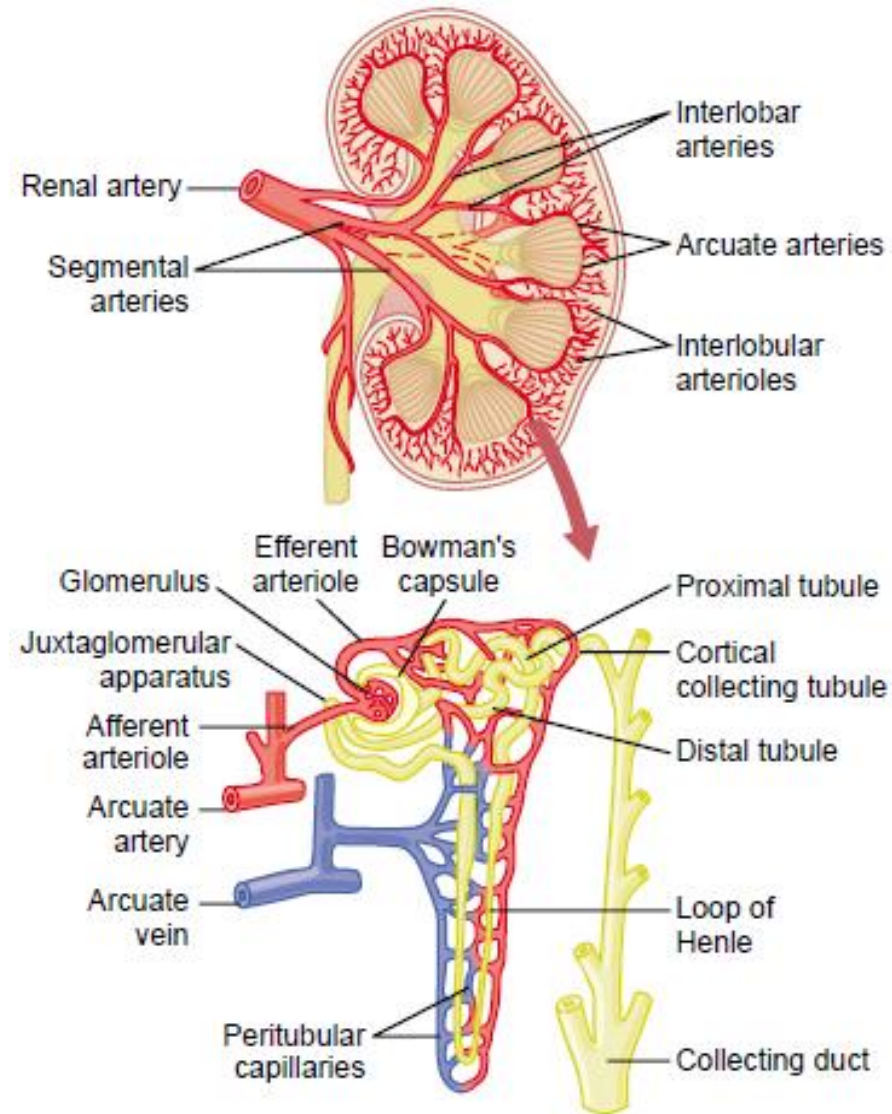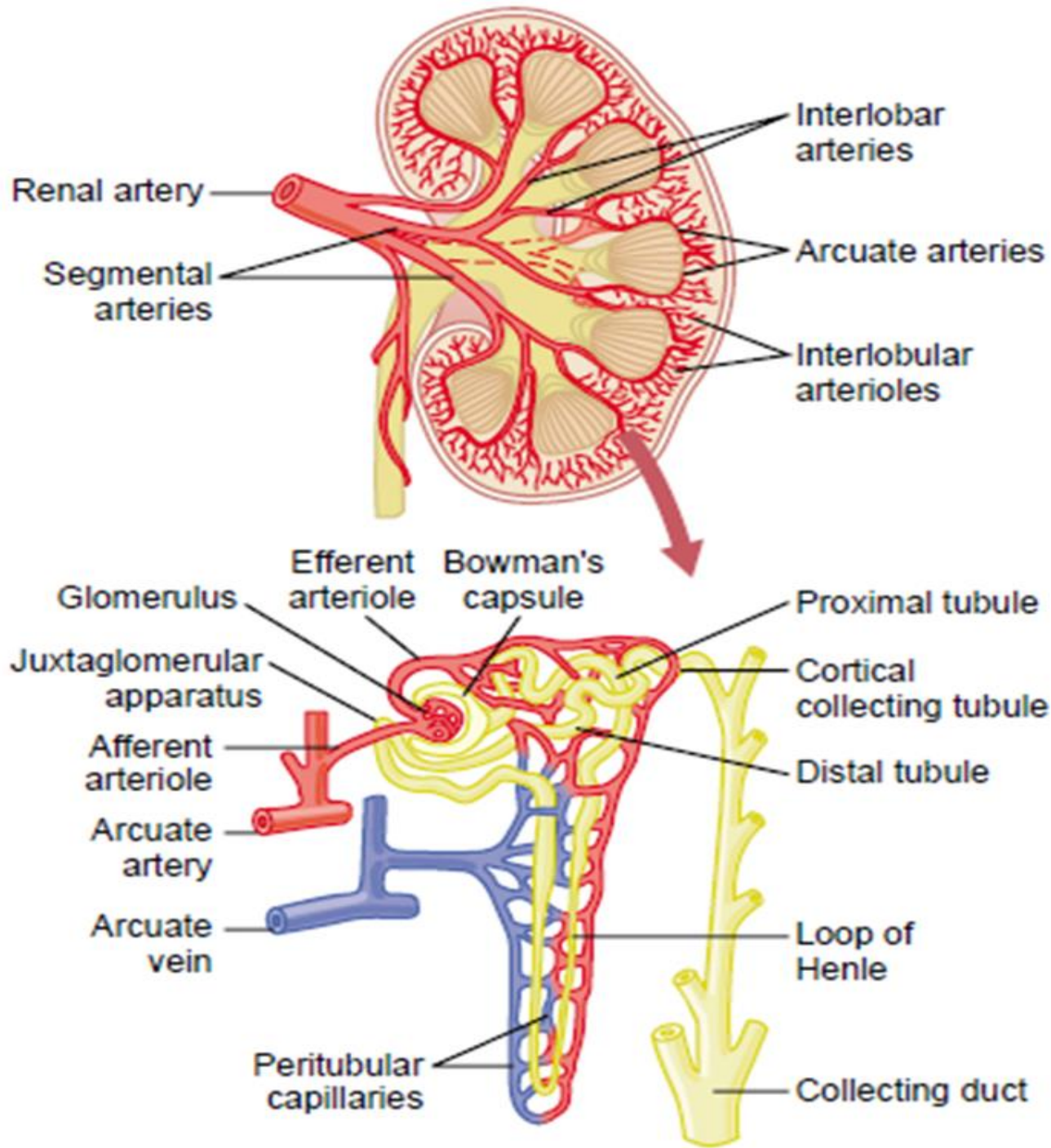Minor calyx
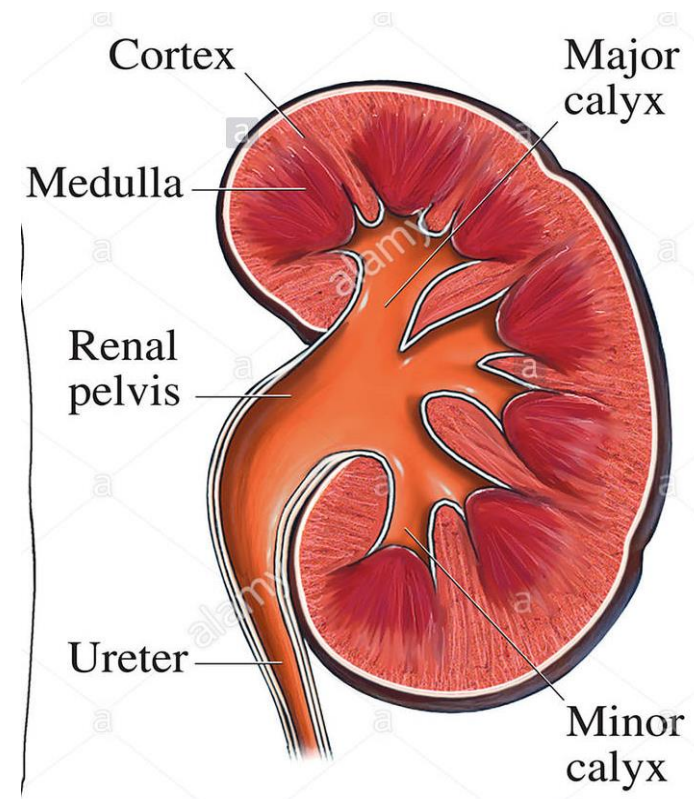
▪ **The outer border of the pelvis is divided into open-ended pouches called major calyces that extend downward and divide into minor calyces, which collect urine from the tubules of each papilla.**

Cortex

Medulla

Renal pelvis

Ureter

Major calyx

Minor calyx
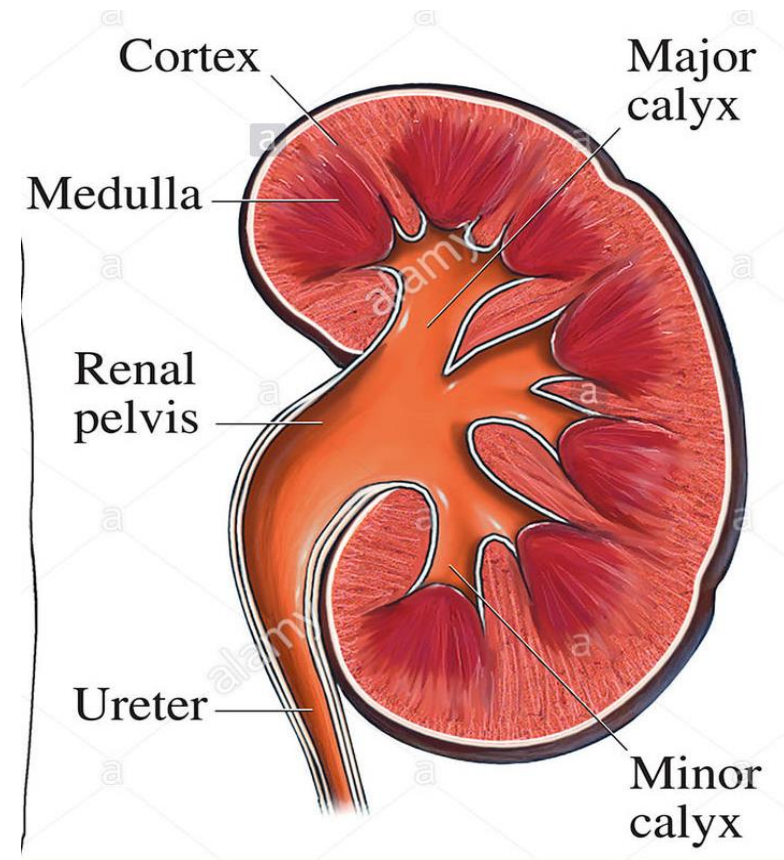
❖ Renal Blood Supply

- **Blood flow to the two kidneys is normally about 22 % of the cardiac output, or 1100 ml/min.**

- The renal artery enters the kidney through the hilum and then branches progressively to form the **interlobar arteries, arcuate arteries, interlobular arteries** (also called radial arteries) and **afferent** arterioles, which lead to the **glomerular capillaries,** where large amounts of fluid and solutes (except the plasma proteins) are filtered to begin urine formation .

Renal artery

Segmental arteries

Interlobar arteries

Arcuate arteries

Interlobular arterioles

Glomerulus

Efferent arteriole

Bowman's capsule

Proximal tubule

Juxtaglomerular apparatus

Cortical collecting tubule

Afferent arteriole

Distal tubule

Arcuate artery

Arcuate vein

Loop of Henle

Peritubular capillaries

Collecting duct
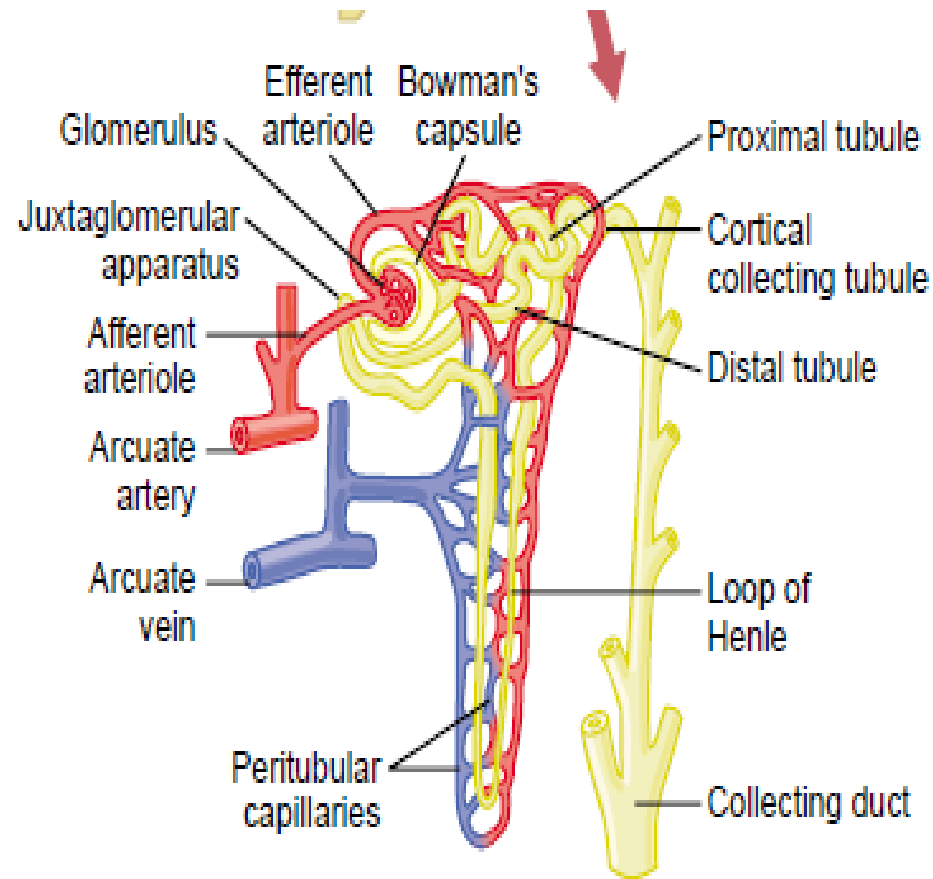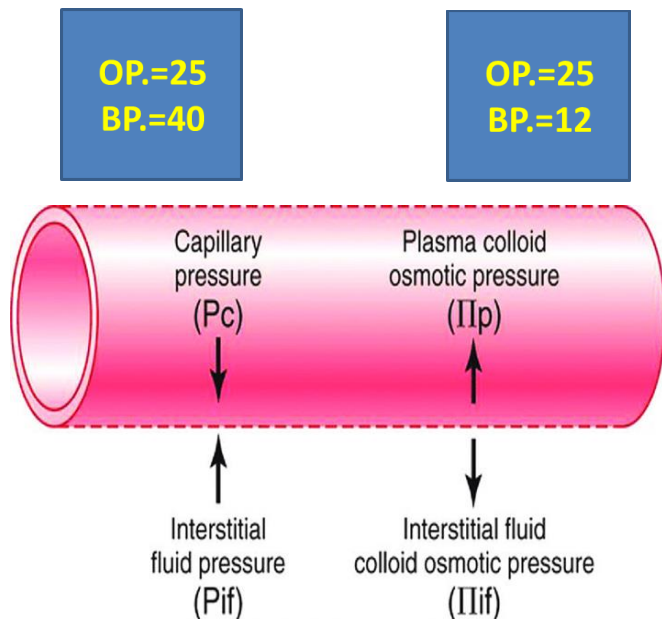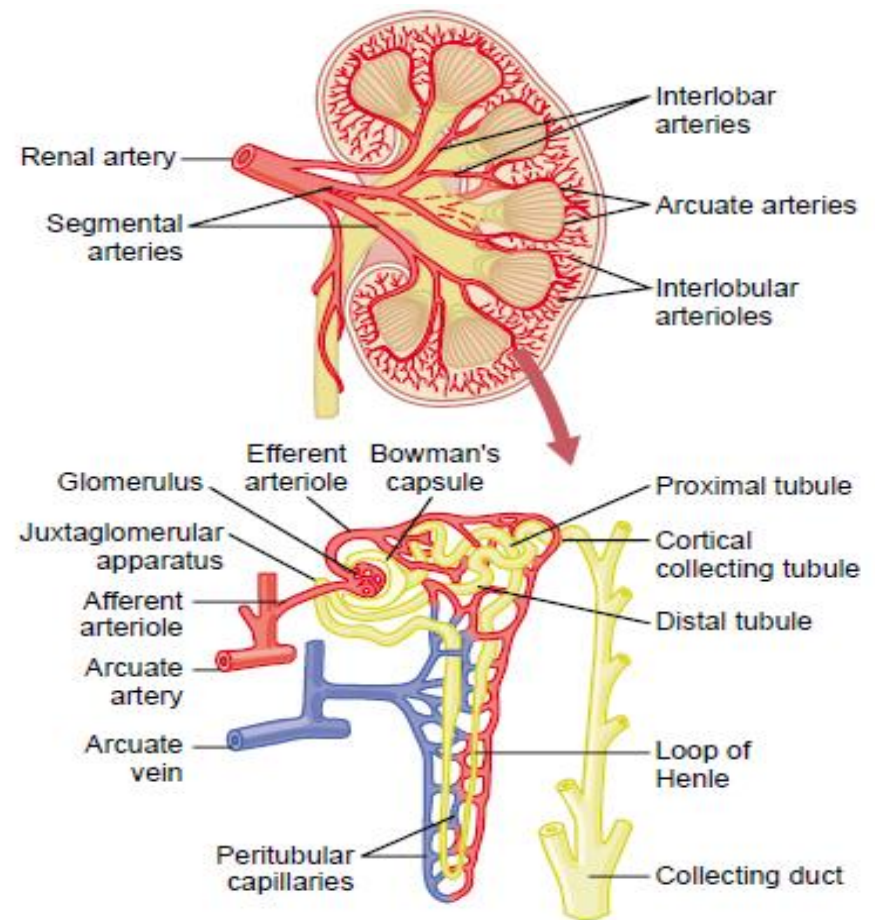
- **The distal ends of the capillaries of each glomerulus coalesce to form the efferent arteriole, which leads to a second capillary network, the peritubular capillaries, that surrounds the renal tubules.**
- **The renal circulation is unique in that it has two capillary beds:**
1) **The glomerular.**
2) **Peritubular capillaries.**

which are arranged in series and separated by the efferent arterioles, which help regulate the hydrostatic pressure in both sets of capillaries.

Glomerulus

Juxtaglomerular apparatus

Afferent arteriole

Arcuate artery

Arcuate vein

Peritubular capillaries

Efferent arteriole

Bowman's capsule

Proximal tubule

Cortical collecting tubule

Distal tubule
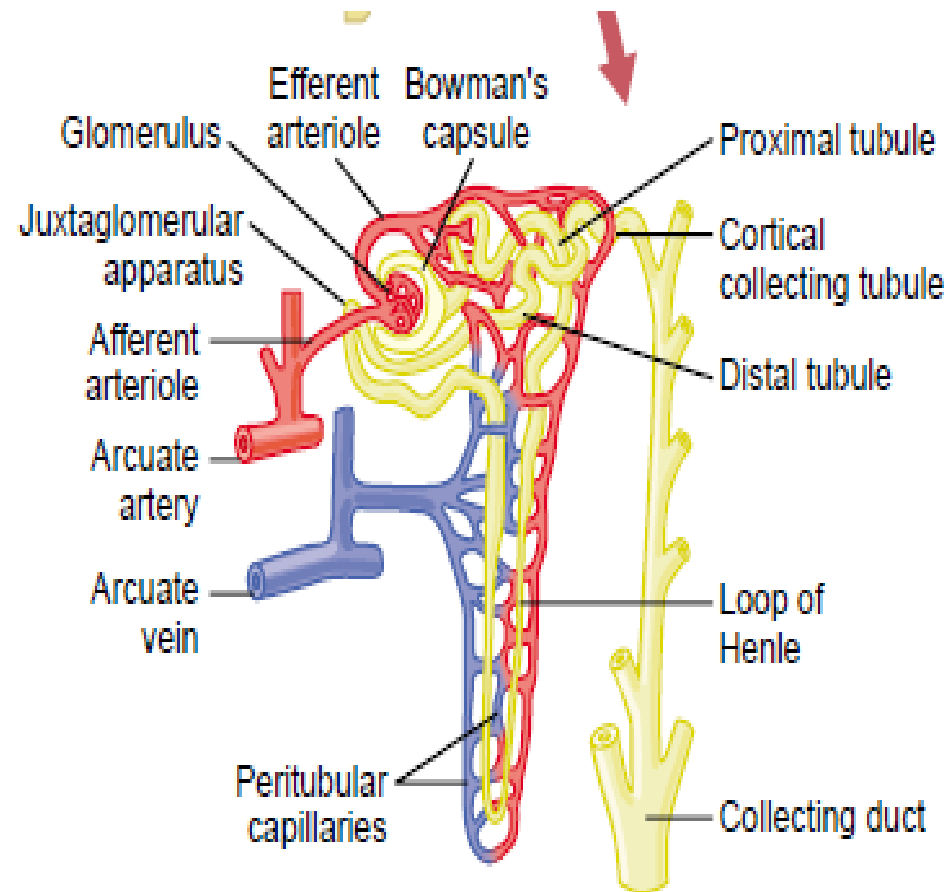
Loop of Henle

Collecting duct
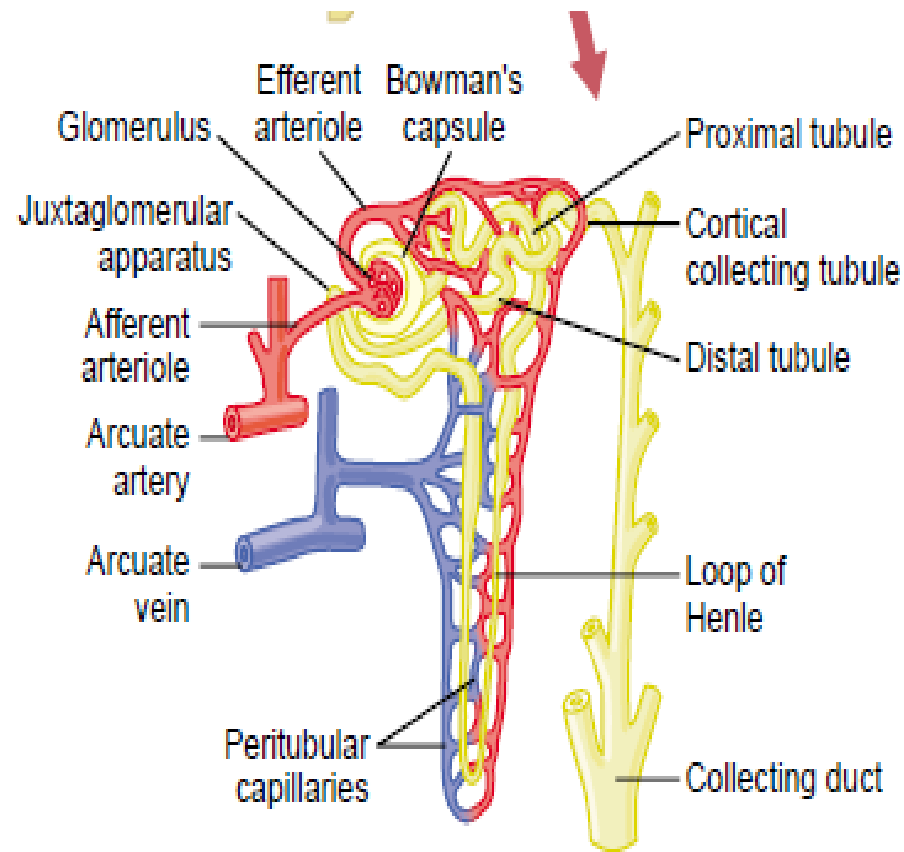
- **High hydrostatic pressure in the glomerular capillaries (60 mmHg) causes rapid fluid filtration.**
- **whereas a much lower hydrostatic pressure in the peritubular capillaries (13 mm Hg) permits rapid fluid reabsorption.**

OP.=25
BP.=40

OP.=25
BP.=12

Capillary pressure (Pc)

Plasma colloid osmotic pressure (Πp)

Interstitial fluid pressure (Pif)

Interstitial fluid colloid osmotic pressure (Πif)

Efferent arteriole

Bowman's capsule

Glomerulus

Juxtaglomerular apparatus

Afferent arteriole

Arcuate artery

Arcuate vein

Peritubular capillaries

Proximal tubule

Cortical collecting tubule

Distal tubule

Loop of Henle

Collecting duct

- **By adjusting the resistance of the afferent and efferent arterioles, the kidneys can regulate the hydrostatic pressure in both the glomerular and the peritubular capillaries.**

- **Thereby changing the rate of:**

➤ **Glomerular filtration.**

➤ **Tubular reabsorption,**

➤ **OR both.**

in response to body homeostatic demands.

Renal artery —
Segmental arteries
Interlobar arteries
Arcuate arteries
Interlobular arterioles

Glomerulus
Juxtaglomerular apparatus
Afferent arteriole
Arcuate artery
Arcuate vein
Peritubular capillaries
Efferent arteriole
Bowman's capsule
Proximal tubule
Cortical collecting tubule
Distal tubule
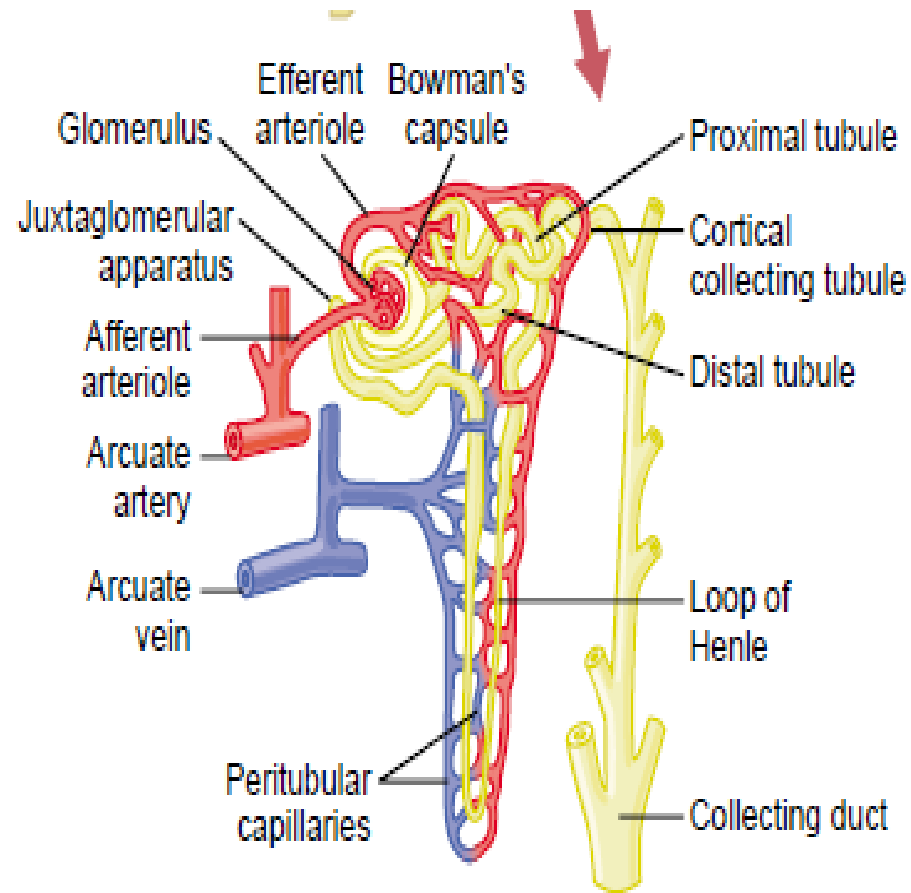Loop of Henle
Collecting duct

- **The peritubular capillaries empty into the vessels of the venous system.**
- **which run parallel to the arteriolar vessels and progressively form the** interlobular **vein,** arcuate **vein,** interlobar **vein, and** renal **vein, which leaves the kidney beside the renal artery and ureter.**

Efferent arteriole
Glomerulus
Bowman's capsule
Proximal tubule
Juxtaglomerular apparatus
Cortical collecting tubule
Afferent arteriole
Distal tubule
Arcuate artery
Arcuate vein
Loop of Henle
Peritubular capillaries
Collecting duct

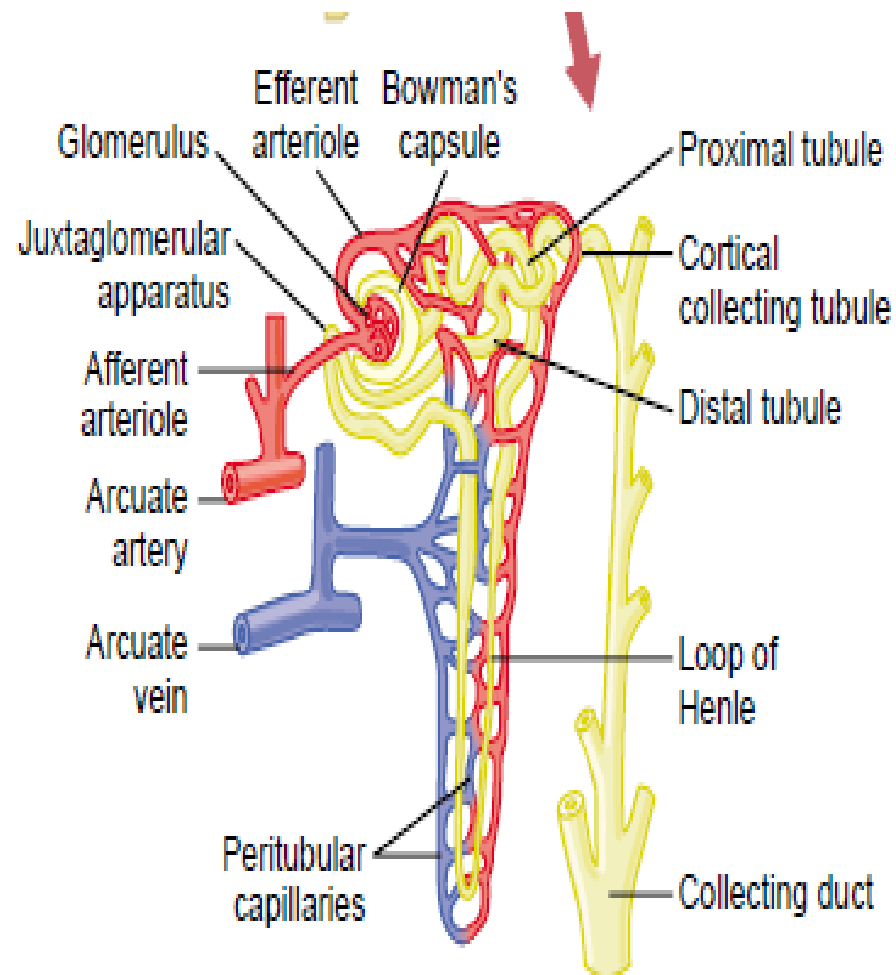## ❖ The nephron:

- It is the functional unit of the kidney

- Each kidney in the human contains about 1million nephrons, each capable of forming urine.

- The kidney cannot regenerate new nephrons.

- Therefore, with renal injury, disease, or normal aging, there is a gradual decrease in nephron number.
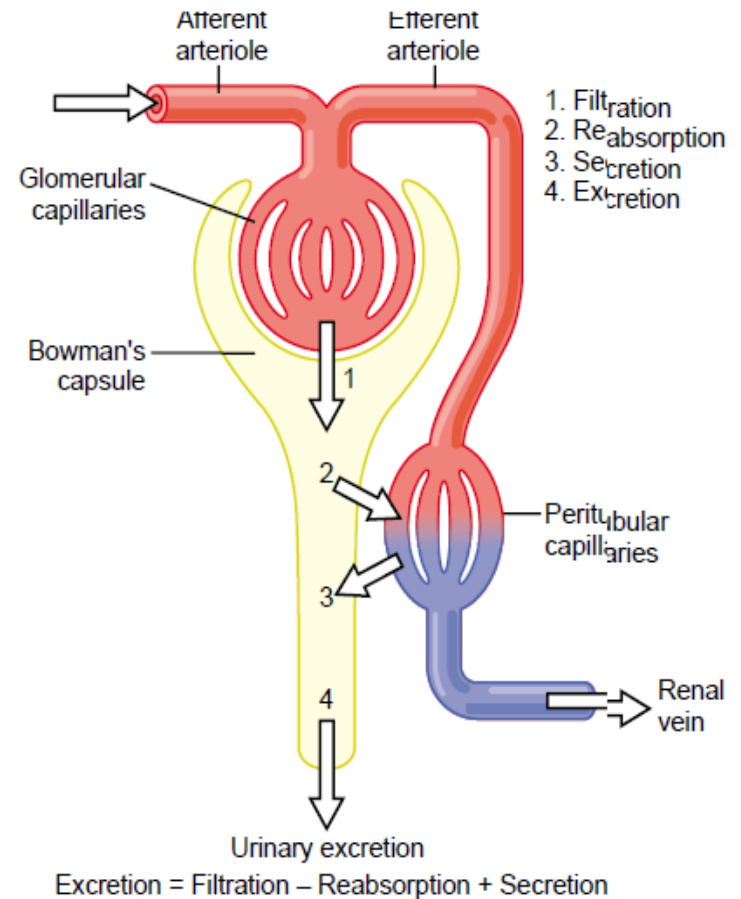
Efferent arteriole

Bowman's capsule

Glomerulus

Proximal tubule

Juxtaglomerular apparatus

Cortical collecting tubule

Afferent arteriole

Distal tubule

Arcuate artery

Arcuate vein

Loop of Henle

Peritubular capillaries

Collecting duct

- **After age 40, the number of functioning nephrons usually decreases about 10 % every 10 years; thus, at age 80, many people have 40% fewer functioning nephrons than they did at age 40 but these changes is adapted.**
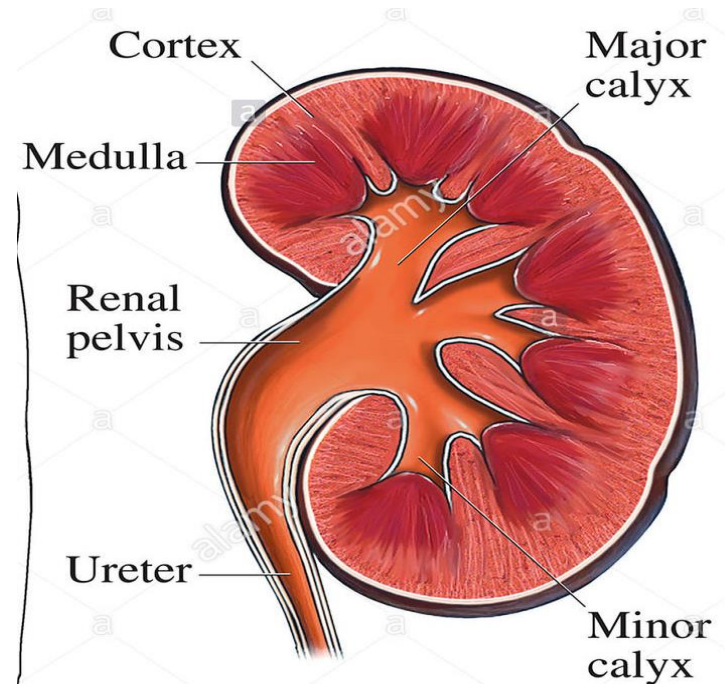
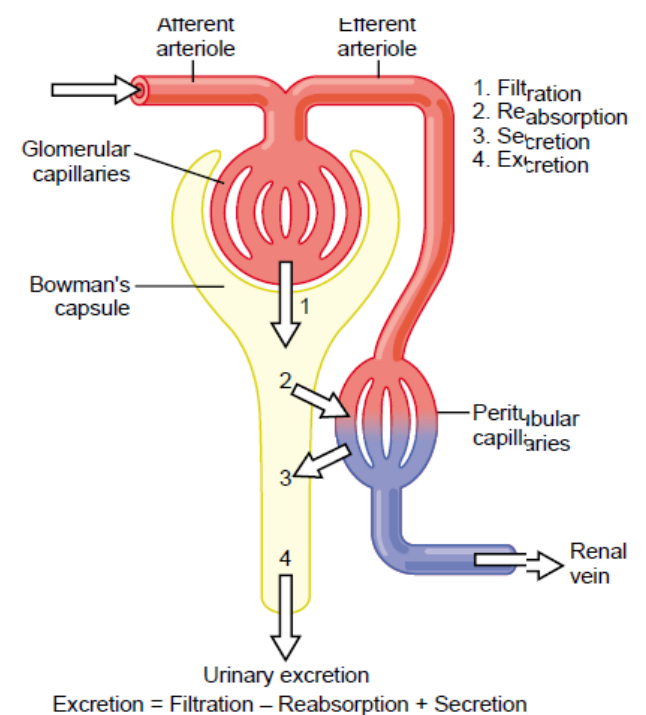- **Each nephron contain glomerulus & a long tubule.**

Efferent Bowman's
Glomerulus arteriole capsule
Juxtaglomerular
apparatus
Proximal tubule
Cortical
collecting tubule
Afferent
arteriole
Distal tubule
Arcuate
artery
Arcuate
vein
Loop of
Henle
Peritubular
capillaries
Collecting duct

- **The glomerulus contains a network of branching and anastomosing glomerular capillaries that, compared with other capillaries, have high hydrostatic pressure (60 mm Hg).**

- **The glomerular capillaries are covered by epithelial cells, and the total glomerulus is encased in Bowman's capsule.**

Afferent arteriole
Efferent arteriole
Glomerular capillaries
Bowman's capsule
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Peritubular capillaries
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion

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.

Afferent arteriole

Efferent arteriole

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Glomerular capillaries

Bowman's capsule

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion

Cortex

Major calyx

Medulla

Renal pelvis

Ureter

Minor calyx

▪ **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 the lower end of the ascending limb are very thin and therefore are called the thin segment of the loop of Henle.**
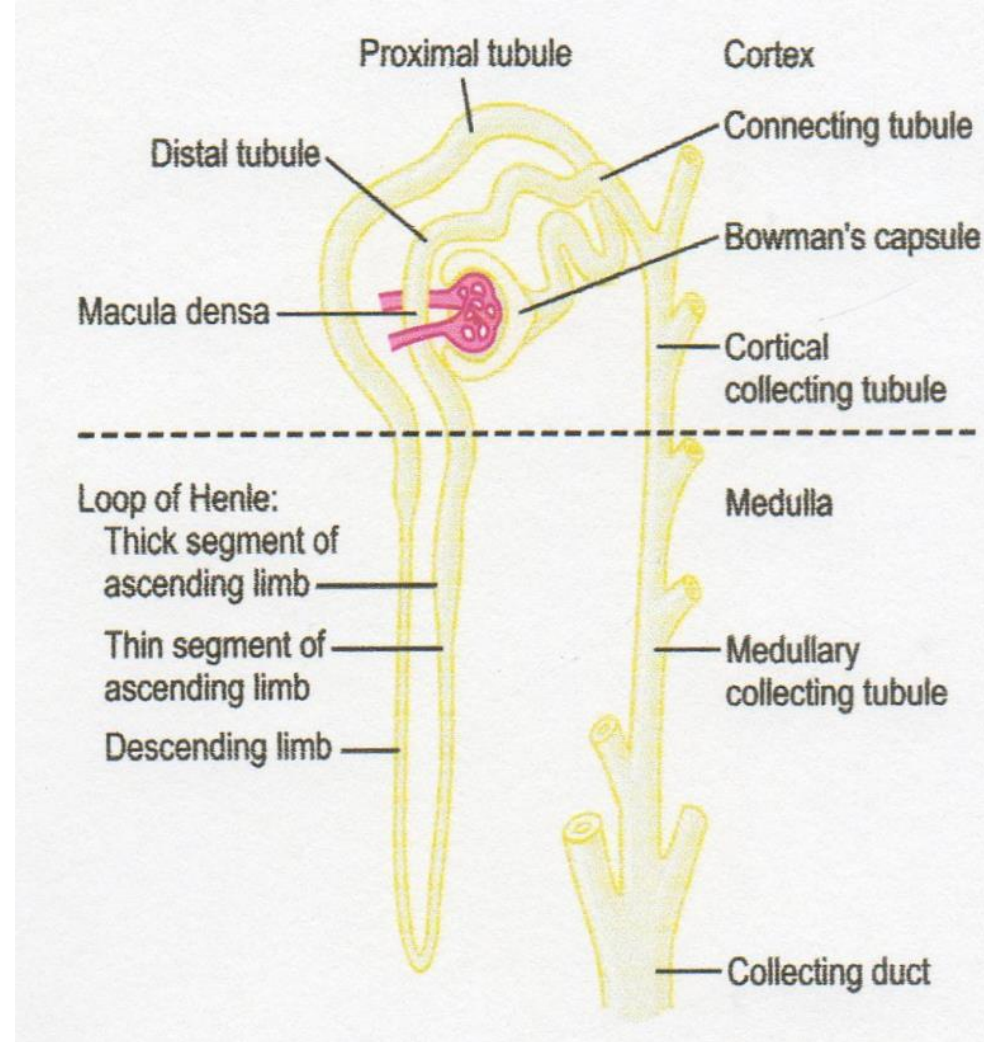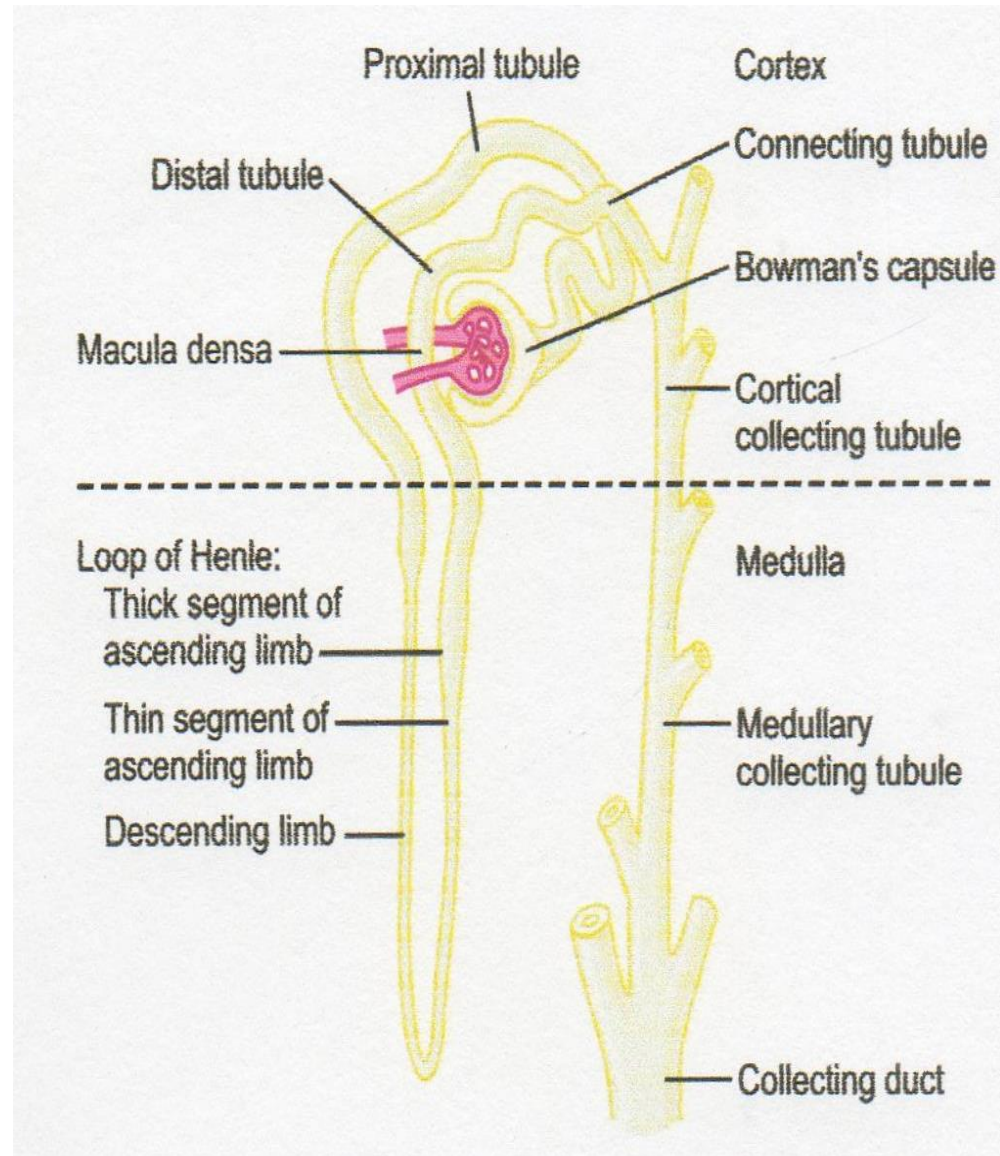
After the ascending limb of the loop has returned partway back to the cortex, its wall becomes much thicker, and it is referred to as the thick segment **of the** ascending limb.

At the end of the thick ascending limb is a short segment, which is actually a plaque in its wall, known as the **macula densa.**

Proximal tubule

Cortex

Connecting tubule

Distal tubule

Bowman's capsule

Macula densa

Cortical collecting tubule

Loop of Henle:
Thick segment of ascending limb

Medulla

Thin segment of ascending limb

Medullary collecting tubule

Descending limb
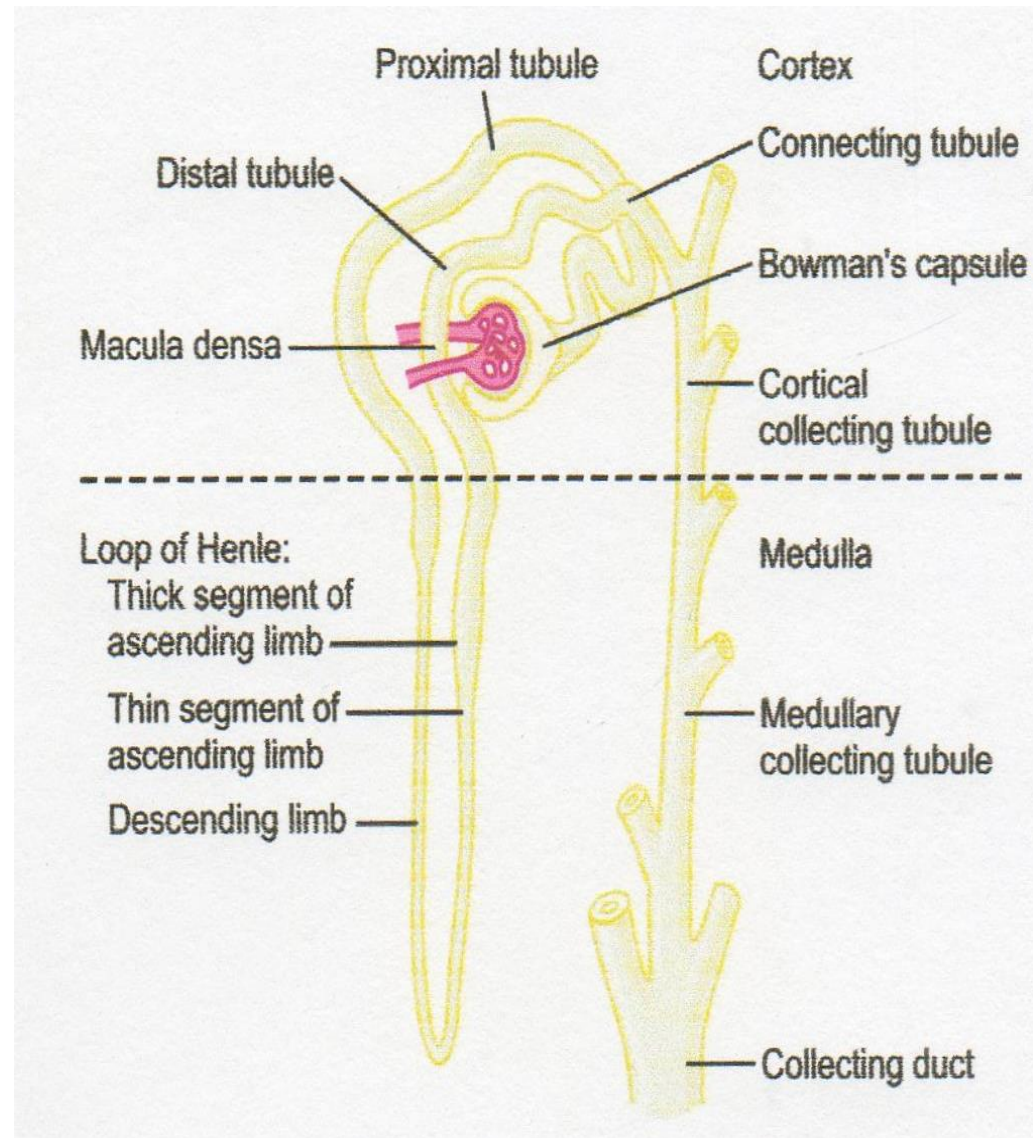
Collecting duct

▪**Beyond the macula densa, fluid enters the distal tubule, which, like the proximal tubule, lies in the renal cortex.**

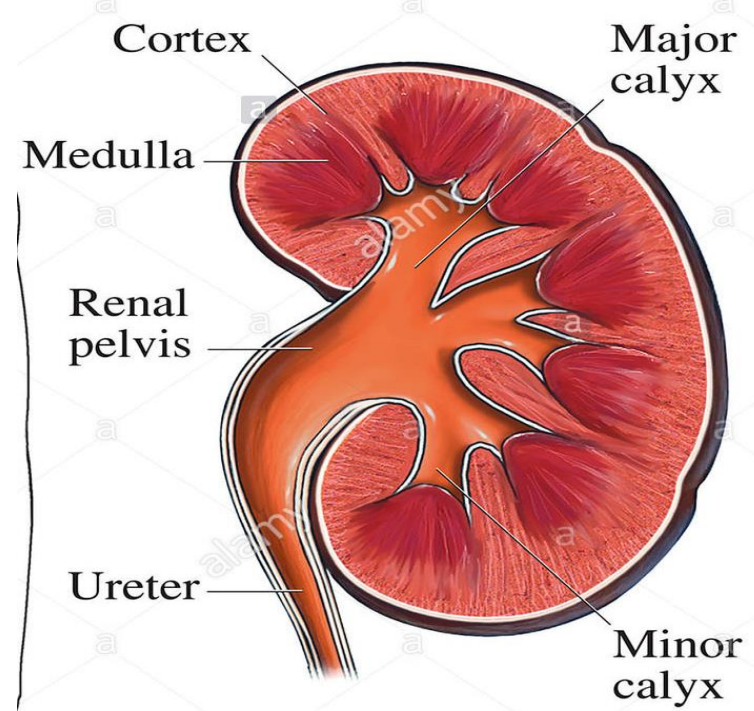▪**This is followed by the connecting tubule and the cortical collecting tubule, which lead to the cortical collecting duct.**

Proximal tubule

Cortex

Distal tubule

Connecting tubule

Bowman's capsule

Macula densa

Cortical collecting tubule

Loop of Henle:
Thick segment of ascending limb

Medulla

Thin segment of ascending limb

Medullary collecting tubule

Descending limb

Collecting duct

- **The initial parts of 8 to 10 cortical collecting ducts join to form a single larger collecting duct that runs downward into the medulla and becomes the medullary collecting duct.**

- **The collecting ducts merge to form progressively larger ducts that eventually empty into the renal pelvis through the tips of the renal papillae.**

- **In each kidney, there are about 250 collecting ducts, each of which collects urine from about 4000 nephrons.**


Cortex — Major calyx — Medulla — Renal pelvis — Ureter — Minor calyx

Proximal tubule — Cortex — Distal tubule — Connecting tubule — Macula densa — Bowman's capsule — Cortical collecting tubule — Loop of Henle: Thick segment of ascending limb — Medulla — Thin segment of ascending limb — Medullary collecting tubule — Descending limb — Collecting duct

THANK YOU
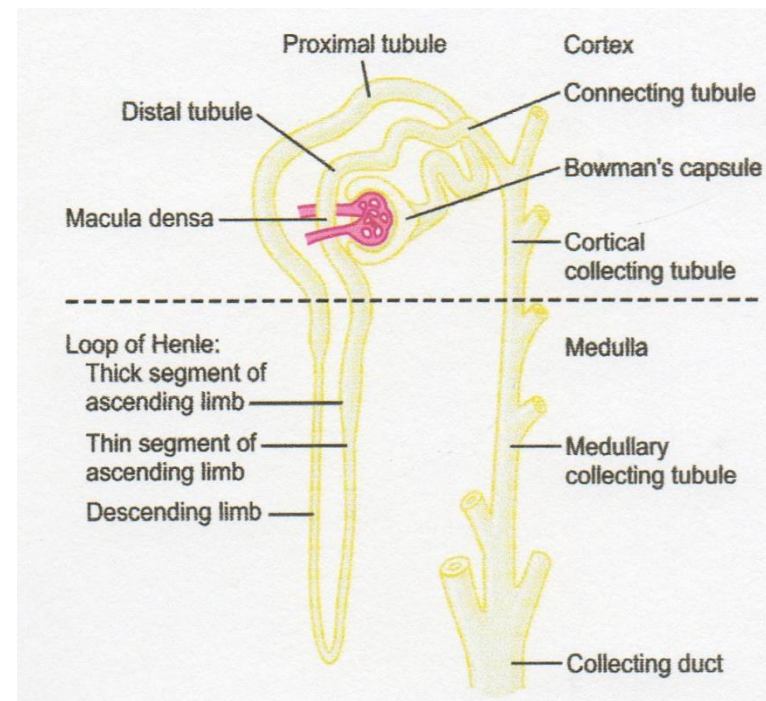
Physiologic anatomy
of
the bladder

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

the bladder

▪ **The urinary bladder: is a smooth muscle chamber composed of two main parts:**

(1) **The body, which is the major part of the bladder in which urine collects.**

(2) **The neck: is a funnel-shaped extension of the body, passing inferiorly and anteriorly into the urogenital triangle and connecting with the urethra**
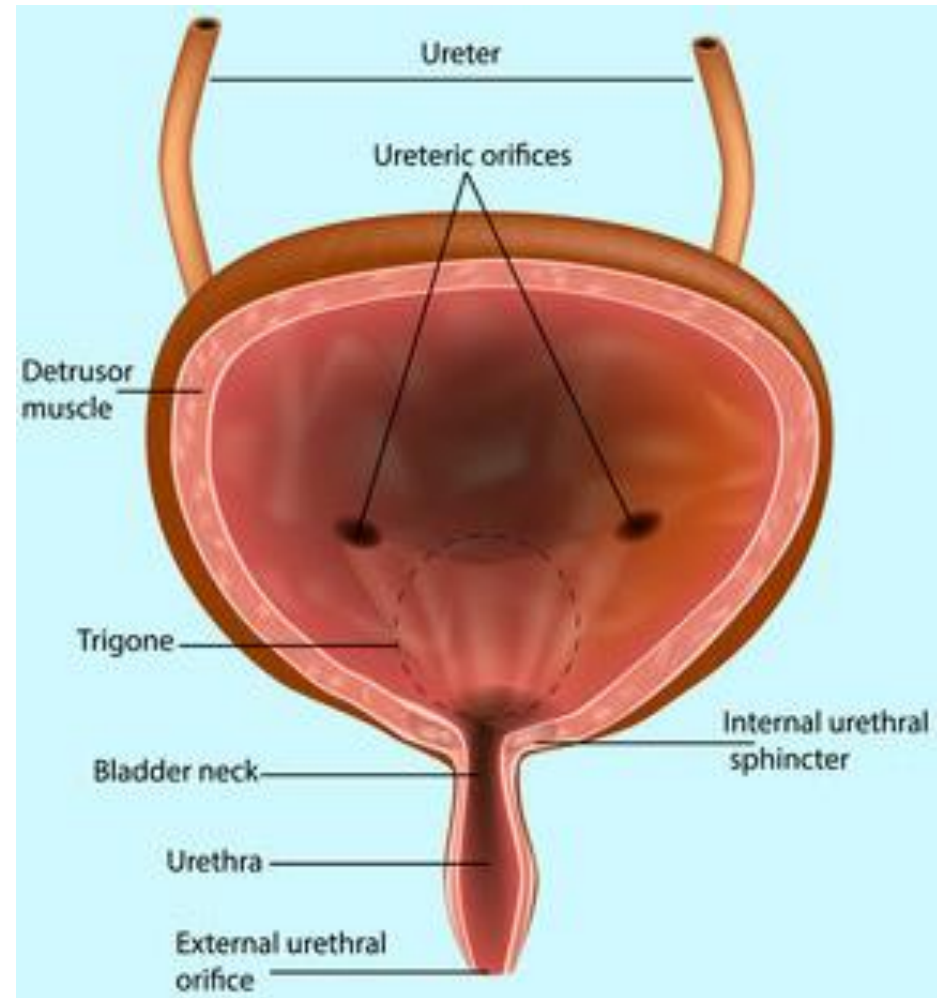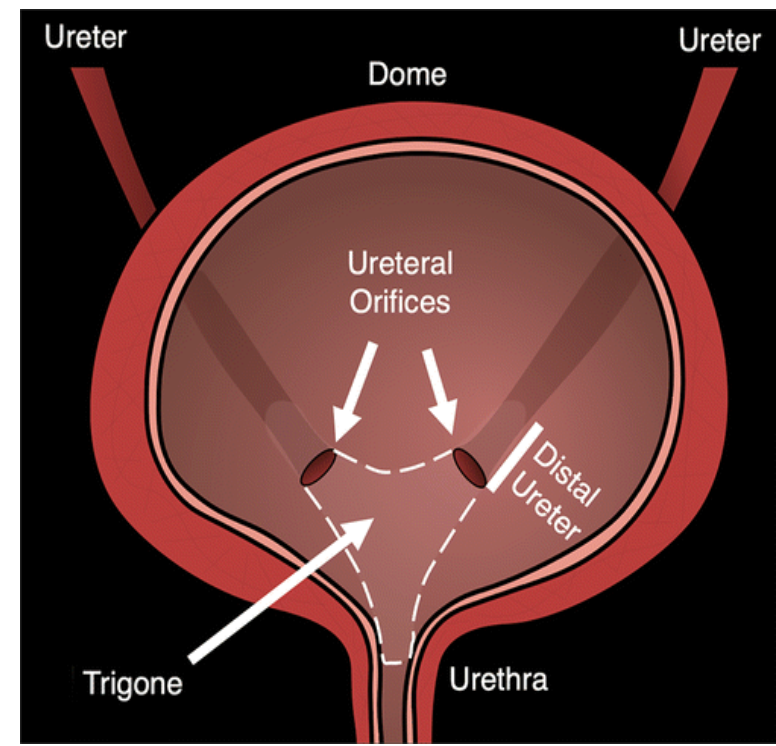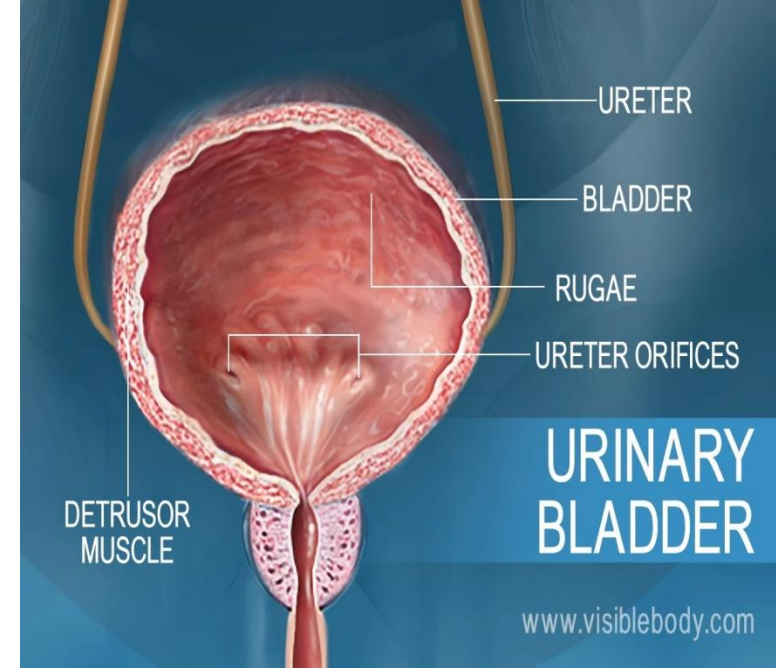
- **The lower part of the bladder neck is also called the posterior urethra because of its relation to the urethra.**

- **The smooth muscle of the bladder is called the detrusor muscle.**

- **It's muscle fibers extend in all directions and, when contracted, can increase the pressure in the bladder to 40 - 60 mm Hg.**

- **Thus, contraction of the detrusor muscle is a major step in emptying the bladder.**


URETER
BLADDER
RUGAE
URETER ORIFICES
DETRUSOR MUSCLE
URINARY BLADDER
www.visiblebody.com

Ureter
Ureter
Dome
Ureteral Orifices
Distal Ureter
Trigone
Urethra

■ **On the posterior wall of the bladder, lying immediately above the bladder neck, is a small triangular area called the trigone.**

■ **At the lowermost apex of the trigone, the bladder neck opens into the posterior urethra.**

■**The two ureters enter the bladder at the uppermost angles of the trigone.**

■ **The trigone can be identified by the fact that its mucosa is smooth, in contrast to the remaining bladder mucosa, which is folded to form rugae.**
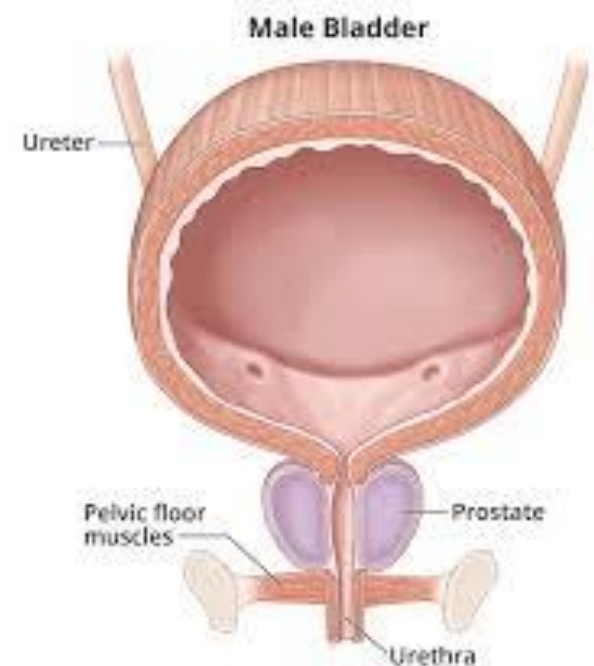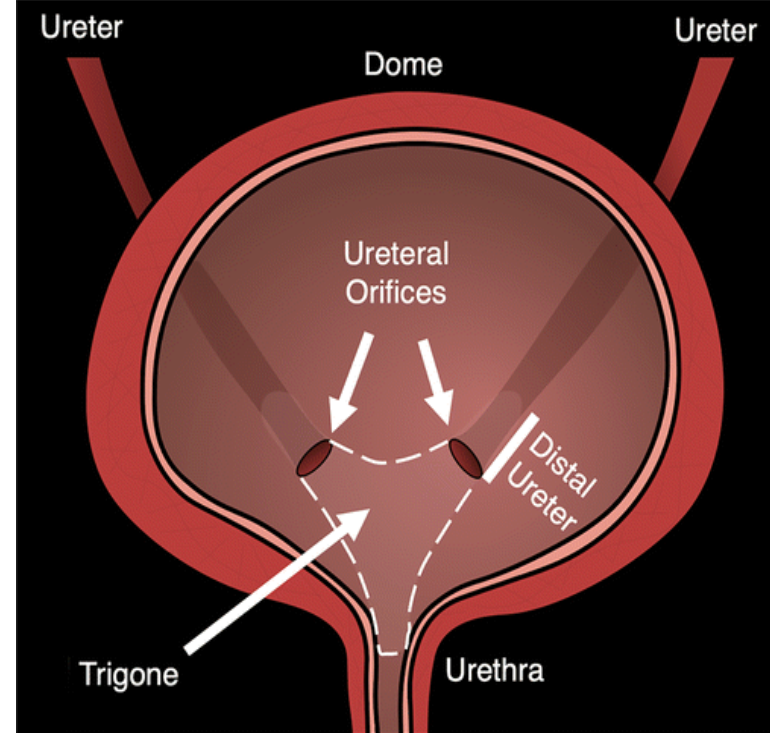
- **The bladder neck (posterior urethra) is (2 - 3 cm) long, and its wall is composed of detrusor muscle interlaced with a large amount of elastic tissue. The muscle in this area is called the internal sphincter.**

- **Beyond the posterior urethra, the urethra passes through the urogenital diaphragm, which contains a layer of muscle called the external sphincter of the bladder.**
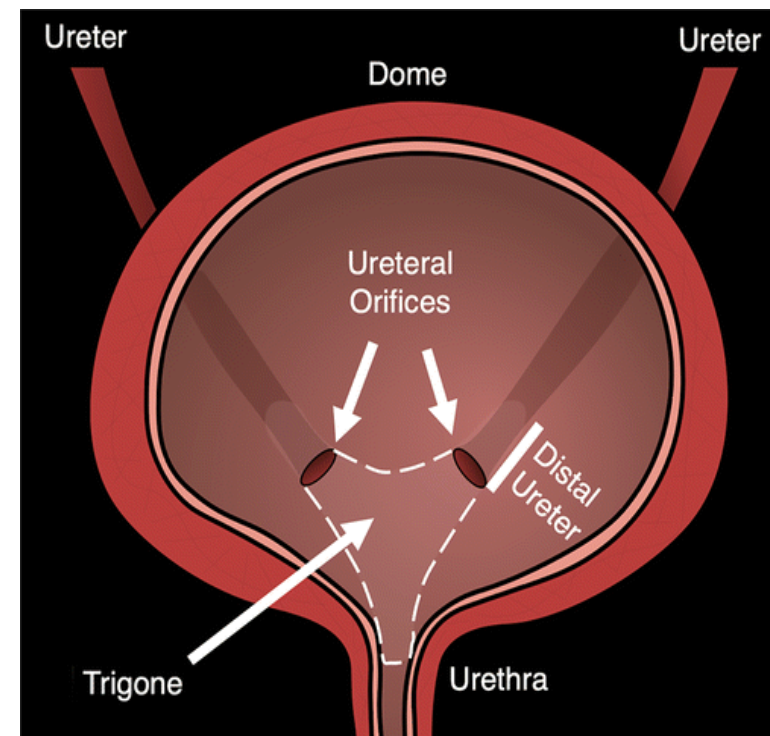
- This muscle is a **voluntary skeletal muscle**, in contrast to the muscle of the bladder body and bladder neck, which is entirely **smooth muscle**.

- The external sphincter muscle is under voluntary control of the nervous system and can be used to consciously prevent urination even when involuntary controls are attempting to empty the bladder.
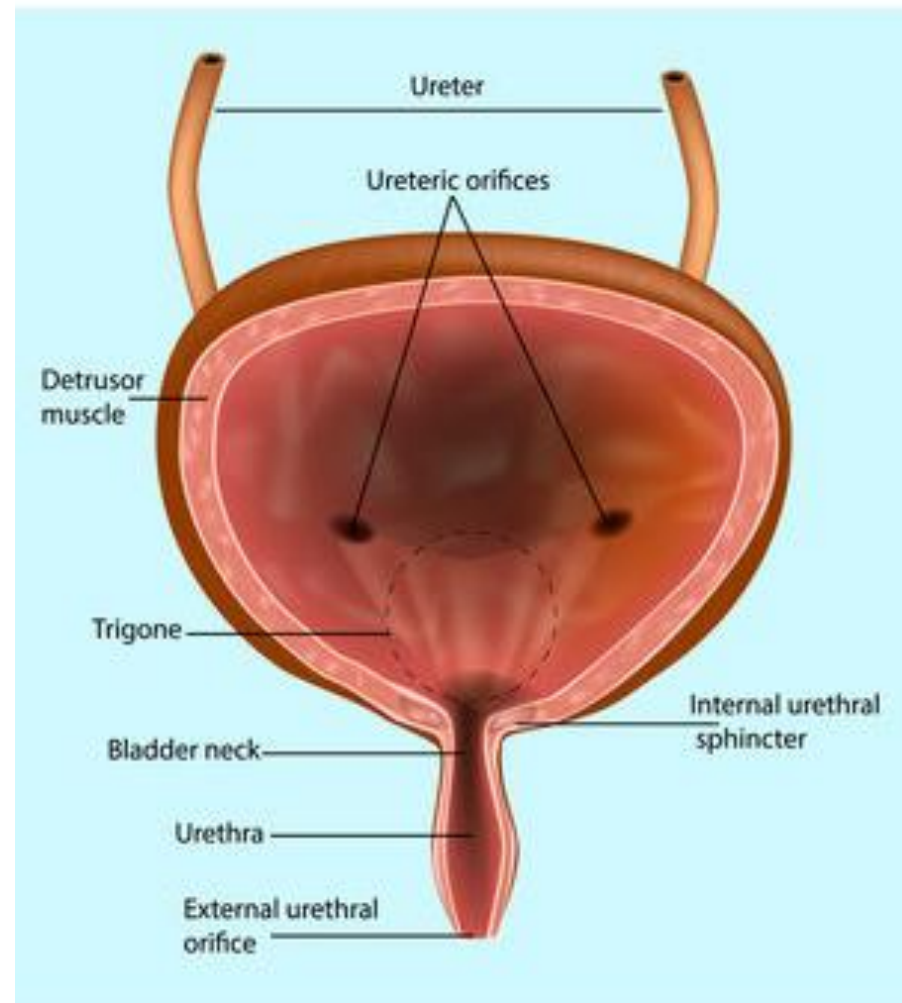
- **Ureters:** The walls of the ureters contain smooth muscle and are innervated by both sympathetic and parasympathetic nerves as well as by an intramural plexus of neurons and nerve fibers that extends along the entire length of the ureters.
- **Peristaltic contractions in the ureter are enhanced by** parasympathetic **stimulation and inhibited by** sympathetic **stimulation.**
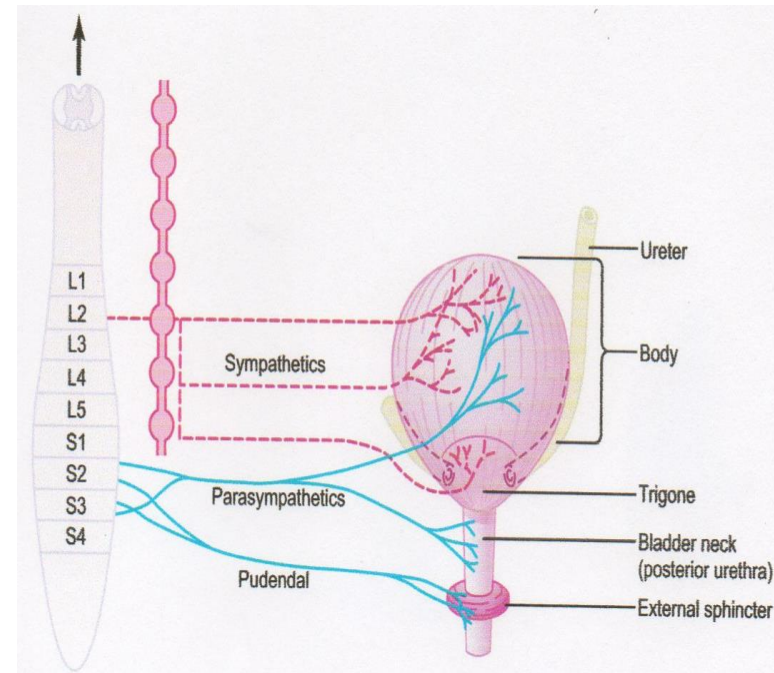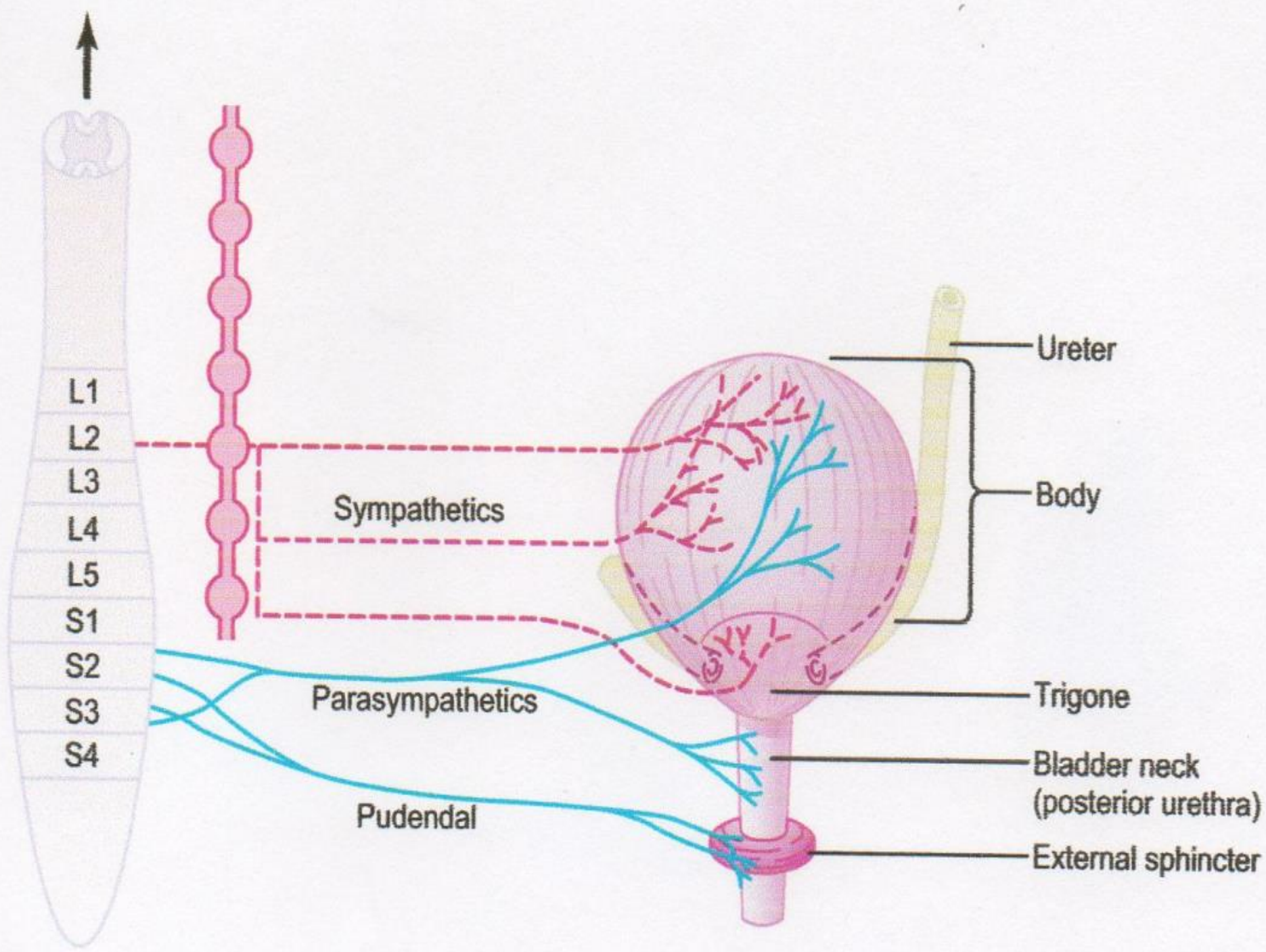

Kidney

Ureter

Bladder

Prostate

Urethra
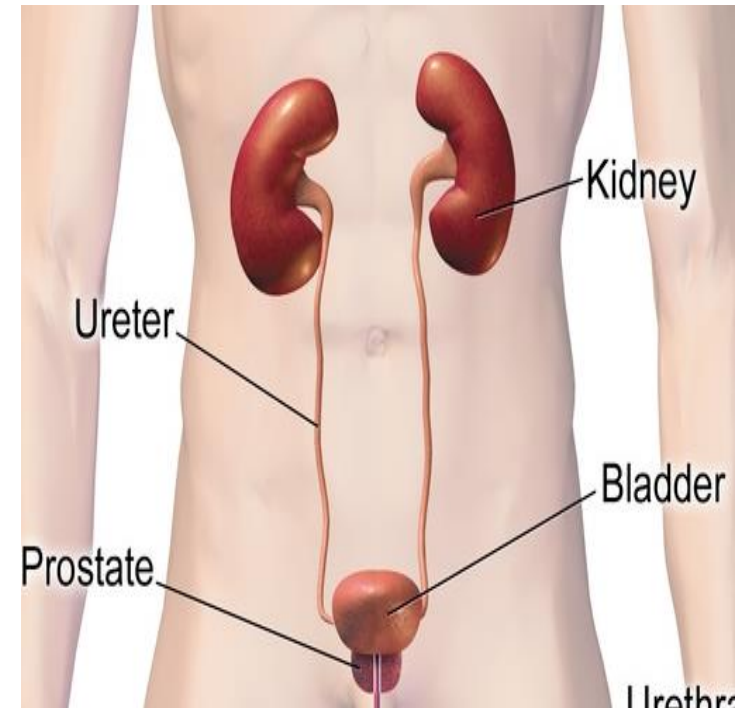
❖ **Micturition**

▪ **Micturition is the process by which the urinary bladder empties when it becomes filled.**

❑ **This involves two main steps:**

1) **First, the bladder fills progressively until the tension in its walls rises above a threshold level.**

2) **Second step: is a nervous reflex called the micturition reflex.**

L1
L2
L3
L4
L5
S1
S2
S3
S4

Sympathetics

Parasympathetics

Pudendal

Ureter

Body

Trigone

Bladder neck
(posterior urethra)

External sphincter

❖ **Filling of the bladder and bladder wall tone; the cystometrogram**

▪ **When there is no urine in the bladder, the intravesicular pressure is about 0, but by the time 30 to 50 milliliters of urine has collected, the pressure rises to 5 to 10 centimeters of water.**

▪ **Additional urine—200 to 300 milliliters— can collect with only a small additional rise in pressure; this constant level of pressure is caused by intrinsic tone of the bladder wall itself .**
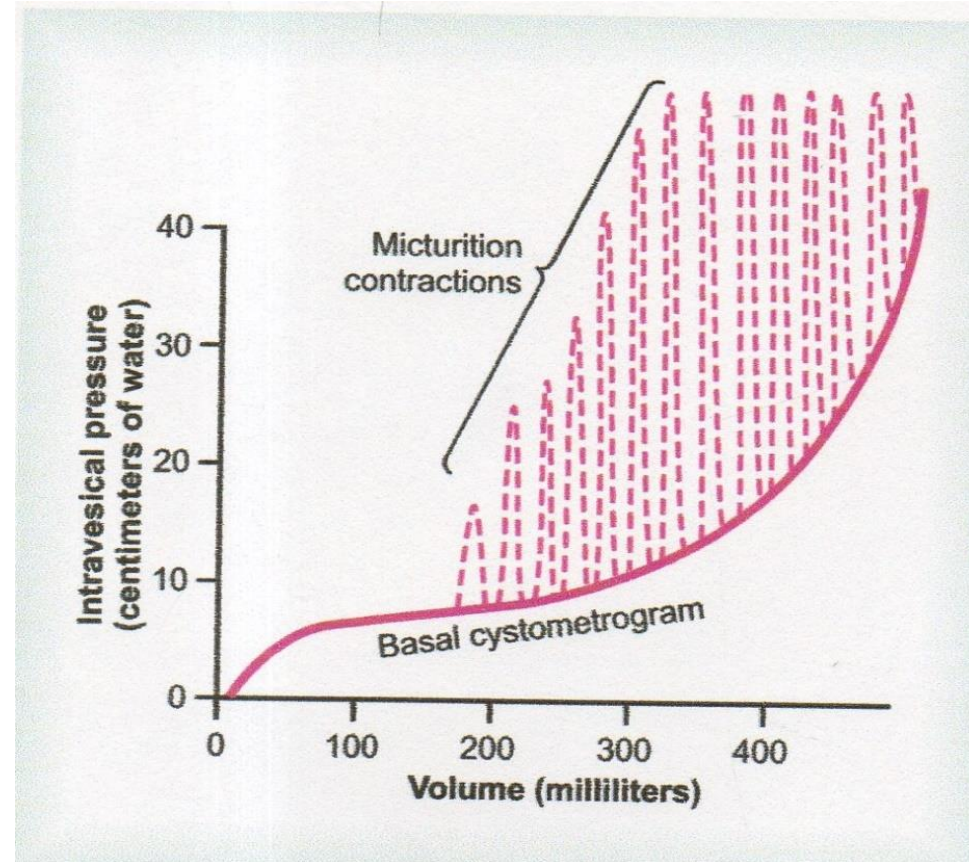
- **Beyond 300 to 400 milliliters**, collection of more urine in the bladder causes the pressure to rise rapidly.
- The pressure peaks may rise to more than 100 centimeters of water.
- These pressure peaks are called micturition waves in the cystometrogram and are caused by the micturition reflex.
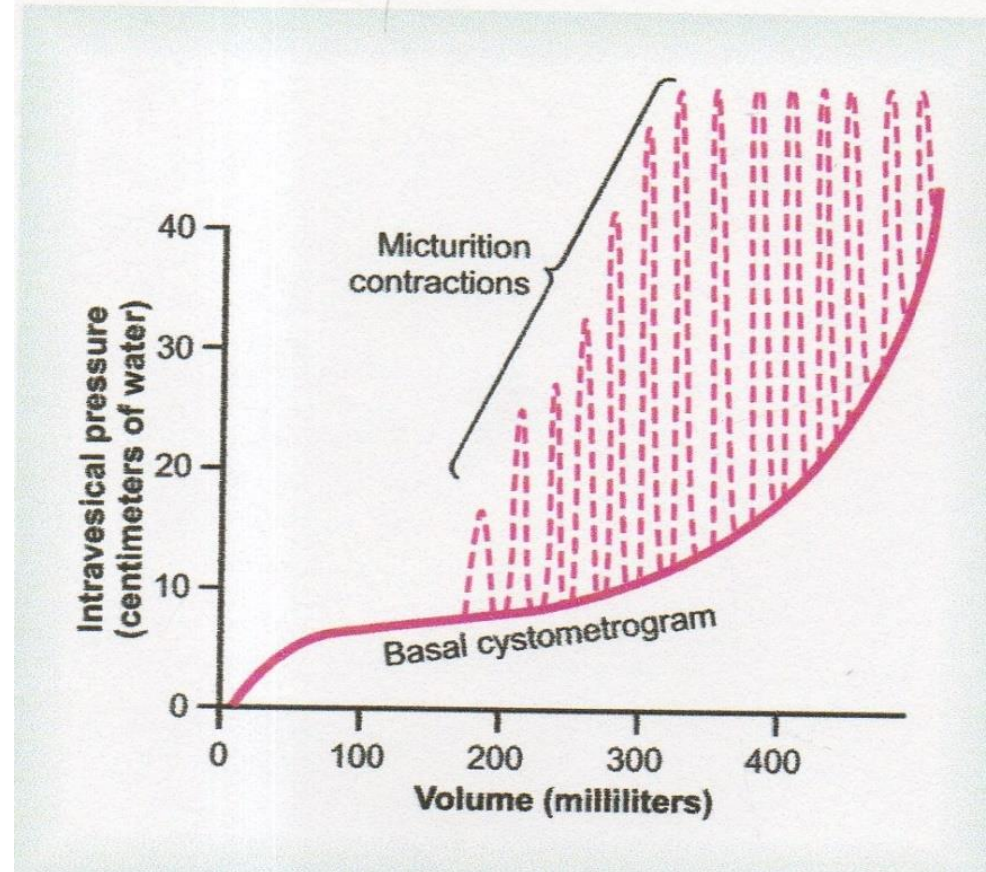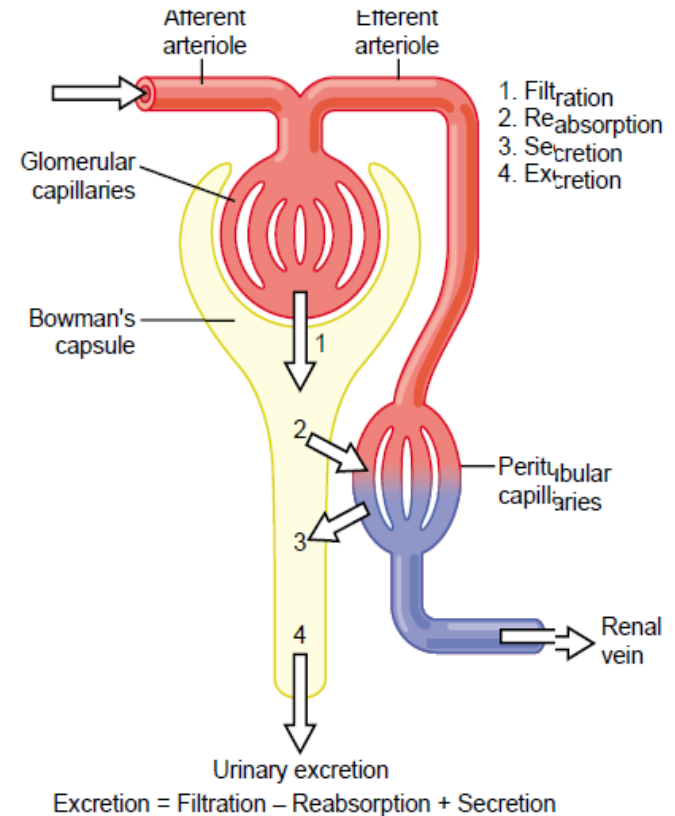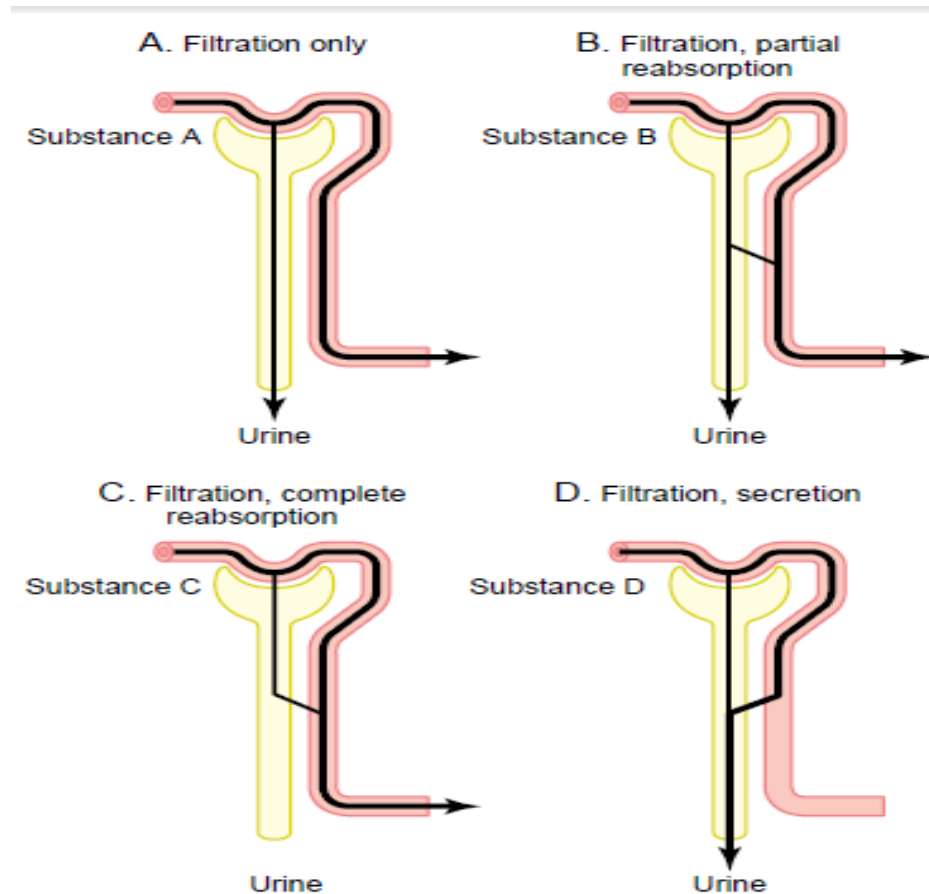
❖ Urine Formation

Urinary excretion rate = Glomerular filtration rate - Tubular reabsorption rate + Tubular secretion rate
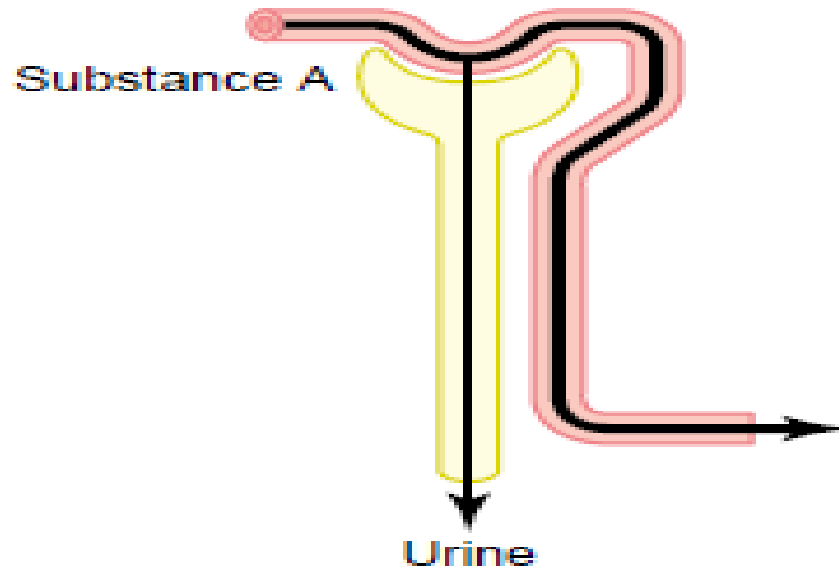

Excretion = Filtration – Reabsorption + Secretion
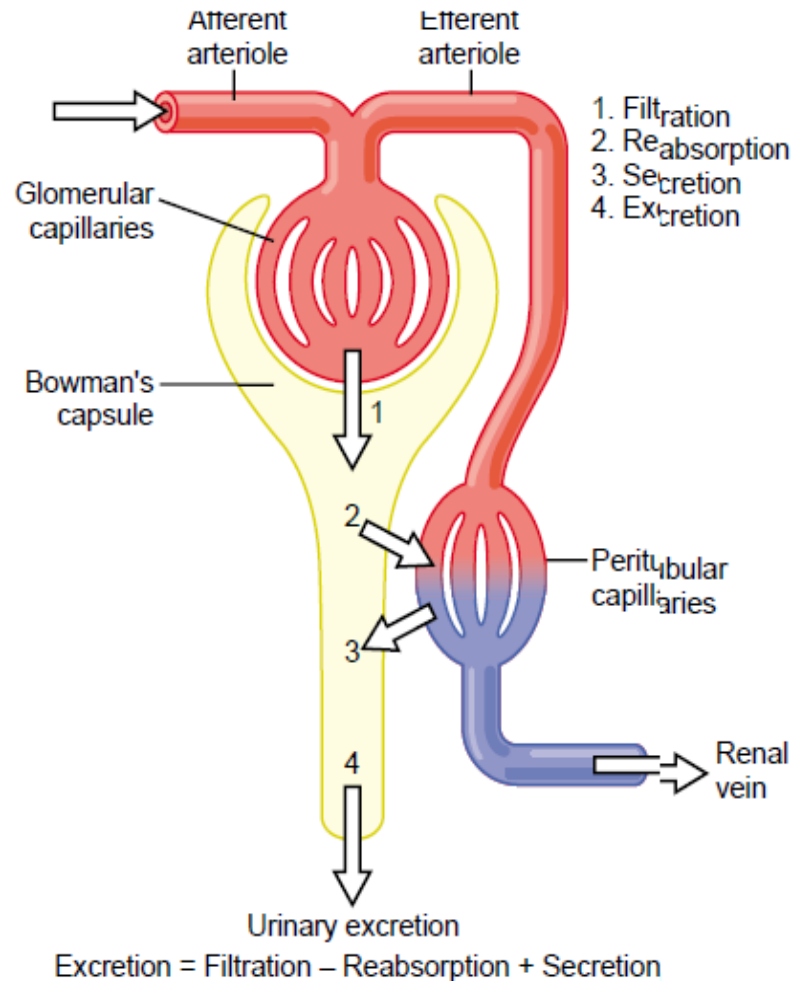
- **Urine formation begins when a large amount of fluid is freely filtered from the glomerular capillaries into Bowman's capsule (except for proteins).**
- **The concentration of glomerular filtrate in Bowman's capsule is almost the same as in the plasma.**
- **As filtered fluid passes through the tubules, it is modified by reabsorption of water and specific solutes back into the blood or by secretion of other substances from the peritubular capillaries into the tubules.**
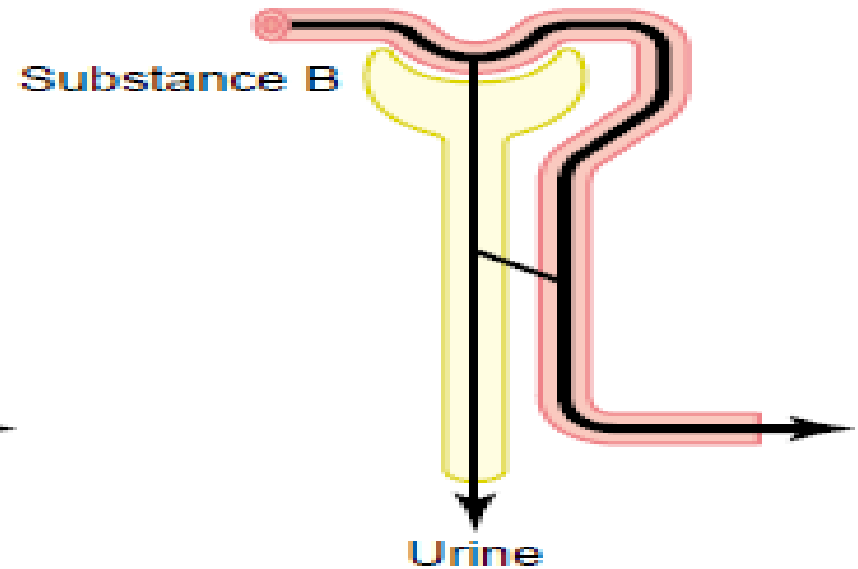

Afferent arteriole — Efferent arteriole

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Glomerular capillaries

Bowman's capsule

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion

- **Tubular reabsorption is more important than tubular secretion in the formation of urine.**

- **Tubular secretion plays an important role in determining the amounts of potassium and hydrogen ions and a few other substances that are excreted in the urine.**
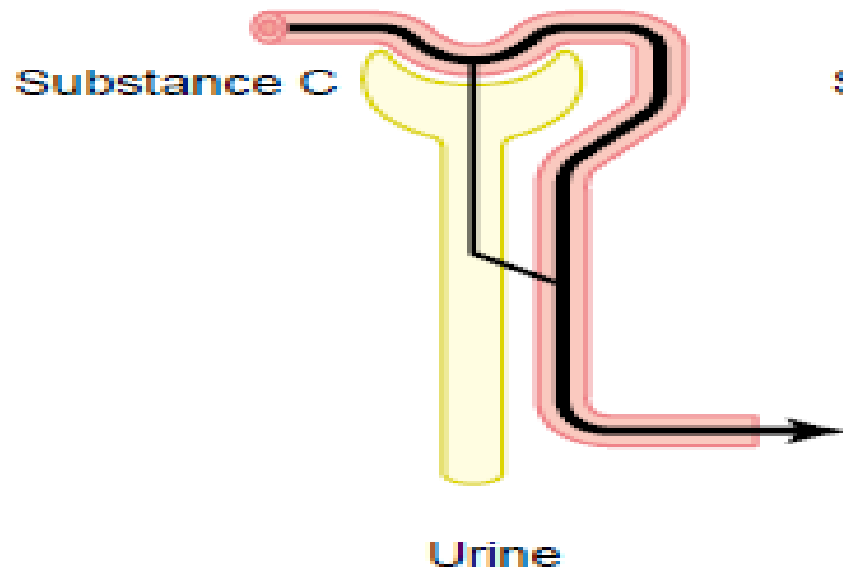

A. Filtration only — Substance A — Urine

B. Filtration, partial reabsorption — Substance B — Urine

C. Filtration, complete reabsorption — Substance C — Urine

D. Filtration, secretion — Substance D — Urine

A. Filtration only

Substance A

Urine

B. Filtration, partial reabsorption

Substance B

Urine

C. Filtration, complete reabsorption

Substance C

Urine

D. Filtration, secretion

Substance D
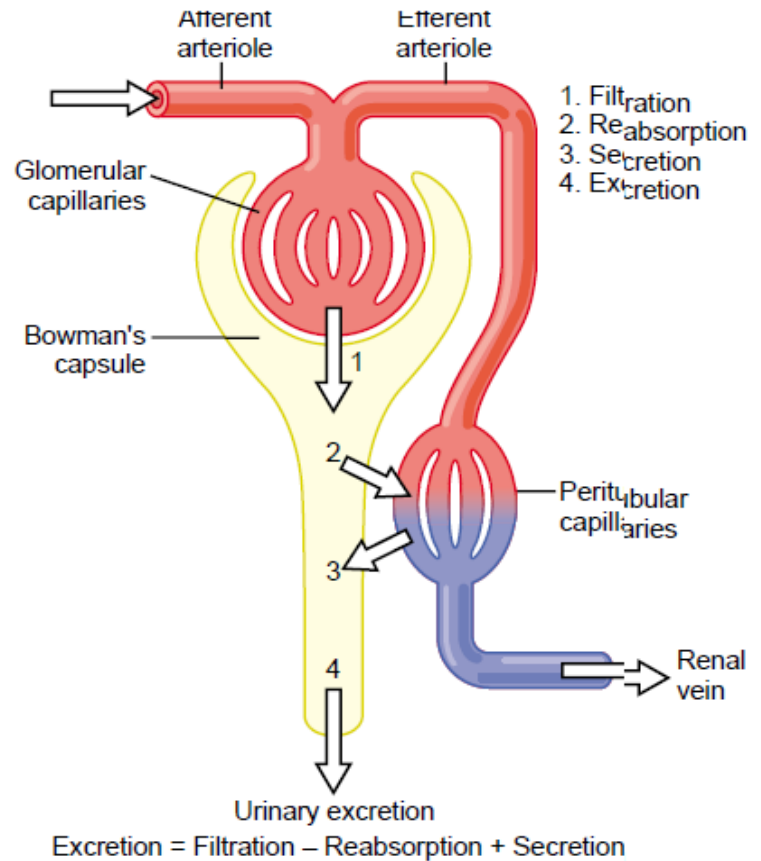
Urine
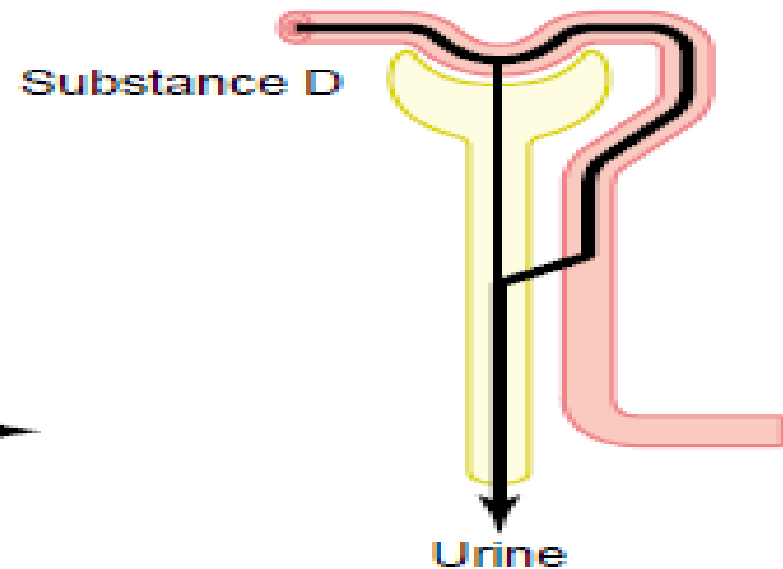
❖ Each of the processes:

1) **Glomerular filtration.**
2) **Tubular reabsorption.**
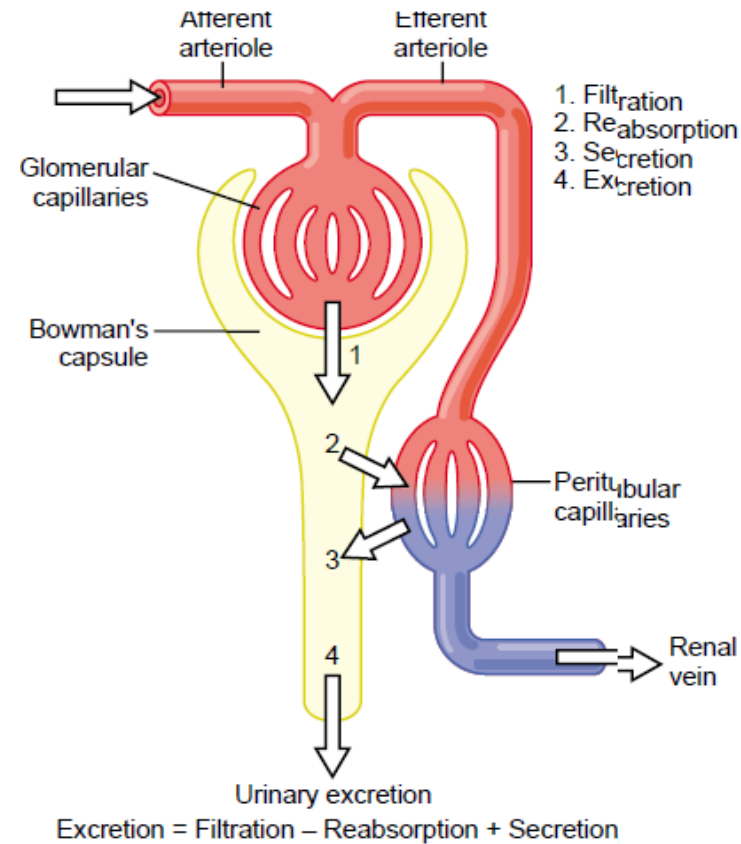3) **Tubular secretion.**

▪ **Is regulated according to the needs of the body.**

▪ **Changes in glomerular filtration and tubular reabsorption usually act in a coordinated manner to produce the necessary changes in renal excretion.**

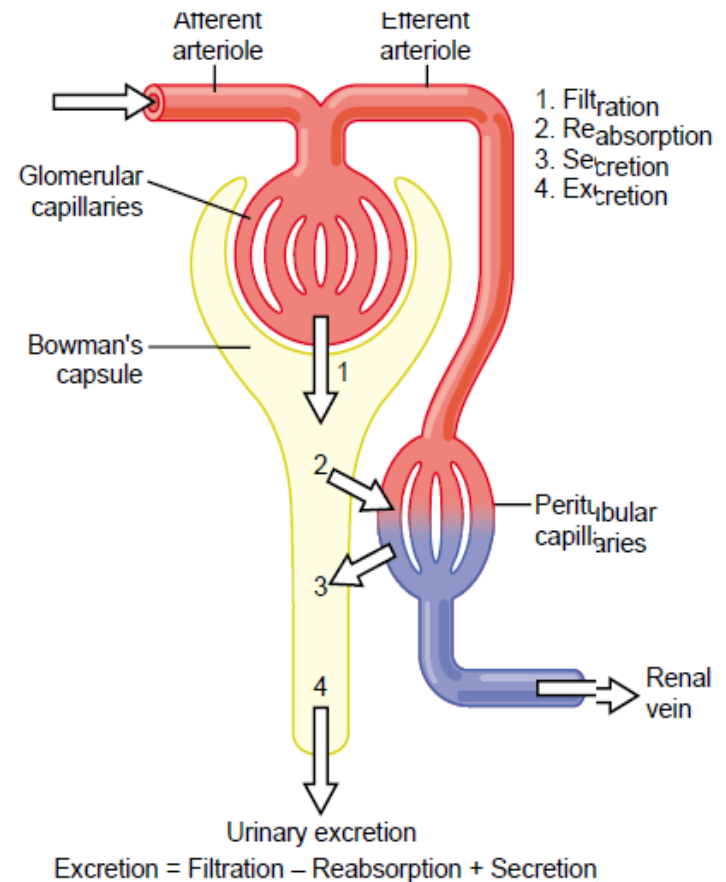
Afferent arteriole
Efferent arteriole
1. Filtration
2. Reabsorption
3. Secretion
4. Excretion
Glomerular capillaries
Bowman's capsule
Peritubular capillaries
Renal vein
Urinary excretion
Excretion = Filtration – Reabsorption + Secretion

❖**Why are large amounts of solutes filtered and then reabsorbed by the kidneys?**

1- High glomerular filteration rate (GFR); allows the kidneys to rapidly remove waste products from the body that depend primarily on glomerular filtration for their excretion.

2- High GFR; allows all the body fluids to be filtered and processed by the kidney many times each day.
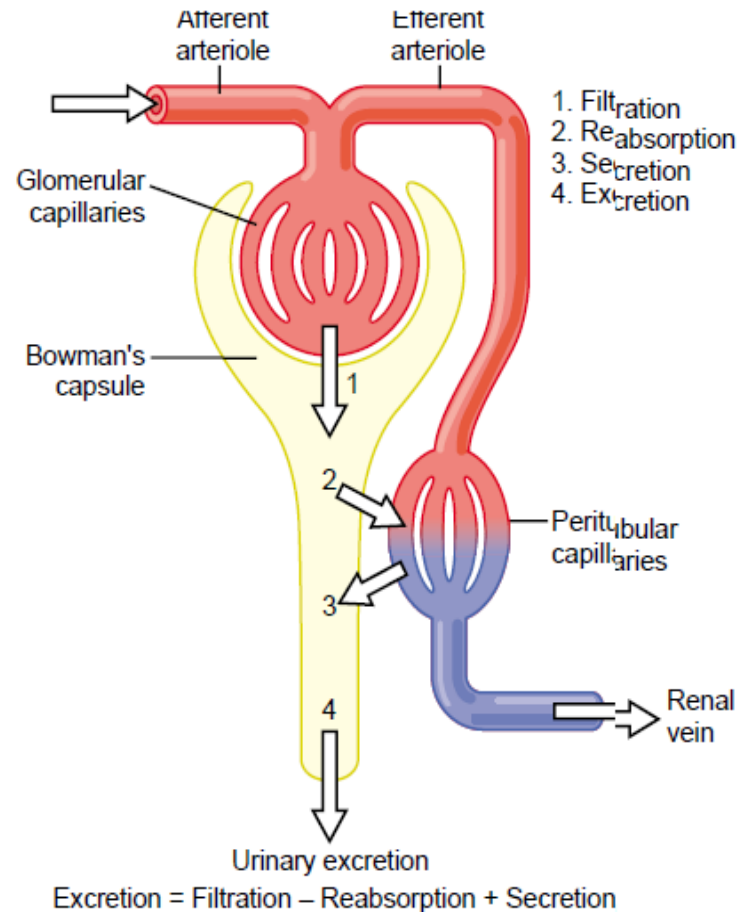

Afferent arteriole — Efferent arteriole

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Glomerular capillaries

Bowman's capsule

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion

- **Because the entire plasma volume is only about 3 liters, whereas the GFR is about 180 L/day, the entire plasma can be filtered and processed about 60 times each day.**

- **This high GFR allows the kidneys to precisely and rapidly control the volume and composition of the body fluids.**

Afferent arteriole

Efferent arteriole

Glomerular capillaries

Bowman's capsule

Peritubular capillaries

Renal vein

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Urinary excretion

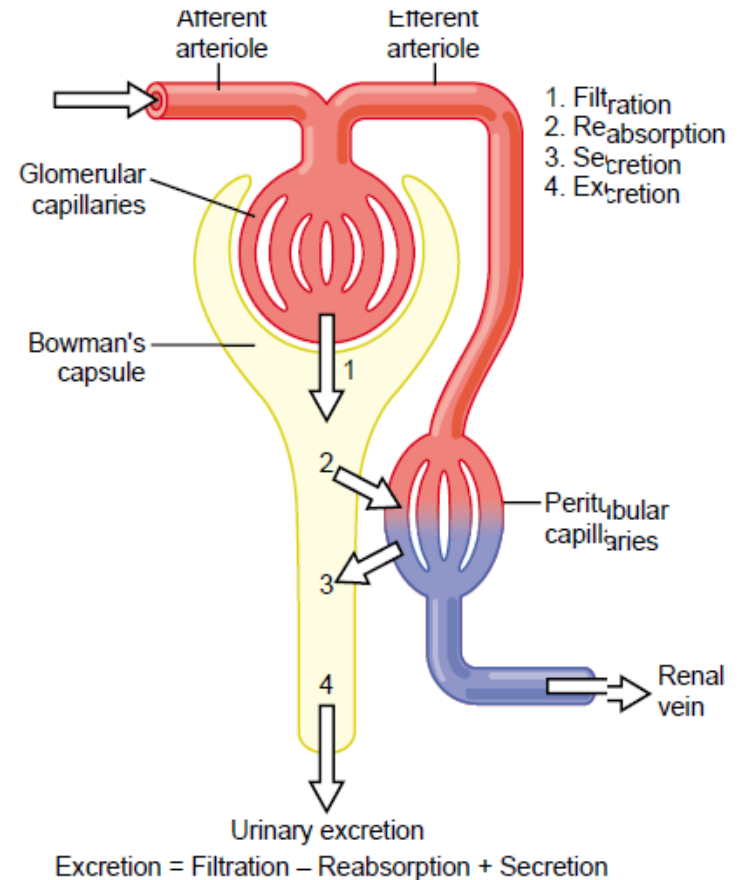Excretion = Filtration – Reabsorption + Secretion

❖ **Glomerular filtration; the first step in urine formation**

▪ **Urine formation begins with filtration of large amounts of fluid through the glomerular capillaries into** **Bowman's capsule**

Afferent arteriole

Efferent arteriole

Glomerular capillaries

Bowman's capsule

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

1

2

3

4

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion

❖ Composition of the glomerular filtrate

- The glomerular filtrate is essentially protein-free and devoid of cellular elements, including red blood cells.

- The concentrations of other constituents including most salts and organic molecules are similar to the concentrations in the plasma.

- A few low-molecular-weight substances, such as calcium and fatty acids, that are not freely filtered because they are partially (half) bound to the plasma proteins.

Afferent arteriole — Efferent arteriole

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Glomerular capillaries

Bowman's capsule

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion
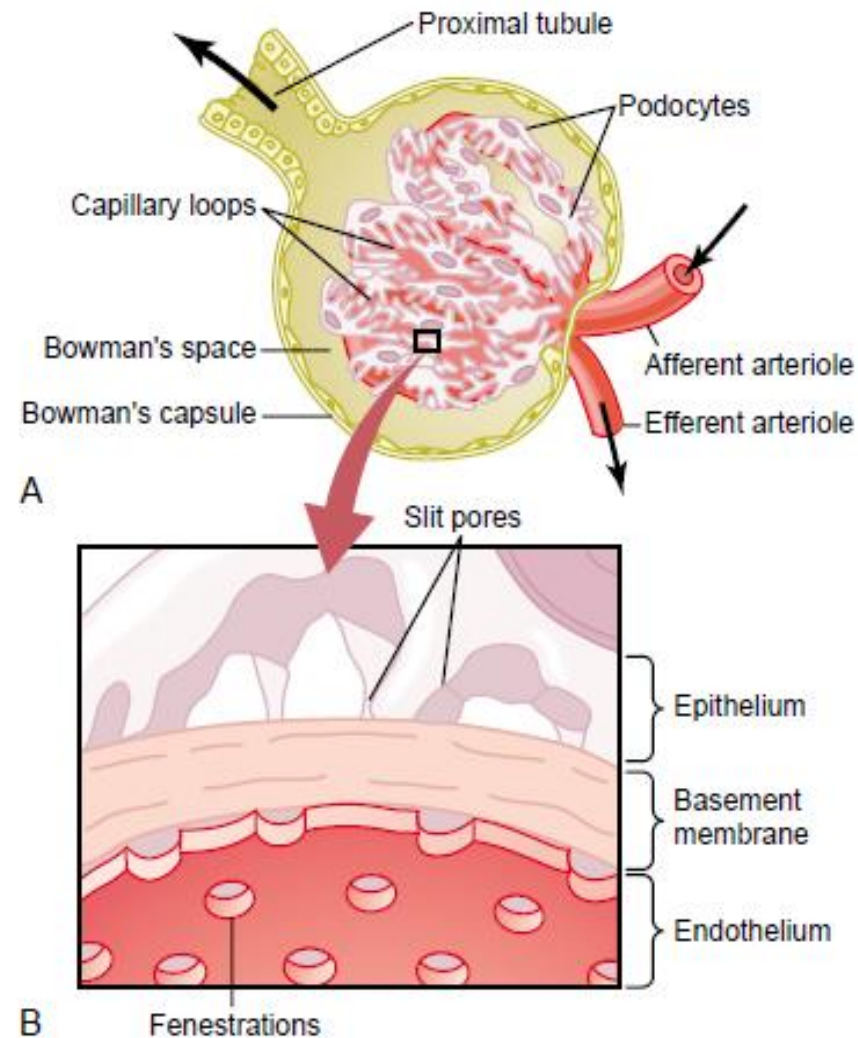
❖ Glomerular Capillary Membrane

▪ **The glomerular capillary membrane is similar to that of other capillaries, except that it has three (instead of the usual two) major layers:**

(1) **The endothelium of the capillary.**
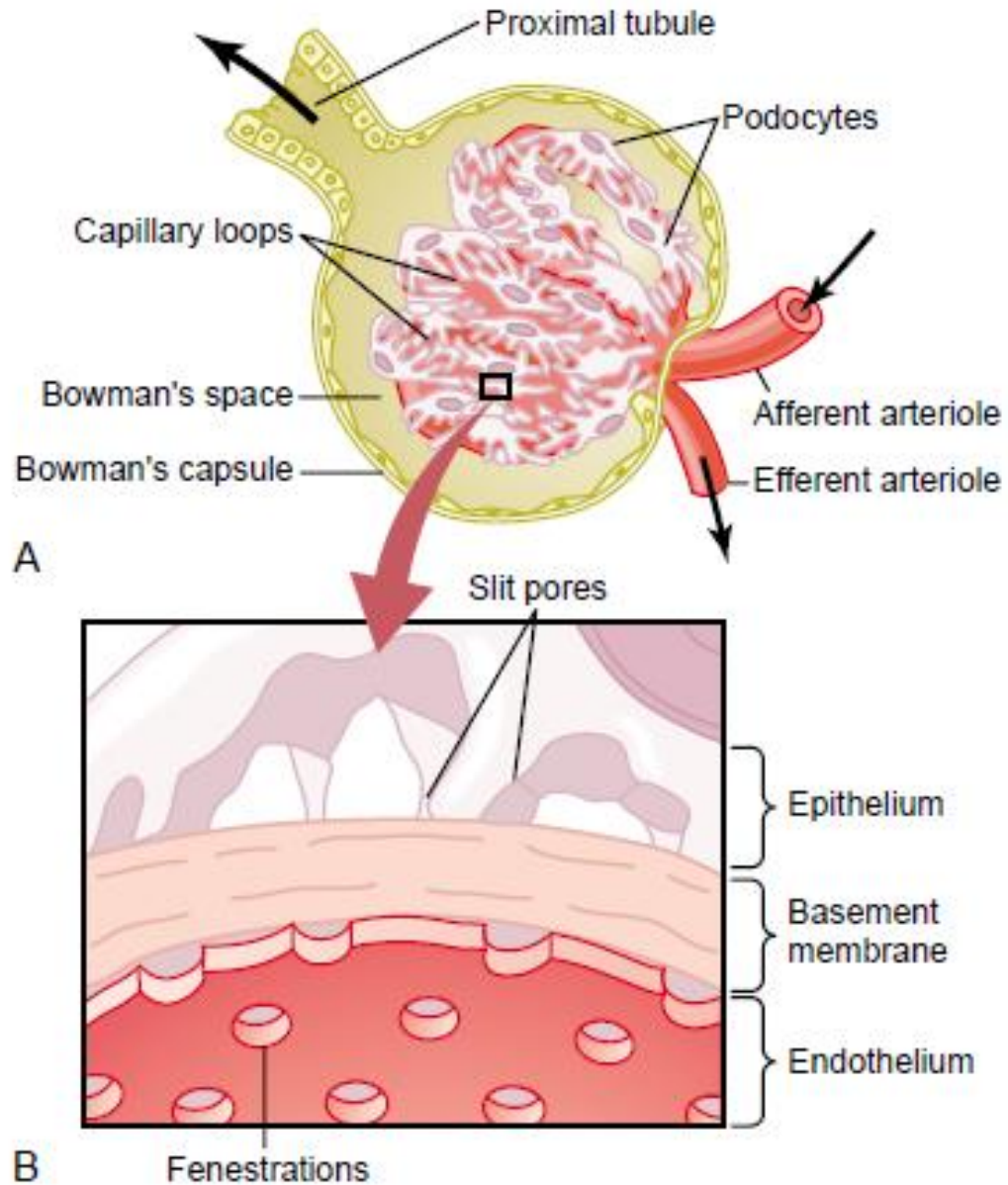
(2) **A basement membrane.**

(3) **A layer of epithelial cells (podocytes) surrounding the outer surface of the capillary basement membrane.**

▪ **Despite the three layers, it filters several hundred times as much water and solutes as the usual capillary membrane.**
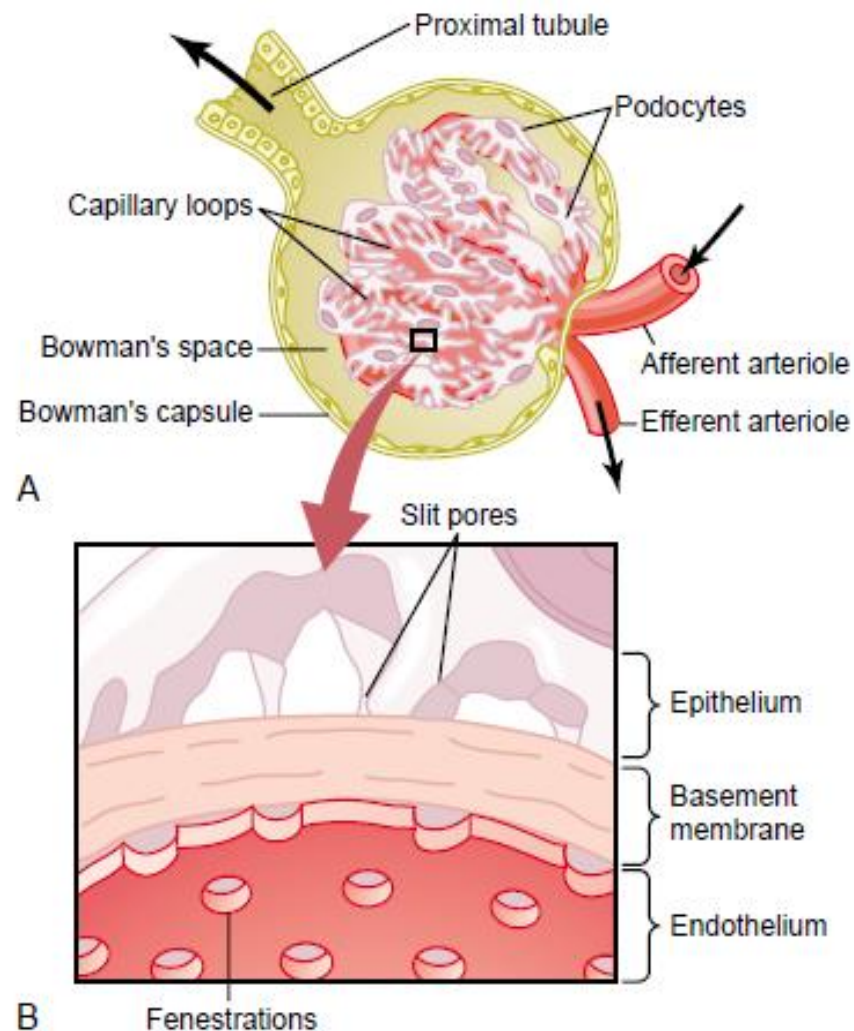
- **The high filtration rate across the glomerular capillary membrane is due partly to its special characteristics.**

1) **The capillary endothelium is perforated by thousands of small holes called fenestrae..**


A

- Proximal tubule
- Podocytes
- Capillary loops
- Bowman's space
- Bowman's capsule
- Afferent arteriole
- Efferent arteriole

B

- Slit pores
- Epithelium
- Basement membrane
- Endothelium
- Fenestrations

2) The basement membrane consists of a meshwork of collagen and proteoglycan fibrillae that have large spaces; through which large amounts of water and small solutes can filter.

- **The basement membrane effectively prevents filtration of plasma proteins, in part because of strong negative electrical charges associated with the proteoglycans.**

Proximal tubule

Podocytes

Capillary loops

Bowman's space

Bowman's capsule

Afferent arteriole

Efferent arteriole

A

Slit pores

Epithelium

Basement membrane

Endothelium

B Fenestrations

3- Epithelial cells layer that line the outer surface of the glomerulus.

- **These cells are not continuous but have long footlike processes (podocytes) that encircle the outer surface of the capillaries.**

- **The foot processes are separated by gaps called slit pores through which the glomerular filtrate moves.**

- **The epithelial cells, which also have negative charges, provide additional restriction to filtration of plasma proteins.**

- **Thus, all layers of the glomerular capillary wall provide a barrier to filtration of plasma proteins.**
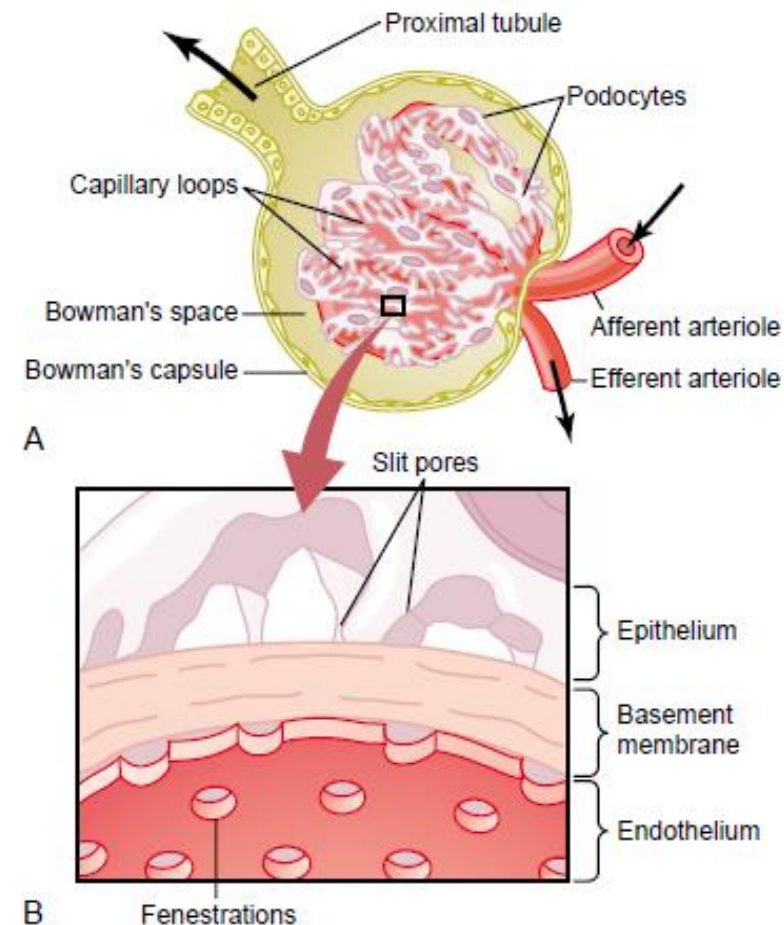
❖ **GFR is about 20 per cent of the renal plasma flow**

▪ **The glomerular capillaries have a much higher rate of filtration than most other capillaries because of a high glomerular hydrostatic pressure and a large capillary filtration coefficient (Kf).**

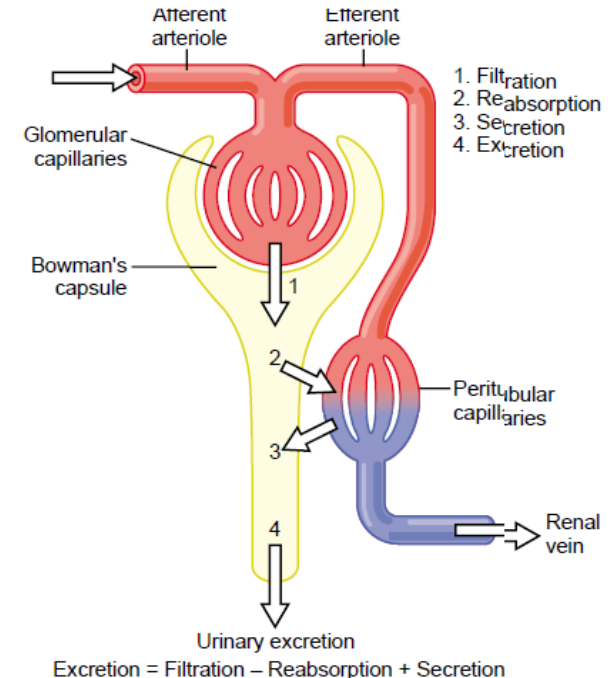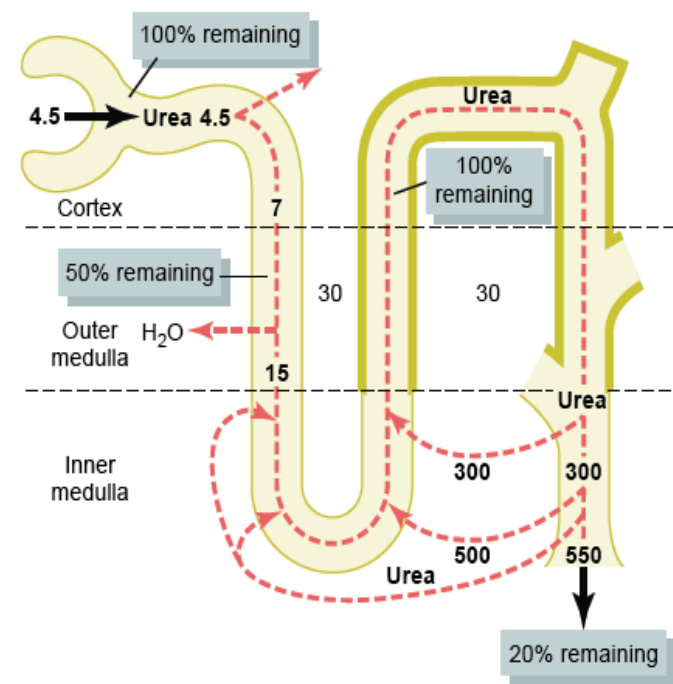▪ **In the average adult human, the GFR is about 125 ml/min, or 180 L/day.**

A

- Proximal tubule
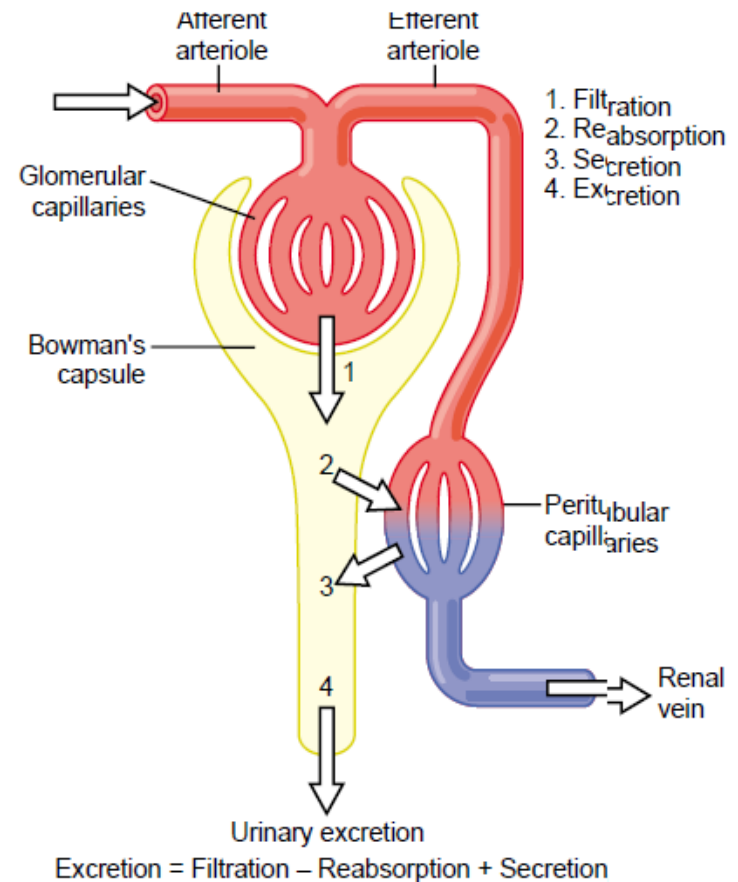- Podocytes
- Capillary loops
- Bowman's space
- Bowman's capsule
- Afferent arteriole
- Efferent arteriole

B

- Slit pores
- Epithelium
- Basement membrane
- Endothelium
- Fenestrations

THANK
YOU
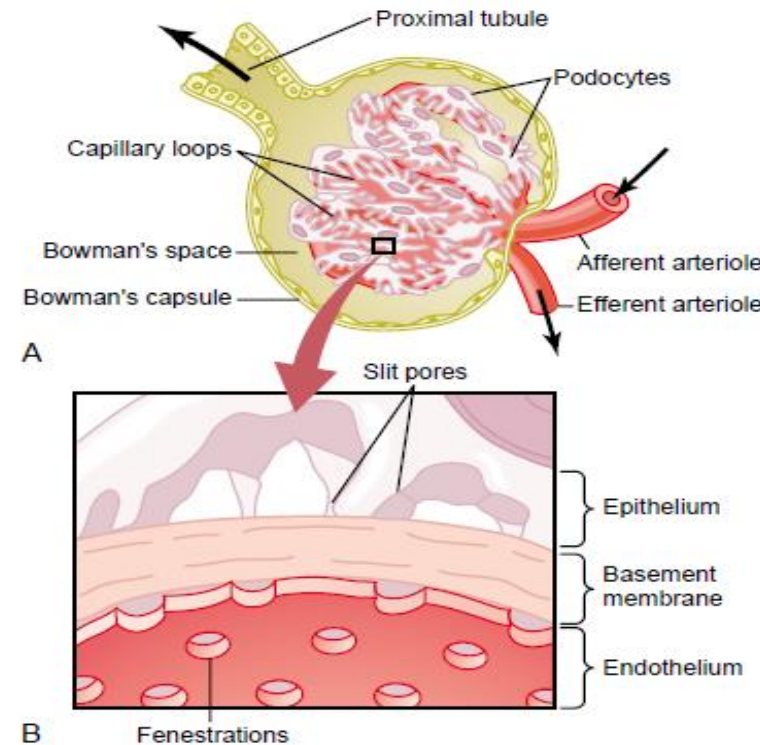
URINE

FORMATION

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

- ❖ **Urine Formation by the Kidneys.**
- ▪ **As the glomerular filtrate enters the renal tubules, it flows through the proximal tubule, the loop of Henle, the distal tubule, the collecting tubule, and, finally, the collecting duct —before it is excreted as urine.**
- ▪ **Along this course, some substances are selectively reabsorbed from the tubules back into the blood, whereas others are secreted from the blood into the tubular lumen.**

100% remaining

4.5 ➔ Urea 4.5

Cortex   7

50% remaining

Outer H₂O
medulla   30   30

          15   Urea

Inner
medulla   300   300

          500   550

Urea

20% remaining

Afferent arteriole   Efferent arteriole

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Glomerular capillaries

Bowman's capsule

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion

- **The processes of glomerular filtration** and **tubular reabsorption are very large relative to urinary excretion for many substances.**
- **A** small **change in them can** cause a **large** change in **urinary excretion.**
- **The changes in tubular reabsorption and glomerular filtration are closely coordinated, so that large fluctuations in urinary excretion are avoided.**
- **Glomerular filtration is nonselective while tubular reabsorption is highly selective.**

Afferent arteriole — Efferent arteriole

Glomerular capillaries

Bowman's capsule

1. Filtration
2. Reabsorption
3. Secretion
4. Excretion

Peritubular capillaries

Renal vein

Urinary excretion

Excretion = Filtration – Reabsorption + Secretion

❖ **Tubular reabsorption includes passive and active mechanisms**

▪ **For a substance to be reabsorbed, it must first be transported:**

(1)across the tubular epithelial membranes into the renal interstitial fluid.

(2)through the peritubular capillary membrane back into the blood.
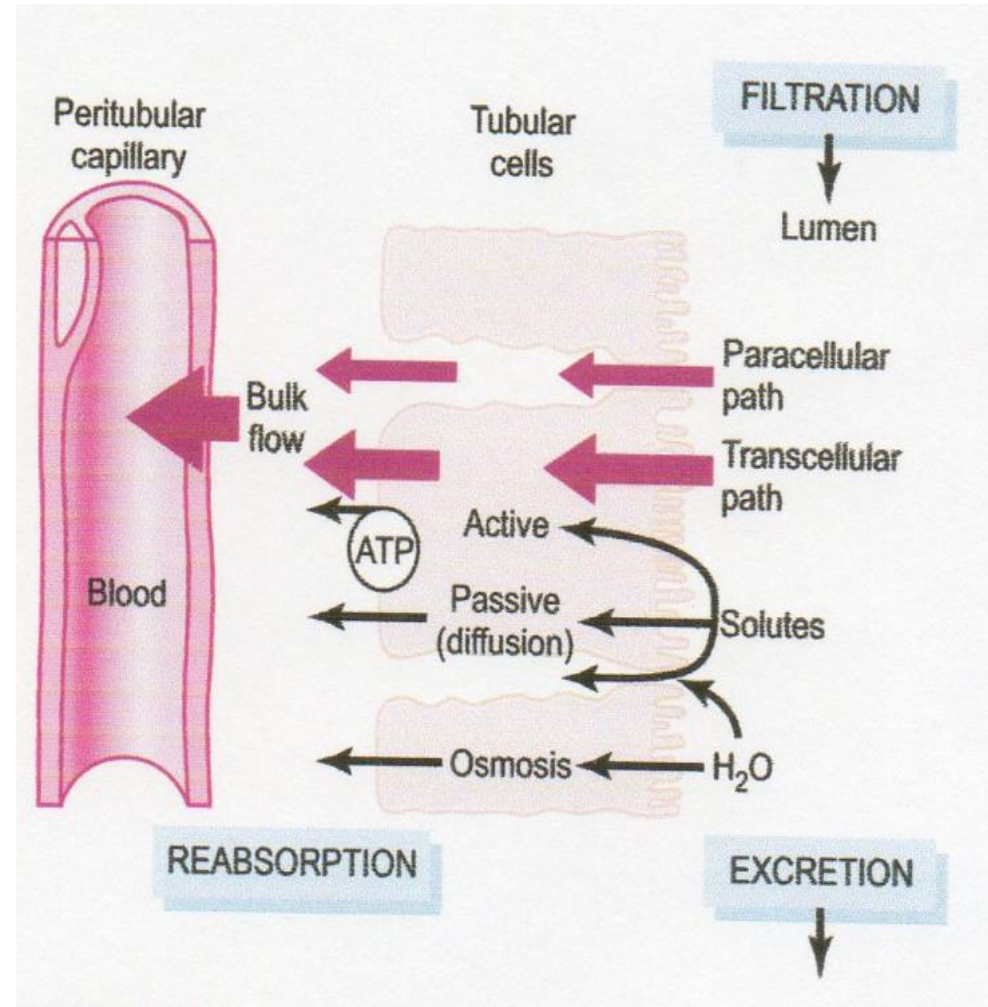
- **Reabsorption across the tubular epithelium into the interstitial fluid includes active or passive transport.**
- **Water and solutes (e.g. sodium) can be transported:**

1) **Through the cell membranes themselves (transcellular route).**

2) **Through the junctional spaces between the cells (paracellular route).**
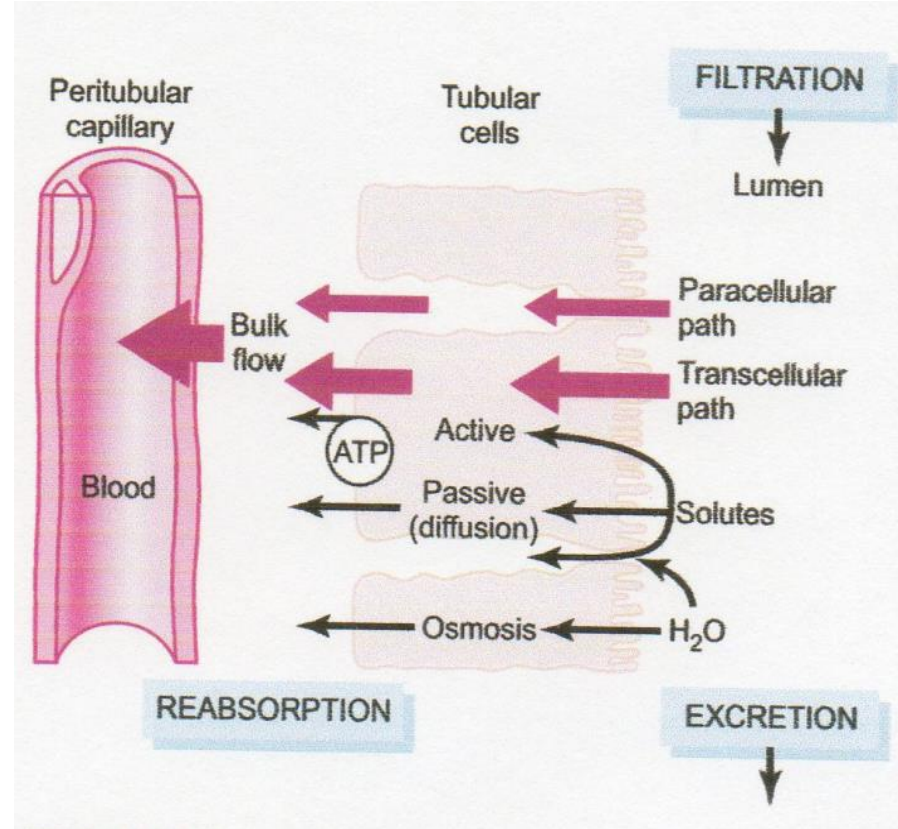
- **Then, they are transported through the peritubular capillary walls into the blood by ultrafiltration (bulk flow) that is mediated by hydrostatic and colloid osmotic forces.**
- **Water is always reabsorbed by a passive (nonactive) physical mechanism called osmosis.**
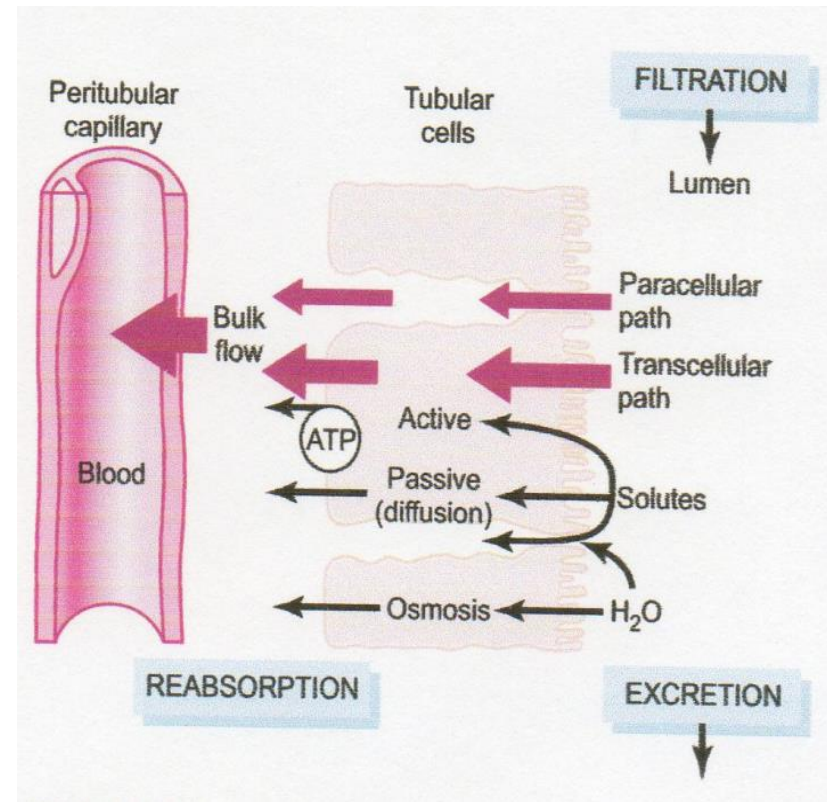
❖ Active Transport

- **Active transport can move a solute against an electrochemical gradient and requires energy derived from metabolism.**
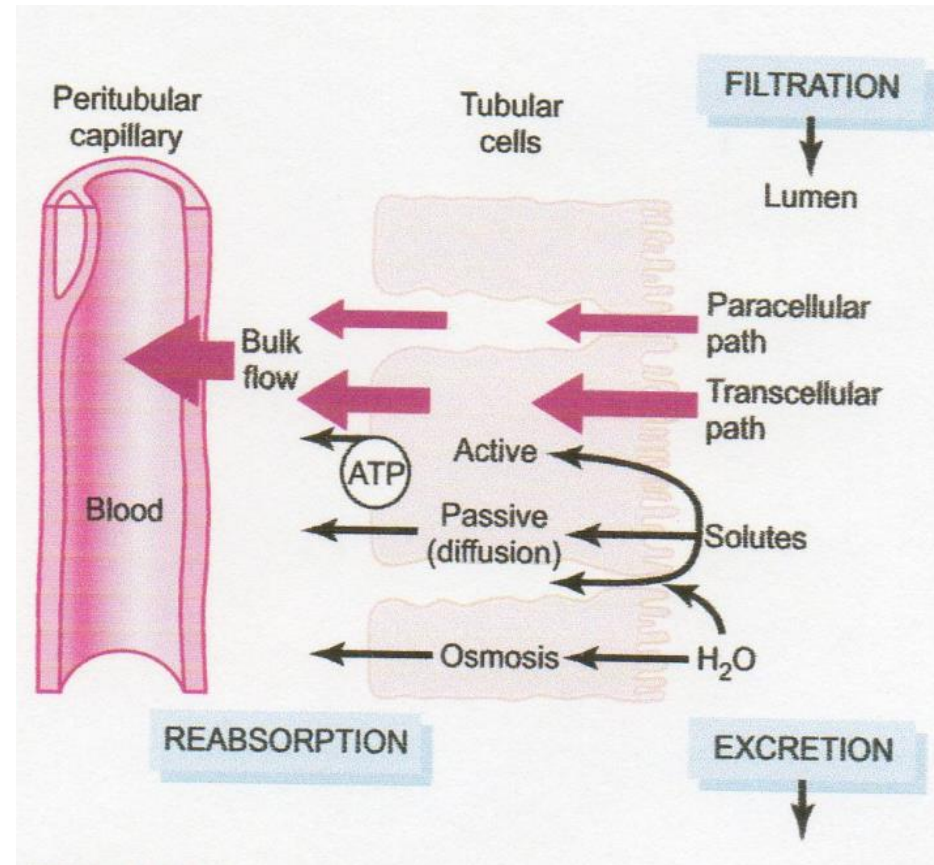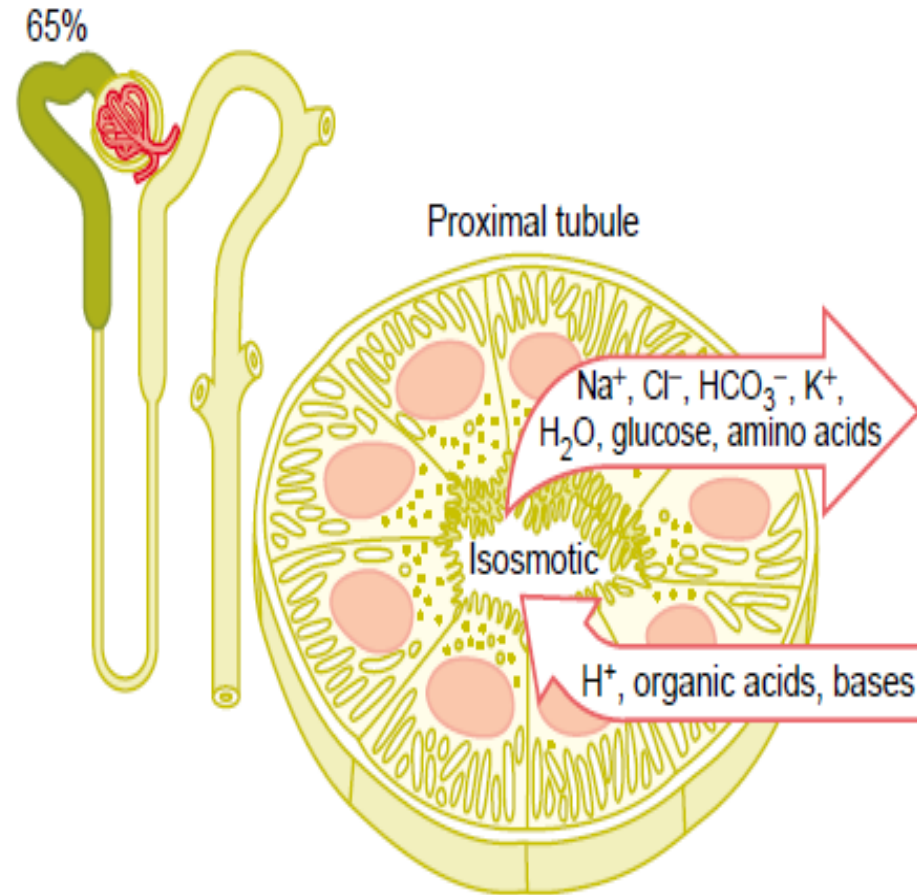
❖ **Reabsorption and secretion along different parts of the nephron**

❑ **Proximal tubular reabsorption**

▪ **Normally, about 65% of the filtered load of sodium and water and a slightly lower percentage of filtered chloride are reabsorbed by the proximal tubule before the filtrate reaches the loops of Henle.**

▪ **These percentages can be increased or decreased in different physiologic conditions.**

65%

Proximal tubule

Na^+, Cl^-, HCO_3^-, K^+, H_2O, glucose, amino acids

Isosmotic

H^+, organic acids, bases
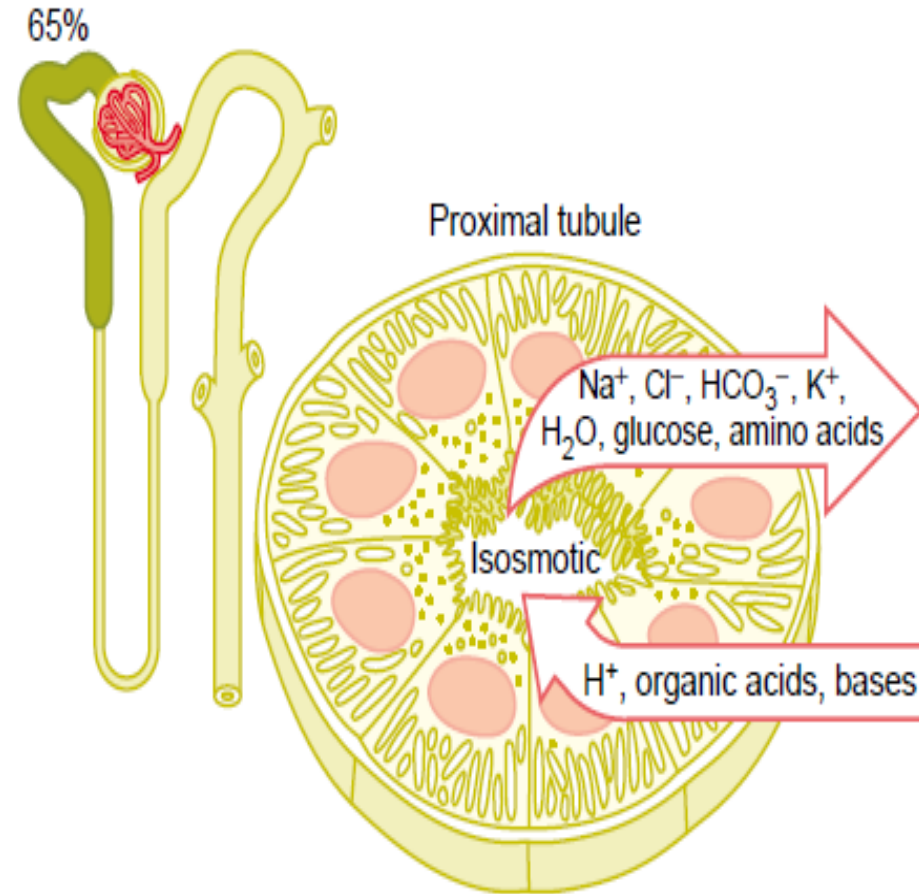
- **The remainder of the sodium is transported from the tubular lumen into the cell by counter-transport mechanisms and secreting other substances into the tubular lumen, especially hydrogen ions.**
- **The secretion of hydrogen ions into the tubular lumen is an important step in the removal of bicarbonate ions from the tubule (by combining H+ with the HCO3$^-$ to form H2CO3, which then dissociates into H2O and CO2).**

65%

Proximal tubule

Na$^+$, Cl$^-$, HCO$_3^-$, K$^+$, H$_2$O, glucose, amino acids

Isosmotic

H$^+$, organic acids, bases

- **Although the sodium-potassium ATPase pump provides the major force for reabsorption of sodium, chloride, and water throughout the proximal tubule.**
- **In the first half of the proximal tubule, sodium is reabsorbed by co-transport along with glucose, amino acids.**

65%

Proximal tubule

Na^+, Cl^-, HCO_3^-, K^+, H_2O, glucose, amino acids

Isosmotic

H^+, organic acids, bases
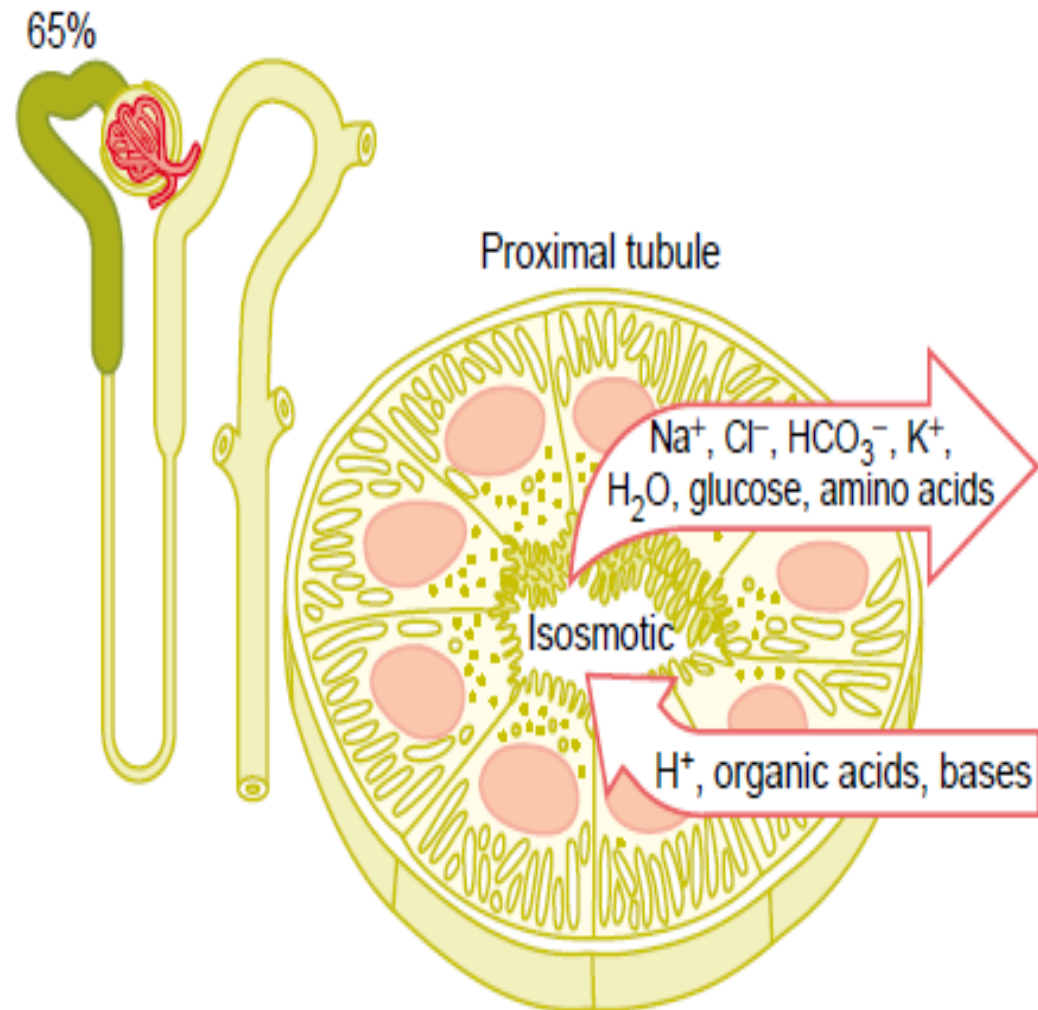
❖ **Secretion of organic acids and bases by the proximal tubule:**

❑ **The proximal tubule secrets:**

➢ **Organic acids and bases such as bile salts, oxalate, urate, and catecholamines (the waste products of metabolism).**

➢ **Harmful drugs or toxins and rapidly clear these substances from the blood (penicillin and salicylates).**


65%

Proximal tubule

Na^+, Cl^-, HCO_3^-, K^+, H_2O, glucose, amino acids

Isosmotic

H^+, organic acids, bases
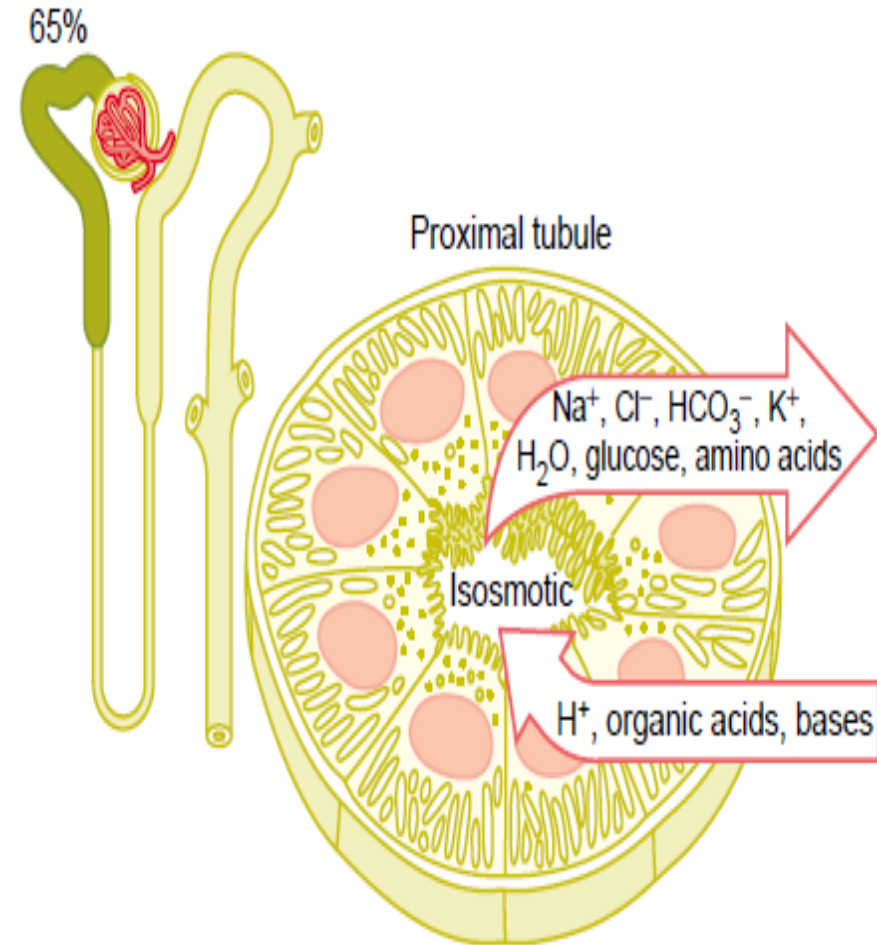
❖ **Solute and Water Transport in the Loop of Henle**

❑ **The loop of Henle:**

▪ **Consists of three functionally distinct segments: the thin descending segment, the thin ascending segment, and the thick ascending segment.**

▪ **The thin descending and thin ascending segments, as their names imply, have thin epithelial membranes with no brush borders, few mitochondria, and minimal levels of metabolic activity.**
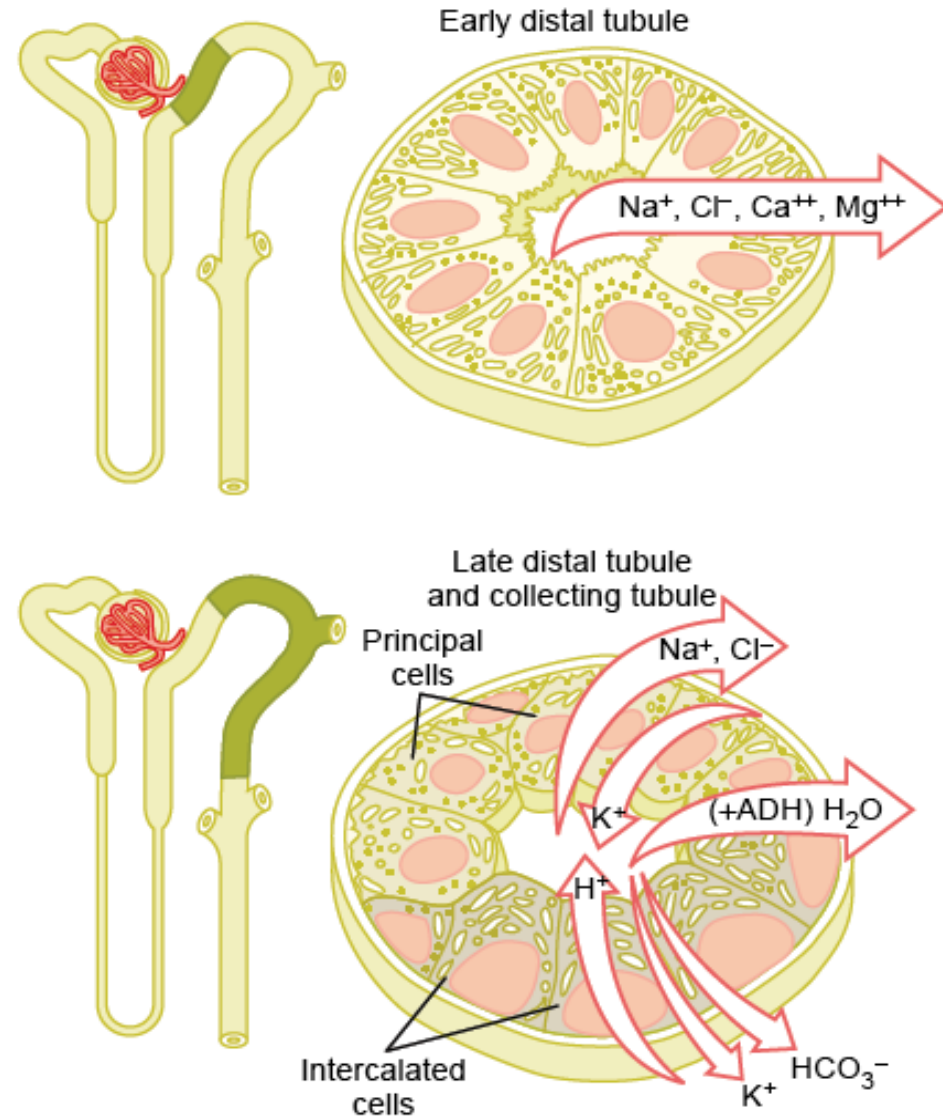
Thin descending loop of Henle

H_2O
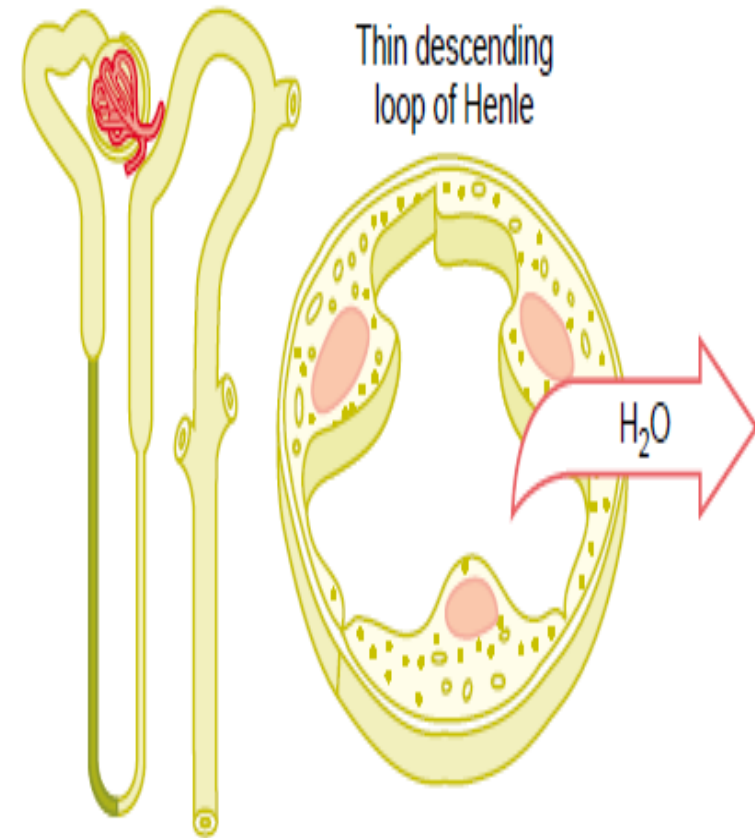
- **The descending part of the thin segment is highly permeable to water and moderately permeable to most solutes, including urea and sodium.**
- **About 20% of the filtered water is reabsorbed in the loop of Henle, and almost all of this occurs in the thin descending limb.**
- **The ascending limb, including both the thin and the thick portions, is virtually impermeable to water, a characteristic that is important for concentrating the urine.**

Thin descending loop of Henle

H_2O
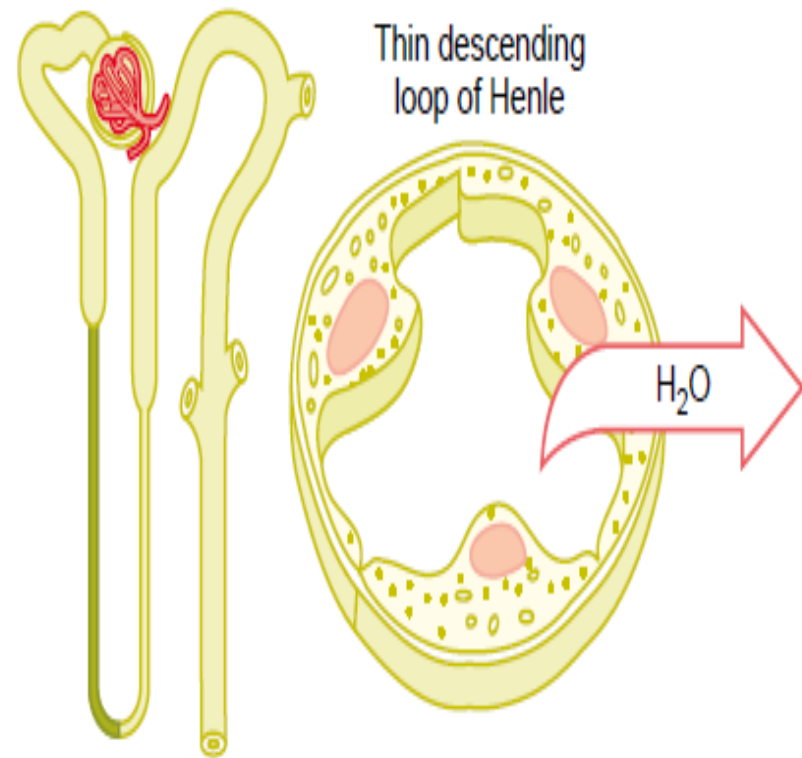
- **The thick segment of the loop of Henle, which begins about halfway up the ascending limb, has thick epithelial cells that have high metabolic activity.**

- **About 25% of the filtered loads of sodium, chloride, and potassium are reabsorbed in the loop of Henle, mostly in the thick ascending limb.**

- **The thin segment of the ascending limb has a much lower reabsorptive capacity than the thick segment.**


Thick ascending loop of Henle

25%

Na^+, Cl^-, K^+, Ca^{++}, HCO_3^-, Mg^{++}

Hypo-osmotic

H^+
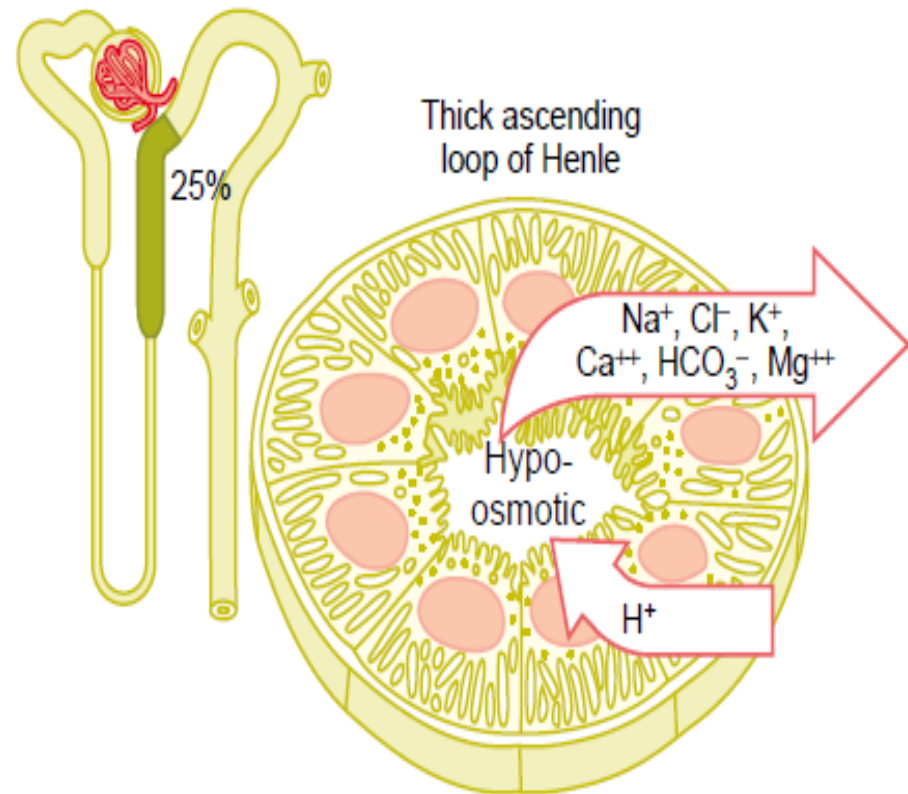
- **The distal tubule is highly convoluted and thick; reabsorbs most of the ions, including sodium, potassium, and chloride, but is virtually impermeable to water and urea (diluting segment).**

- **Approximately 5% of the filtered load of sodium chloride is reabsorbed in the early distal tubule**

Early distal tubule

Na^+, Cl^-, Ca^{++}, Mg^{++}

Late distal tubule and collecting tubule

Principal cells

Na^+, Cl^-

K^+

$(+ADH)$ H_2O

H^+

HCO_3^-

K^+

Intercalated cells

❖ **Late distal tubule and cortical collecting tubule**

▪ **Both of them have similar functional characteristics and they are composed of two cell types.**

1) principal cells.

2) Intercalated cells.

Late distal tubule and collecting tubule

Principal cells

Intercalated cells

Na^+, Cl^-

K^+

(+ADH) H_2O

H^+

HCO_3^-

K^+
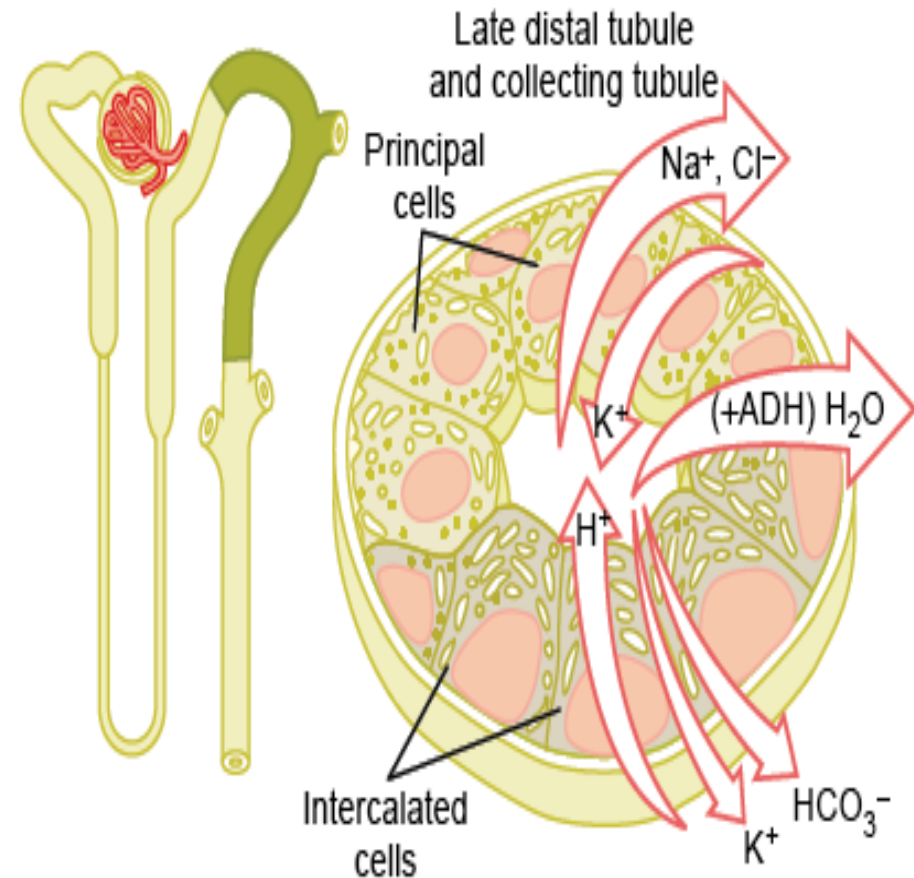
1) Principal cells reabsorb sodium and water and secrete potassium.

- **Sodium reabsorption and potassium secretion by the principal cells depend on the activity of a sodium potassium ATPase pump in each cell's basolateral membrane and on concentration gradient across the luminal membrane.**


Late distal tubule and collecting tubule

Principal cells

Na^+, Cl^-

K^+

$(+ADH)$ H_2O

H^+

Intercalated cells

K^+

HCO_3^-
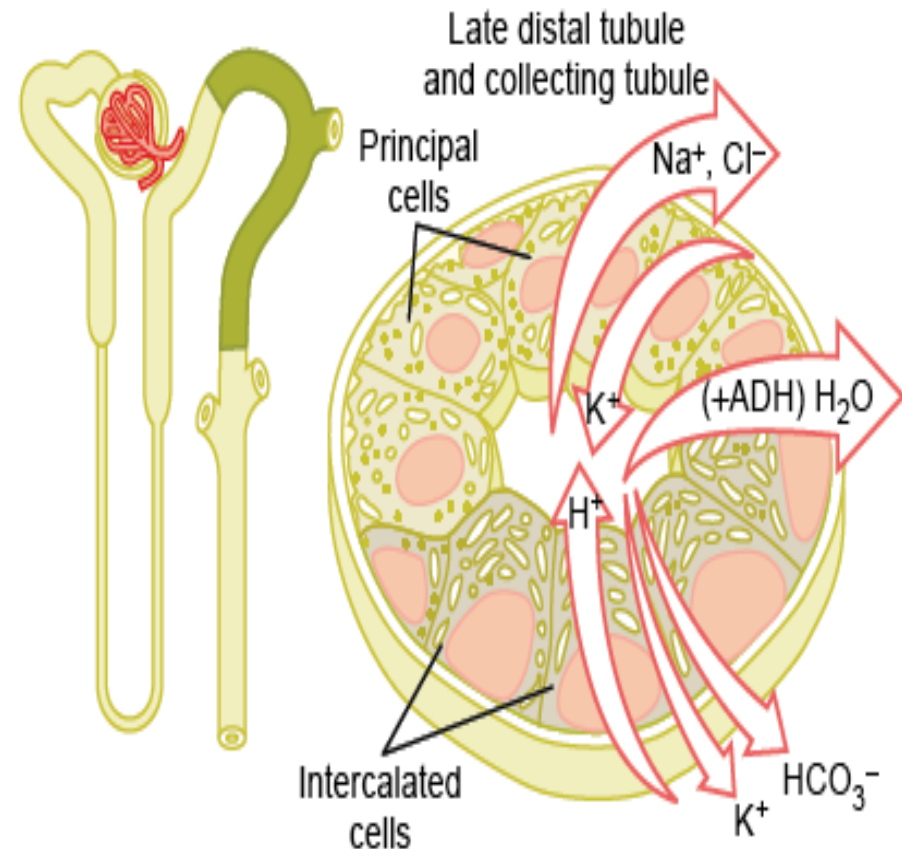
2) Intercalated cells:

- **Hydrogen ion secretion by the intercalated cells is mediated by a hydrogen-ATPase transport mechanism.**

- **The hydrogen ions are then secreted into the tubular lumen (against a large concentration gradient), and for each hydrogen ion secreted, a bicarbonate ion becomes available for reabsorption across the basolateral membrane.**


Late distal tubule and collecting tubule

Principal cells

Intercalated cells

Na^+, Cl^-

K^+

(+ADH) H_2O

H^+

HCO_3^-

K^+
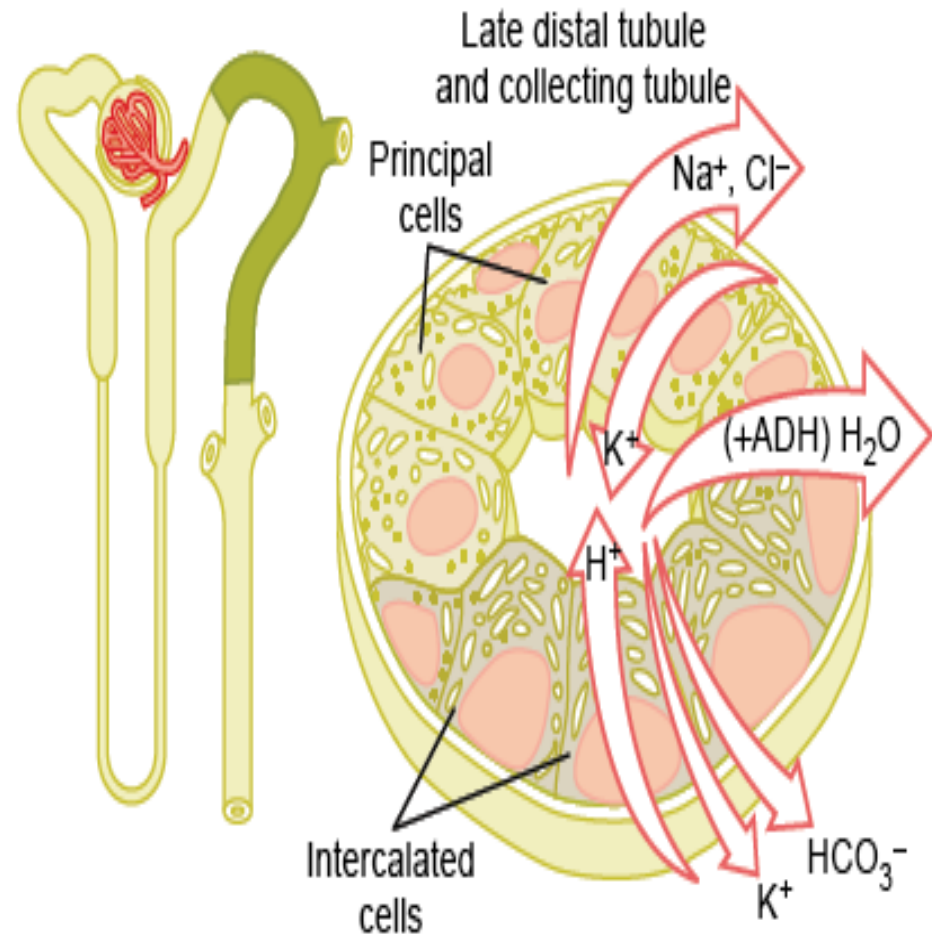
❖ **The more function of the late distal tubule and cortical collecting tubule**

▪ **The tubular membranes of both segments are almost completely impermeable to urea.**

▪ **The permeability of both segments to water is controlled by the concentration of ADH (vasopressin).**

▪ **With high levels of ADH, these tubular segments are permeable to water, but in the absence of ADH, they are almost impermeable to water providing an important mechanism for controlling the degree of dilution or concentration of the urine.**

Late distal tubule and collecting tubule

Principal cells

Intercalated cells

Na^+, Cl^-

K^+

(+ADH) H_2O

H^+

HCO_3^-

K^+
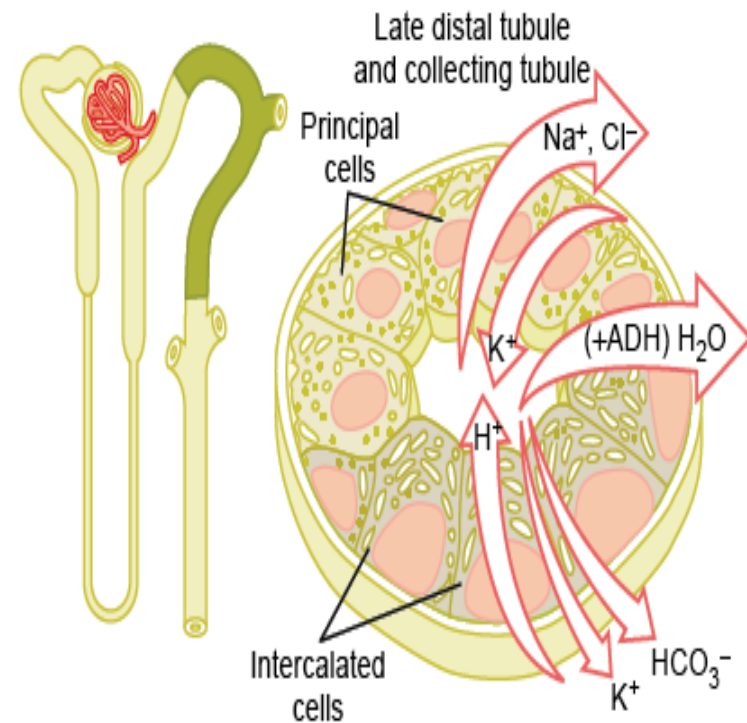
❖ **Medullary collecting duct**

- **It is the final site for processing the urine and reabsorbs less than 10 % of the filtered water and sodium.**

Medullary collecting duct

Na$^+$, Cl$^-$

(+ADH) H$_2$O

Urea

H$^+$

HCO$_3$$^-$
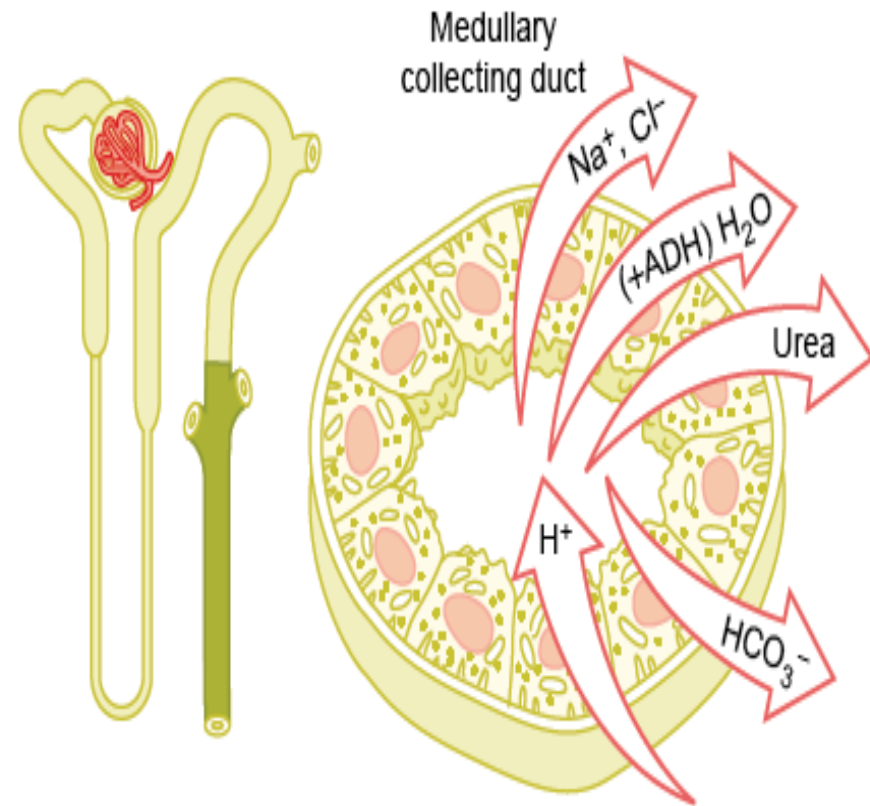
❖ **Special characteristics of the medullary collecting duct:**

• **Their permeability to water is controlled by the level of ADH (↑ urine concentration when ADH↑).**

• **It is permeable to urea (this contributing to the kidneys' overall ability to form a concentrated urine).**

• **It is capable of secreting hydrogen ions against a large concentration gradient (a key role in regulating acid-base balance).**

Medullary collecting duct

Na⁺, Cl⁻

(+ADH) H₂O

Urea

H⁺

HCO₃⁻
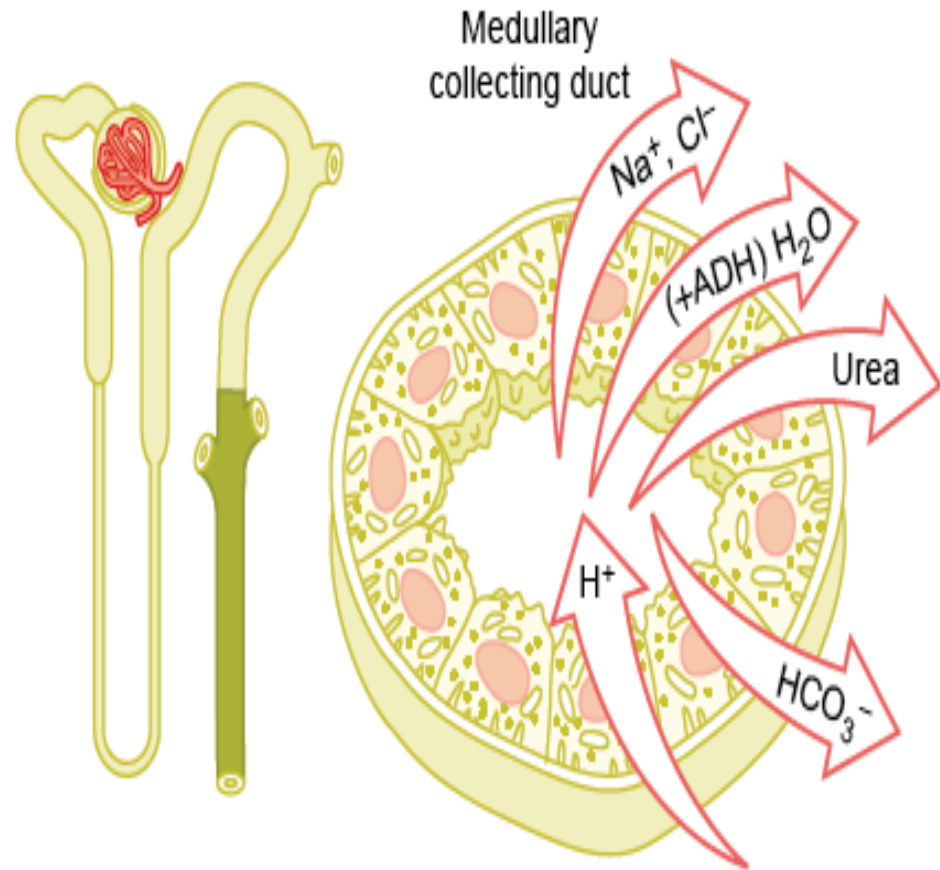
HORMONAL AND AUTACOID CONTROL OF RENAL CIRCULATION

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

❖ Hormonal and autacoid control of renal circulation:

- **There are several hormones and autacoids that can influence GFR(glomerular filtration rate) and renal blood flow**
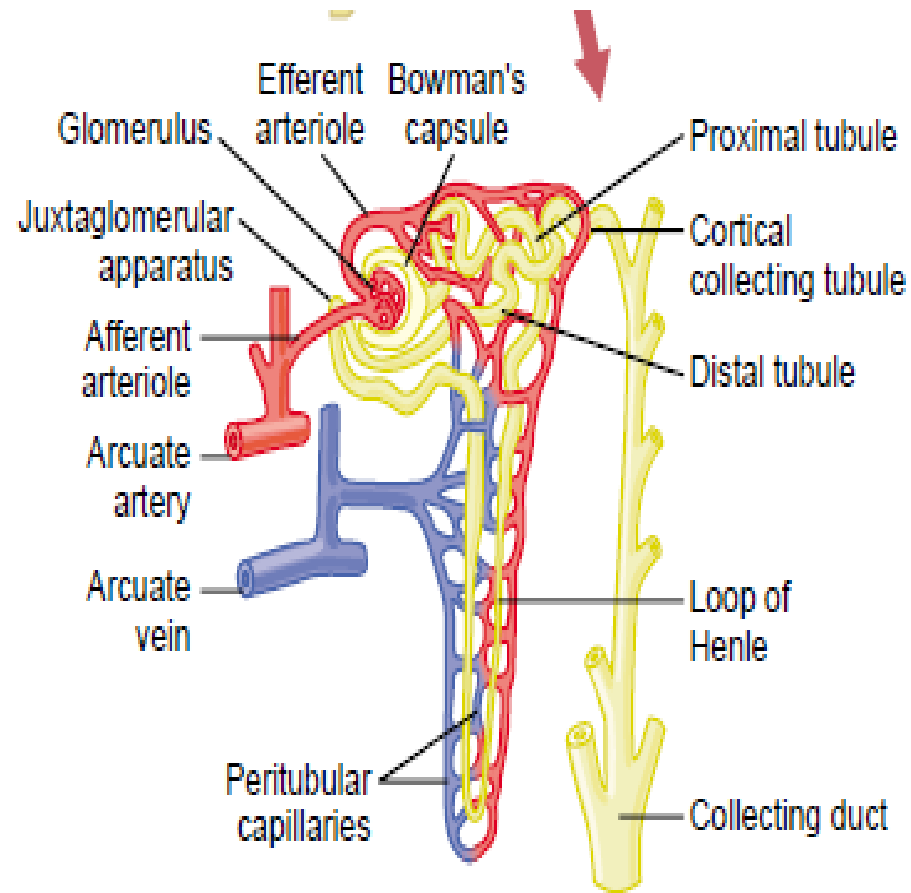
Hormones and Autacoids That Influence Glomerular Filtration Rate (GFR)

Hormone or Autacoid	Effect on GFR
Norepinephrine	↓
Epinephrine	↓
Endothelin	↓
Angiotensin II	←→ (prevents ↓)
Endothelial-derived nitric oxide	↑
Prostaglandins	↑

❖ **Autoregulation of GFR and renal blood flow**

▪ **Autoregulation is the intrinsic feedback mechanisms to the kidneys normally keep the renal blood flow and GFR relatively constant, despite marked changes in arterial blood pressure.**

▪ **For instance, a decrease in arterial pressure to as low as 75 mm Hg or an increase to as high as 160 mm Hg; the changes of GFR will be only a few percentage points) which is independent of systemic influences.**
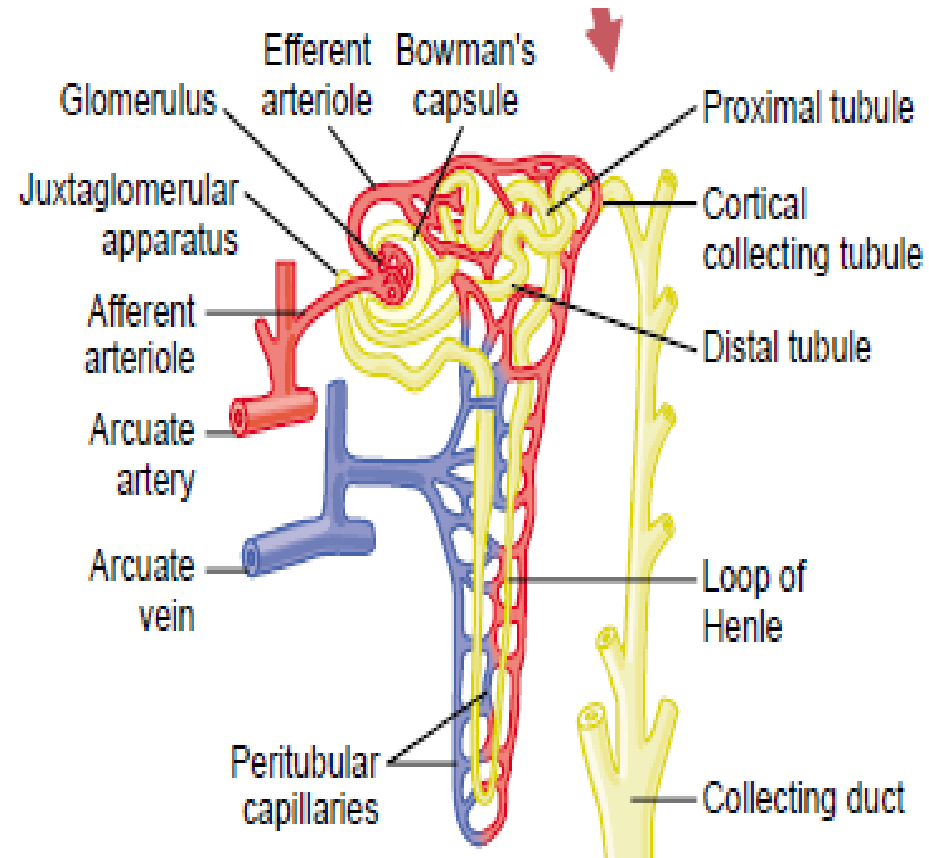
❖ **Role of tubuloglomerular feedback in autoregulation of GFR**

▪ **The tubuloglomerular feedback mechanism has two components that act together to control GFR:**

(1) **An afferent arteriolar feedback mechanism.**

(2) **An efferent arteriolar feedback mechanism.**

▪ **These feedback mechanisms depend on special anatomical arrangements of the juxtaglomerular complex.**
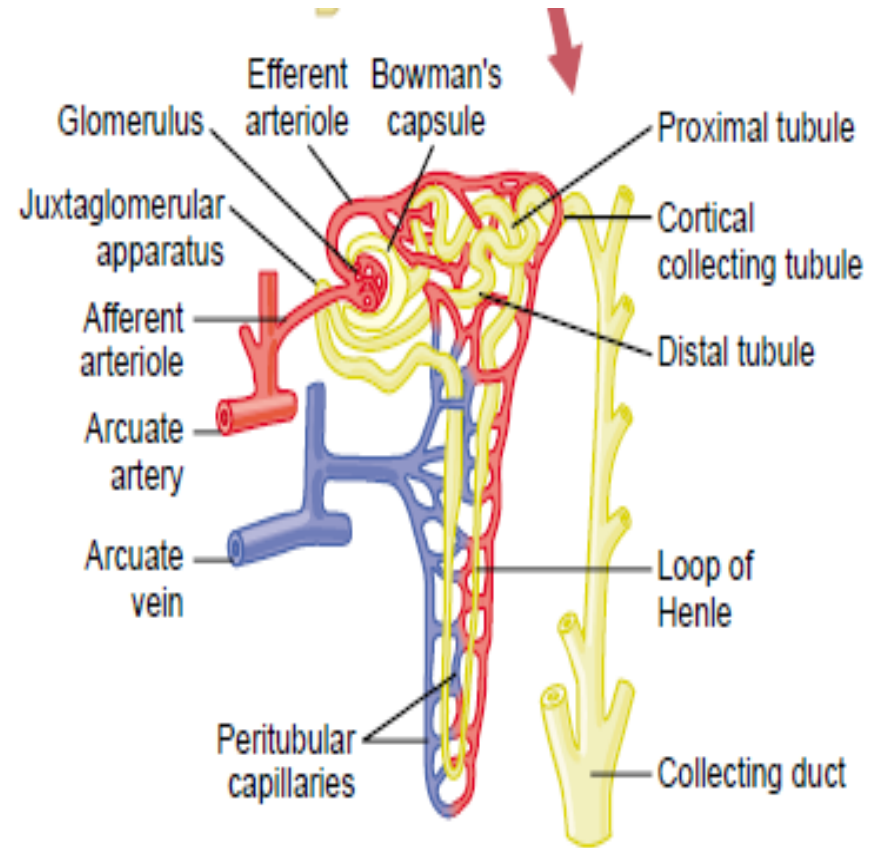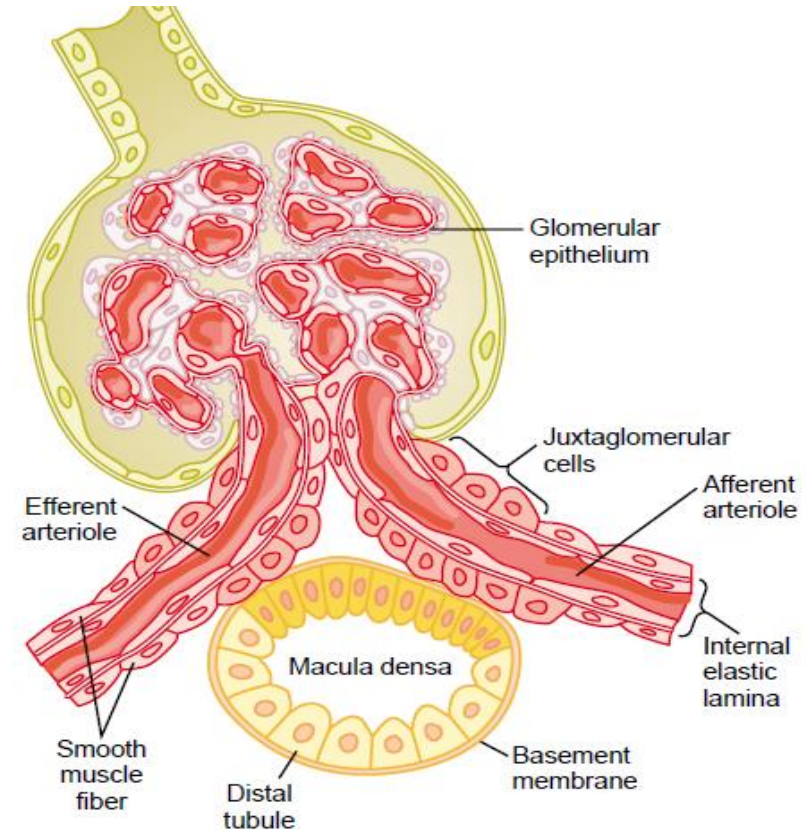
❑ **The juxtaglomerular complex:**

▪ **Consists of:**

1) **Macula densa cells in the initial portion of the distal tubule.**

2) **Juxtaglomerular cells in the walls of the afferent and efferent arterioles.**

▪ **The macula densa is a specialized group of epithelial cells in the distal tubules that comes in close contact with the afferent and efferent arterioles.**
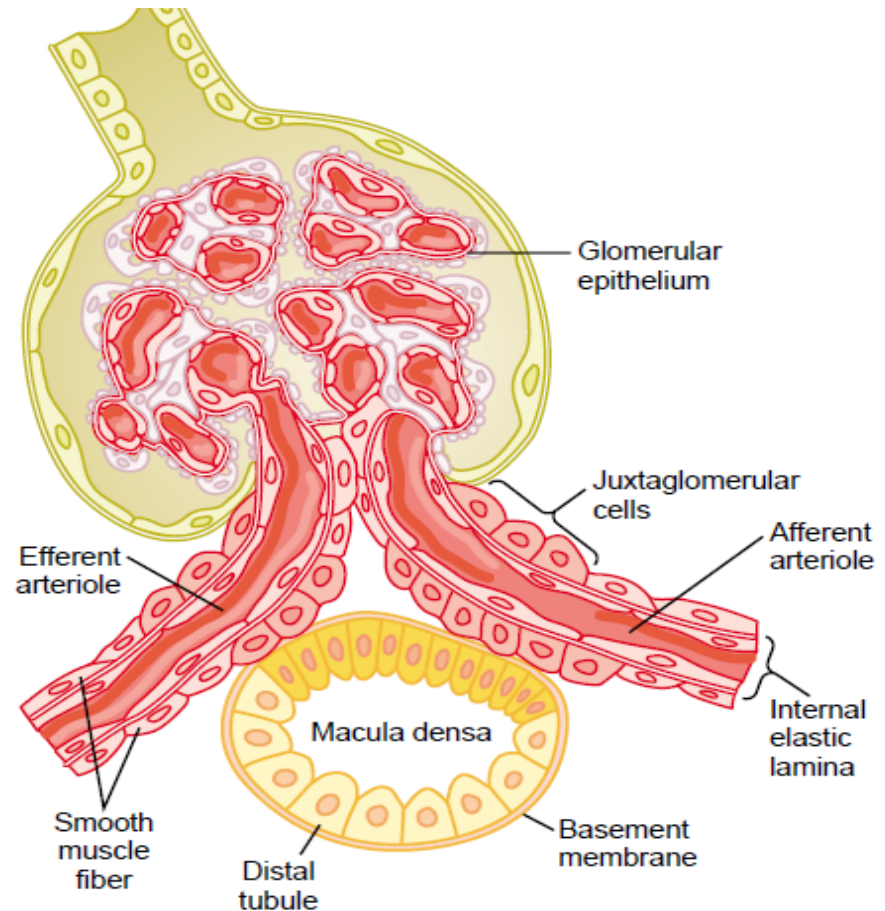
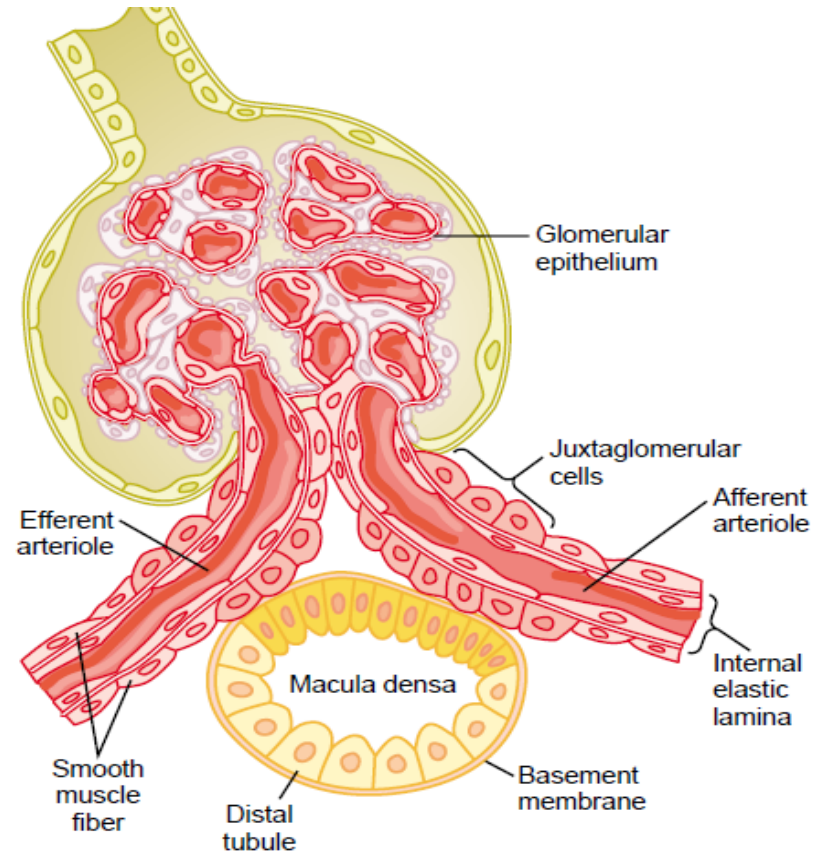▪ **The macula densa cells contain Golgi apparatus, which are intracellular secretory organelles directed toward the arterioles.**

Glomerular epithelium

Juxtaglomerular cells

Afferent arteriole

Internal elastic lamina

Basement membrane

Macula densa

Distal tubule

Smooth muscle fiber

Efferent arteriole

❖ **Decreased macula densa sodium chloride causes dilation of afferent arterioles and increased renin release.**

▪ **The macula densa cells sense changes in volume delivery to the distal tubule, as GFR decreases lead to slow the flow rate in the loop of Henle, causing increased reabsorption of sodium and chloride ions in the ascending loop of Henle.**

▪ **Thereby reducing the concentration of sodium chloride at the macula densa cells.**

Glomerular epithelium

Juxtaglomerular cells

Afferent arteriole

Efferent arteriole

Internal elastic lamina

Macula densa

Smooth muscle fiber

Distal tubule

Basement membrane

- **This initiates a signal from the macula densa that has two effects:**
(1) **It decreases resistance to blood flow in the afferent arterioles, which raises glomerular hydrostatic pressure and helps return GFR toward normal.**
(2) **It increases rennin release from the juxtaglomerular cells of the afferent and efferent arterioles, which are the major storage sites for renin.**


Glomerular epithelium

Juxtaglomerular cells

Afferent arteriole

Efferent arteriole

Internal elastic lamina

Macula densa

Smooth muscle fiber

Distal tubule

Basement membrane

- **Renin released from these cells then functions as an enzyme to increase the formation of angiotensin I, which is converted to angiotensin II.**
- **Finally, the angiotensin II constricts the efferent arterioles, thereby increasing glomerular hydrostatic pressure and returning GFR toward normal.**
- **Angiotensin II–blocking drugs can be useful therapeutic agents in many patients with hypertension and congestive heart failure with GFR monitor.**
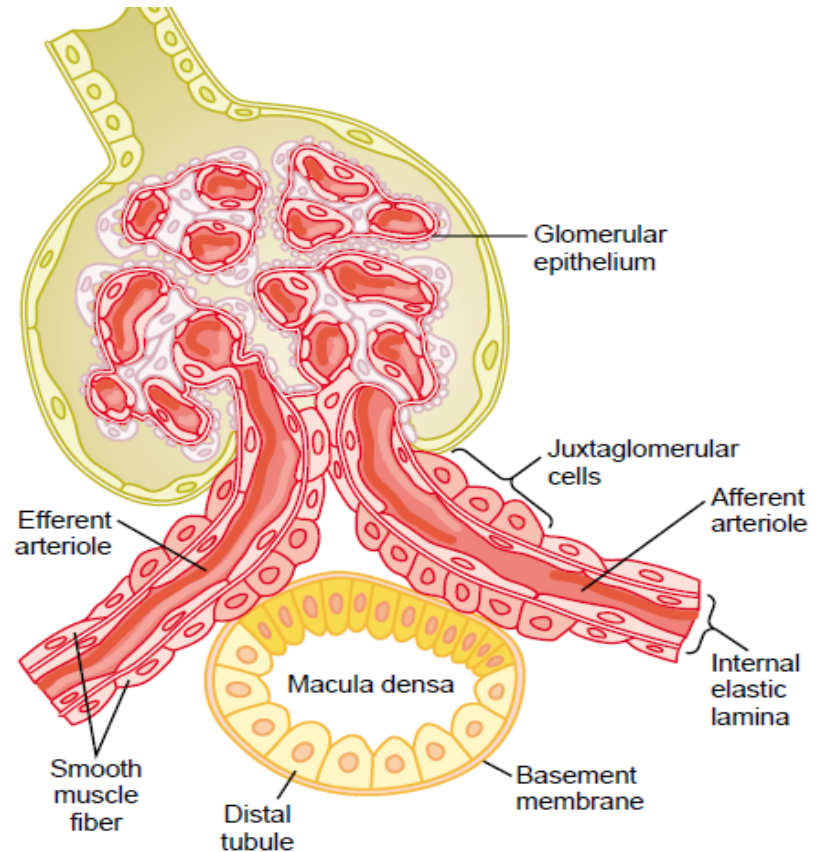
❖ **Hormonal control of tubular reabsorption**

▪ **Several hormones in the body provide specificity of tubular reabsorption for different electrolytes and water**
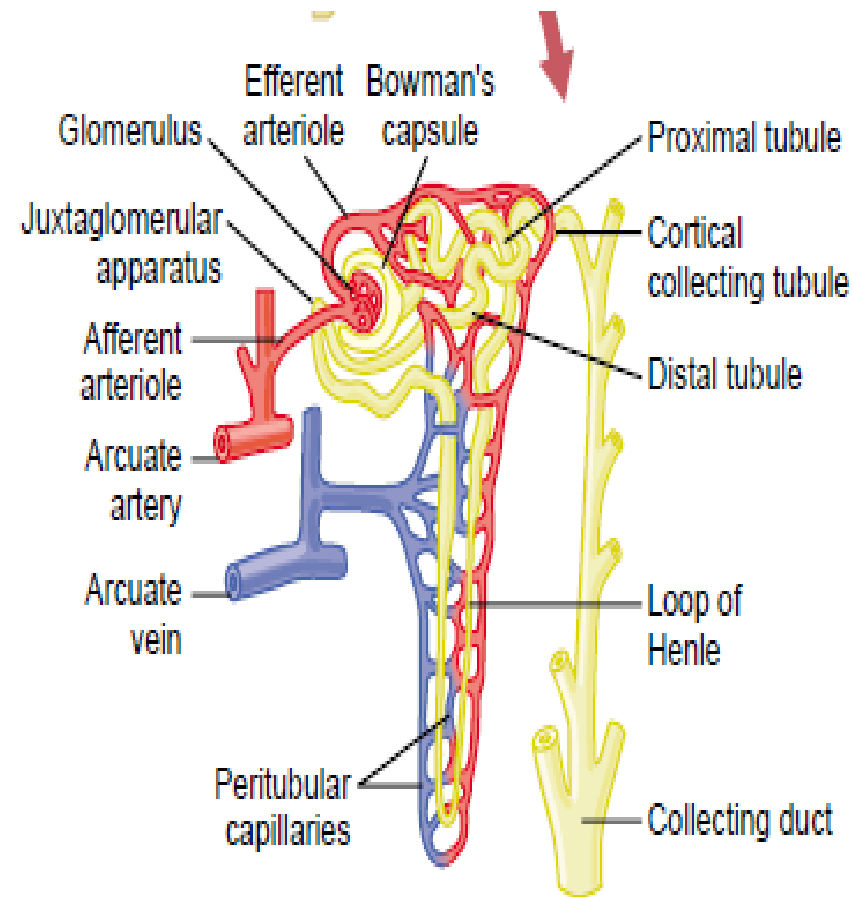
Hormones That Regulate Tubular Reabsorption

| Hormone	Site of Action	Effects
Aldosterone	Collecting tubule and duct	↑ NaCl, H_2O reabsorption, ↑ K^+ secretion
Angiotensin II	Proximal tubule, thick ascending loop of Henle/distal tubule, collecting tubule	↑ NaCl, H_2O reabsorption, ↑ H^+ secretion
Antidiuretic hormone	Distal tubule/collecting tubule and duct	↑ H_2O reabsorption
Atrial natriuretic peptide	Distal tubule/collecting tubule and duct	↓ NaCl reabsorption
Parathyroid hormone	Proximal tubule, thick ascending loop of Henle/distal tubule	↓ PO_4^{---} reabsorption, ↑ Ca^{++} reabsorption

❖ Aldosterone:

- **The primary site of aldosterone action is on the principal cells of the cortical collecting tubule.**

- **Aldosterone increases sodium reabsorption; at the same time increasing potassium secretion is by stimulating the sodium-potassium ATPase pump on the basolateral side of the cortical collecting tubule membrane and also increases the sodium permeability of the luminal side of the membrane.**

- **Absence of aldosterone occurs with adrenal destruction or malfunction (Addison's disease).**

- **Excess aldosterone secretion, as occurs in patients with adrenal tumors (Conn's syndrome).**

Late distal tubule and collecting tubule
Principal cells
Na^+, Cl^-
K^+ (+ADH) H_2O
H^+
Intercalated cells
HCO_3^-
K^+

Bowman's capsule
Afferent arteriole
Efferent arteriole
Loop of Henle with peritubular capillaries
Proximal convoluted tubule
Distal convoluted tubule
From another nephron
Collecting duct
Buzzle.com
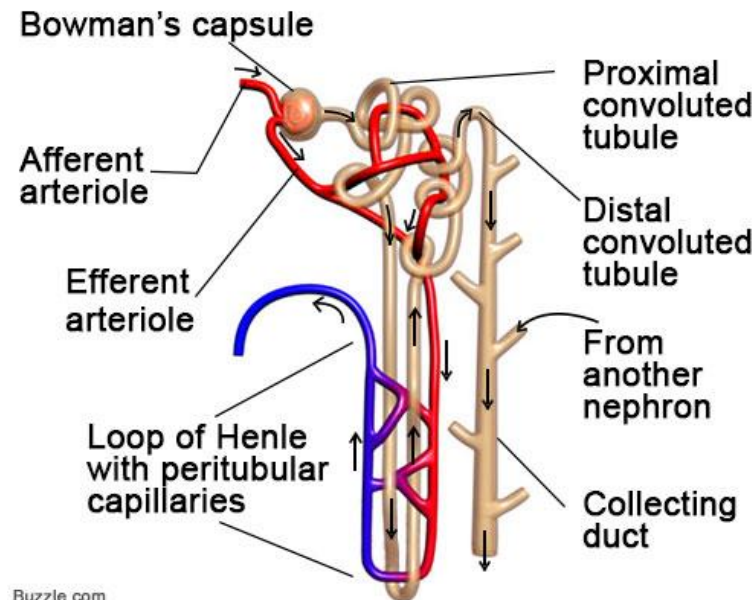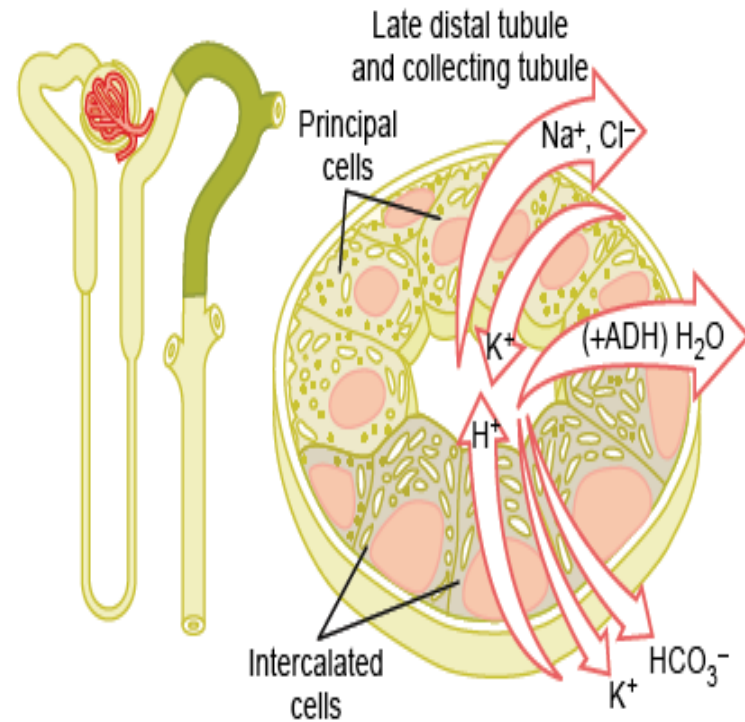
❖ Angiotensin II:

- **It increases sodium and water reabsorption; angiotensin II formation increases in circumstances associated with low blood pressure and/or low extracellular fluid volume, such as during hemorrhage or loss of salt and water from the body fluids.**

- **angiotensin II increase sodium and water reabsorption from the renal tubules through three main effects:**
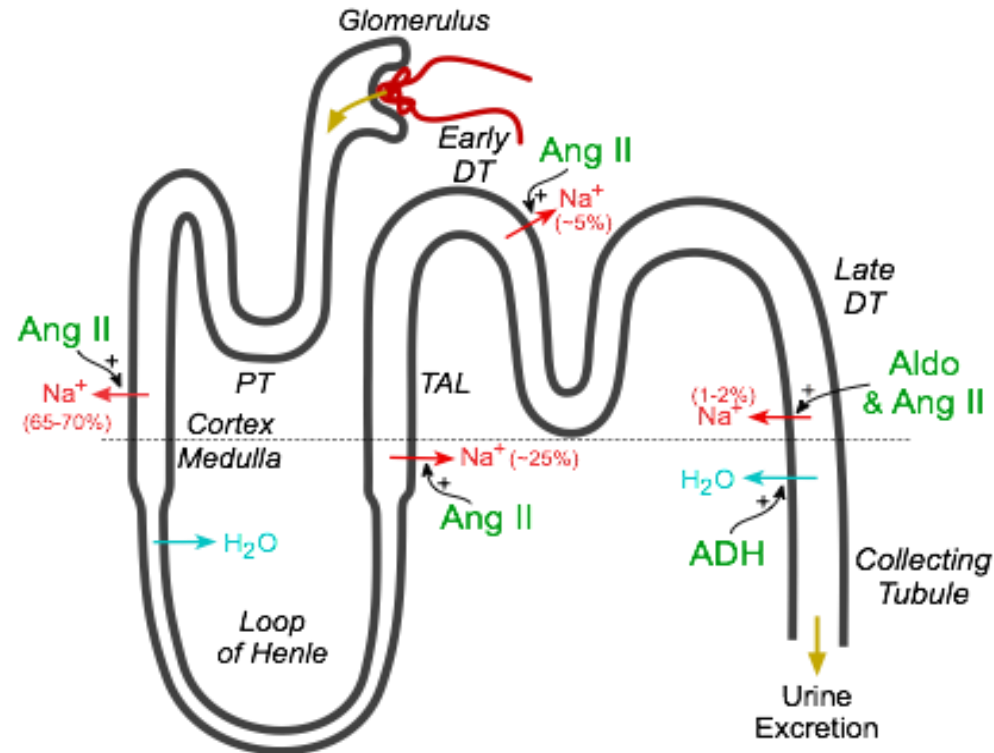
Abbreviations: PT, proximal tubule; TAL, thick ascending limb of loop of Henle; DT, distal tubule; Ang II, angiotensin II; Aldo, aldosterone

1. Angiotensin II stimulates aldosterone secretion.

2. Angiotensin II constricts the efferent arterioles.

3. Angiotensin II directly stimulates sodium reabsorption in the proximal tubules, the loops of Henle, the distal tubules, and the collecting tubules.
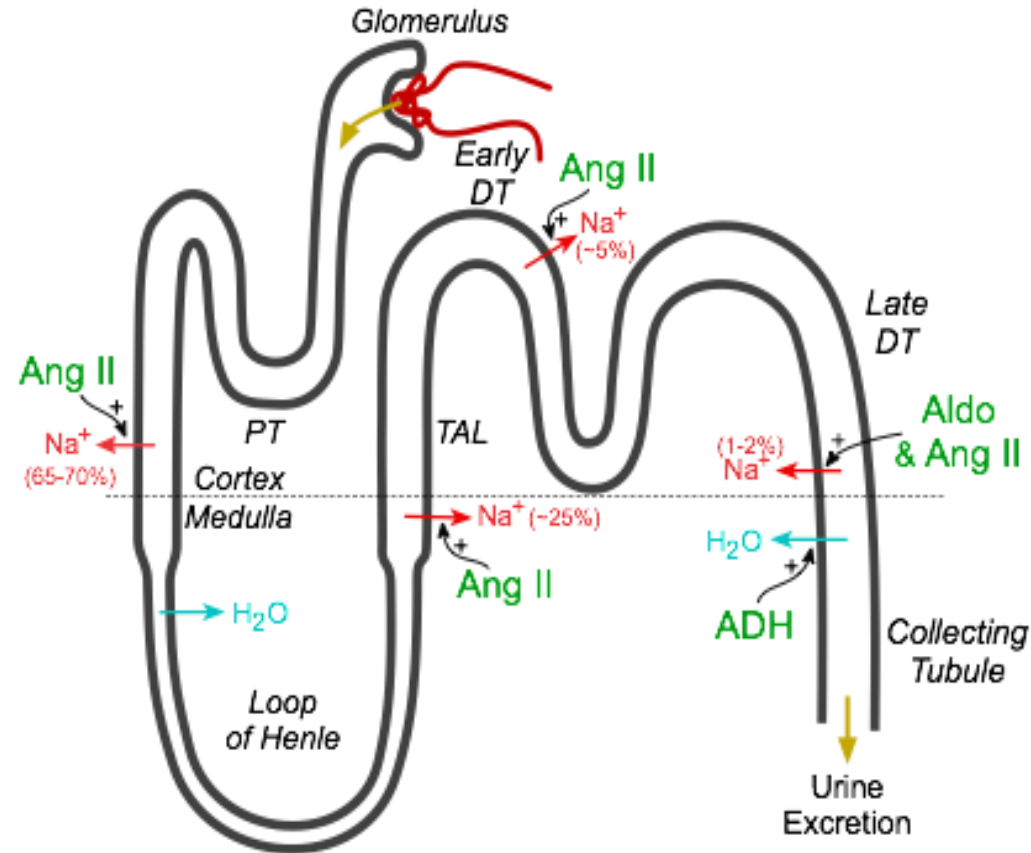
Abbreviations: PT, proximal tubule; TAL, thick ascending limb of loop of Henle; DT, distal tubule; Ang II, angiotensin II; Aldo, aldosterone
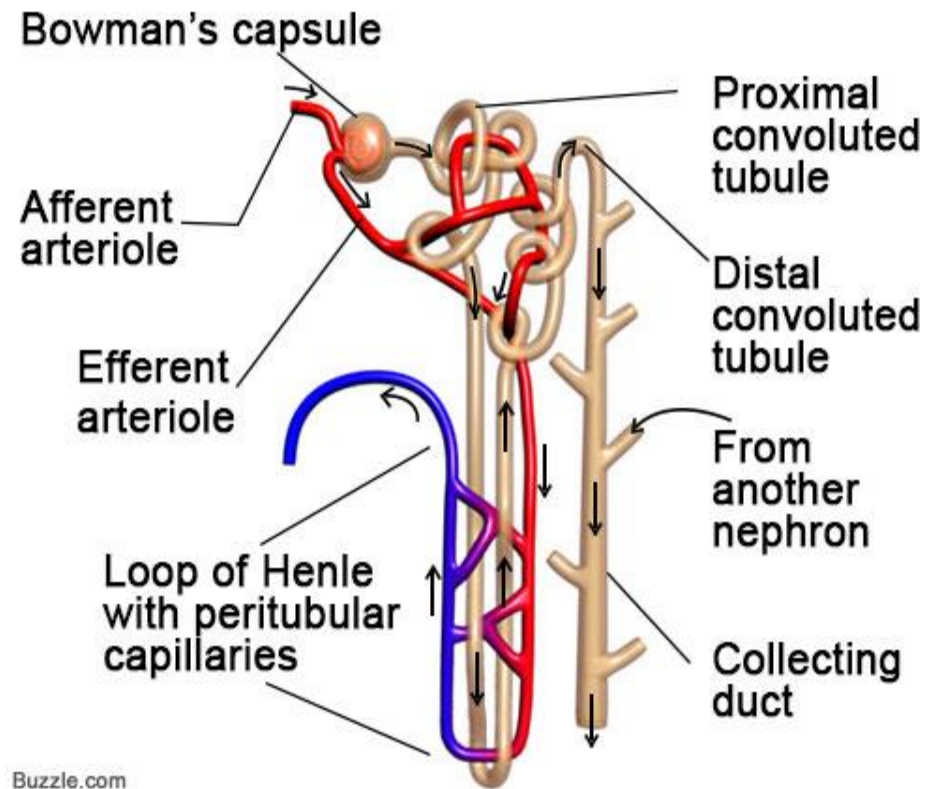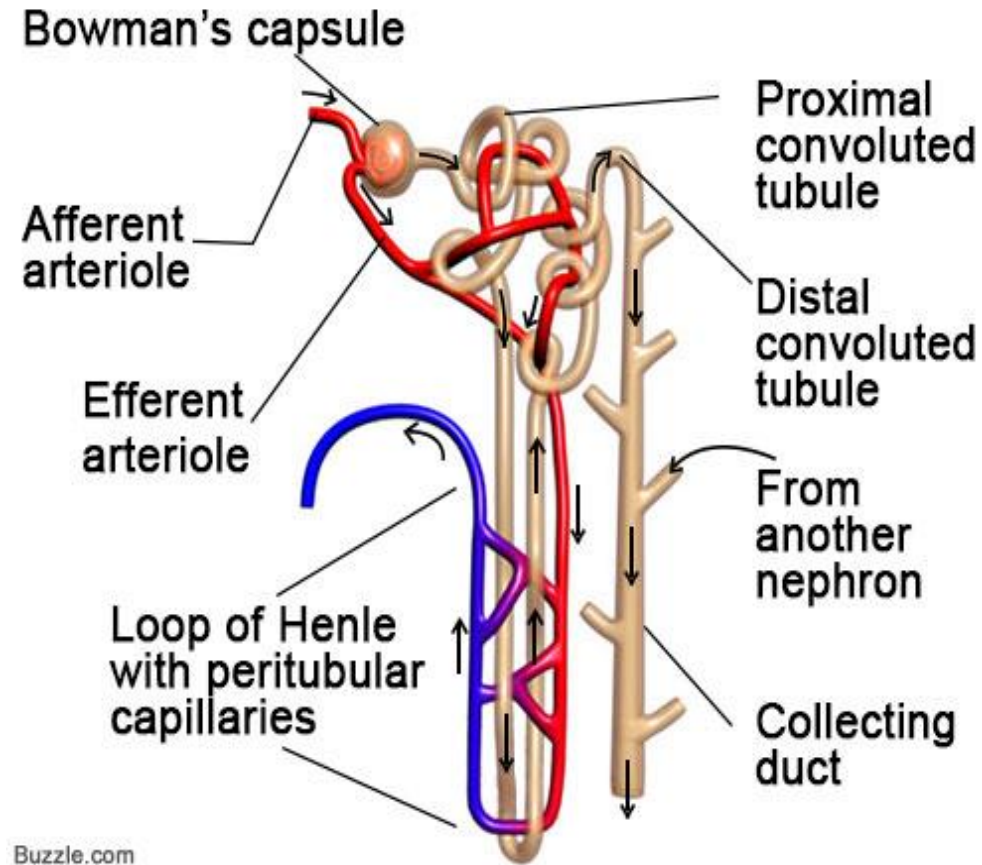
❖ **Antidiuretic hormone (ADH) (vasopressin):**

▪ **It controls urine concentration by that:**

▪ **When osmolarity of the body fluids increases above normal.**

➢ **The posterior pituitary gland secretes more ADH, which increases the permeability of the distal tubules and collecting ducts to water and decreases urine volume.**
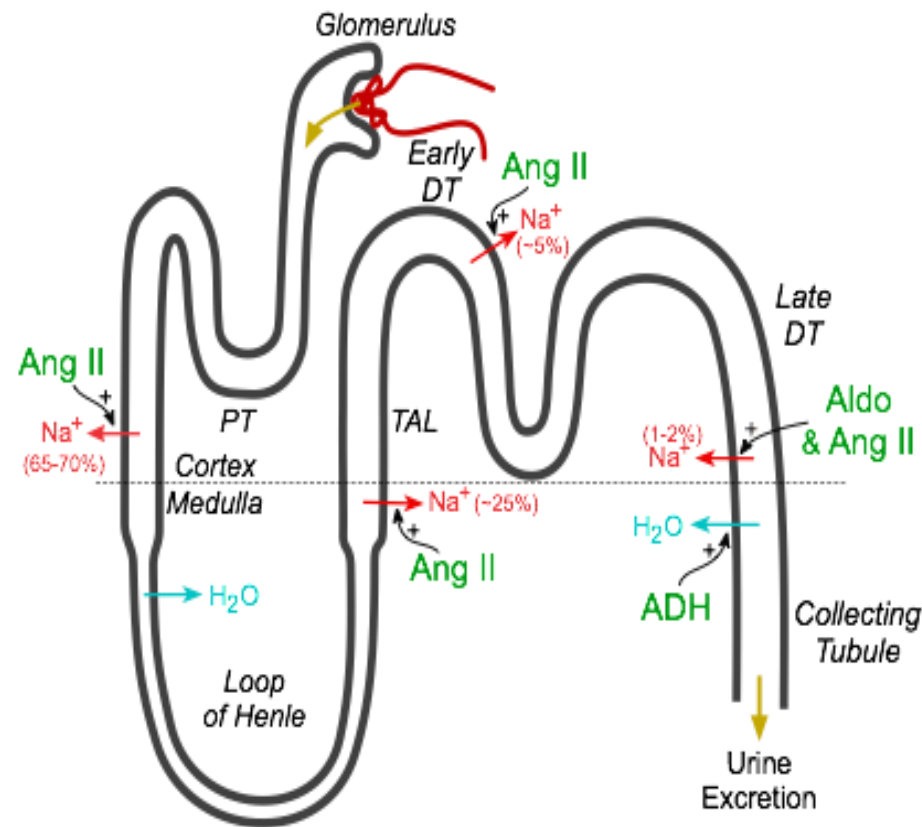
Abbreviations: PT, proximal tubule; TAL, thick ascending limb of loop of Henle; DT, distal tubule; Ang II, angiotensin II; Aldo, aldosterone

- **When there is excess water in the body and extracellular fluid osmolarity is reduced, the secretion of ADH by the posterior pituitary decreases.**
- **Thereby reducing the permeability of the distal tubule and collecting ducts to water, which causes large amounts of dilute urine to be excreted.**


Bowman's capsule

Afferent arteriole

Efferent arteriole

Loop of Henle with peritubular capillaries

Proximal convoluted tubule

Distal convoluted tubule

From another nephron

Collecting duct

Buzzle.com

❖ **Atrial Natriuretic Peptide:**

- **Specific cells of the cardiac atria, when distended because of plasma volume expansion, secrete a peptide called atrial natriuretic peptide.**

- **Which inhibit the reabsorption of sodium and water by the renal tubules, especially in the collecting ducts and increases urinary excretion, which helps to return blood volume back toward normal.**


Bowman's capsule

Afferent arteriole

Efferent arteriole

Loop of Henle with peritubular capillaries

Proximal convoluted tubule

Distal convoluted tubule

From another nephron

Collecting duct

Buzzle.com

❖ **Endothelial-derived nitric oxide:**

• **It decreases renal vascular resistance and increases GFR; it is an autacoid that decreases renal vascular resistance (vasodilation of the kidneys) and is released by the vascular endothelium throughout the body.**

• **Endothelial -derived nitric oxide, nitric oxide allows the kidneys to excrete normal amounts of sodium and water (impaired nitric oxide production will lead to increase the blood pressure).**


Kidney
Calyces
Renal artery
Renal pelvis
Renal vein
Medulla
Ureter
Cortex
ADAM.
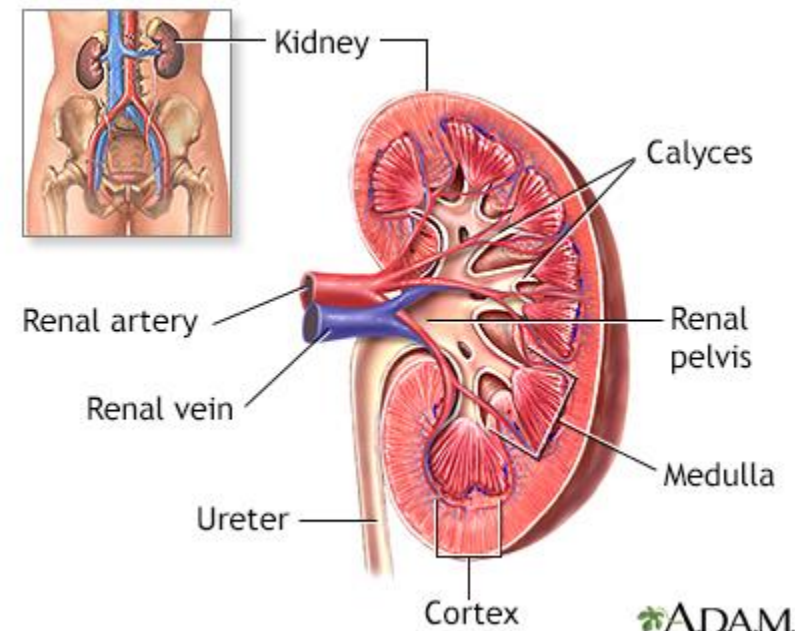
❖ **Parathyroid Hormone**

▪ **Its principal action in the kidneys is to increase tubular reabsorption of calcium, especially in the distal tubules and the loops of Henle.**

▪ **It also inhibit phosphate reabsorption by the proximal tubule and stimulate magnesium reabsorption by the loop of Henle.**
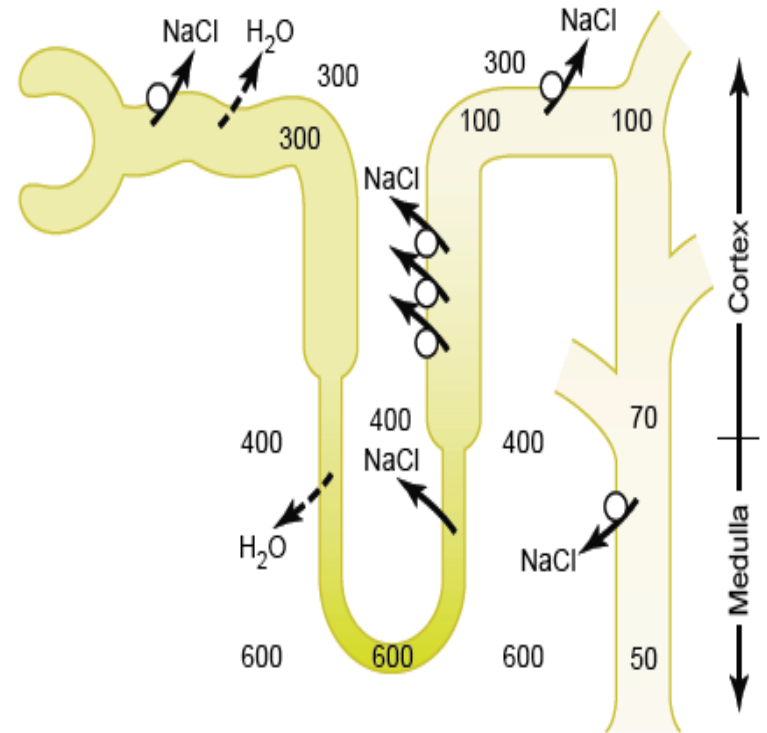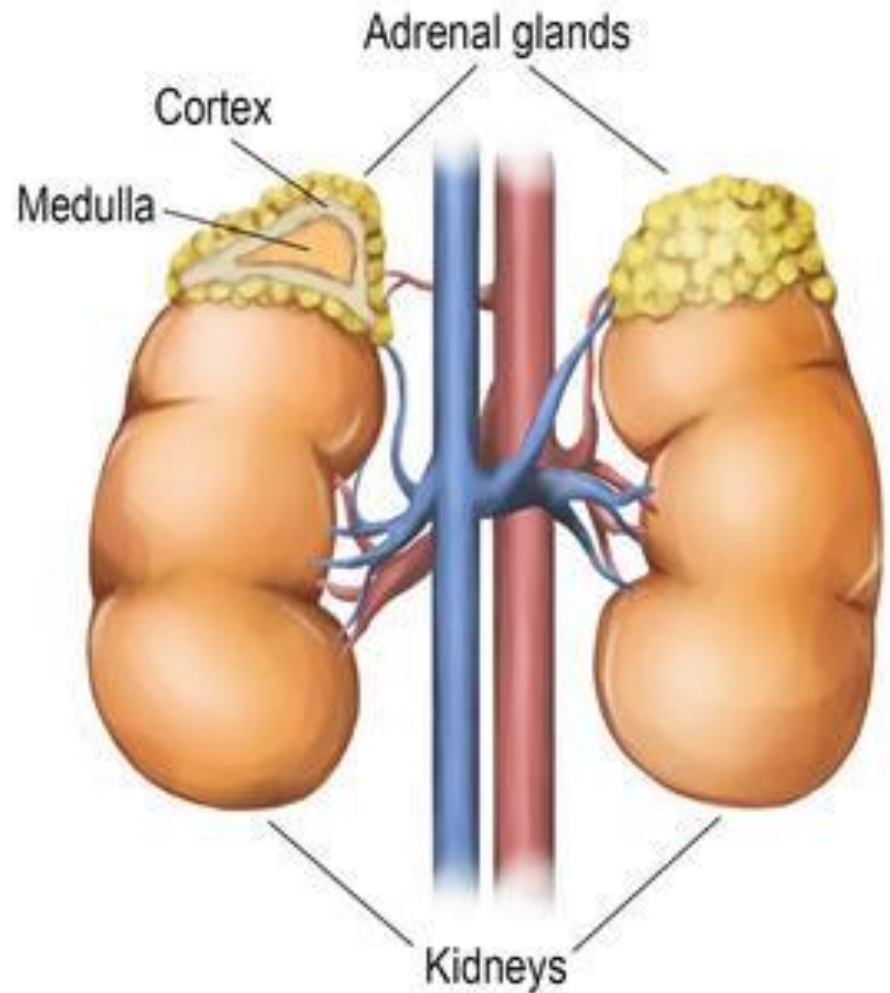
❖ **Sympathetic Nervous System Activation**

○ **Activation of the sympathetic nervous system can decrease sodium and water excretion by:**

▪ **First: Constricting the renal arterioles, thereby reducing GFR.**

▪ **Second: increase sodium reabsorption in the proximal tubule, the thick ascending limb of the loop of Henle, and perhaps in more distal parts of the renal tubule.**

▪ **Third: increases renin release and angiotensin II formation, which adds to the overall effect to increase tubular reabsorption and decrease renal excretion of sodium.**
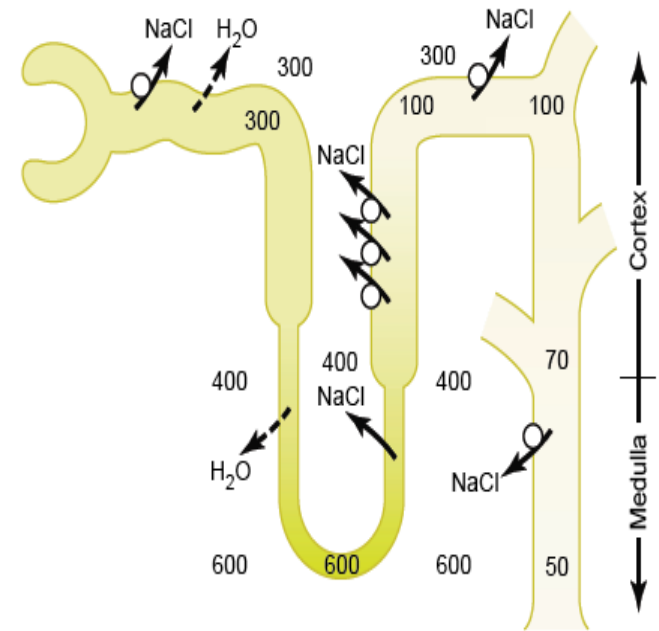
❖ **Norepinephrine and epinephrine:**

• **Released from the adrenal medulla constrict afferent and efferent arterioles.**

•**Causing reductions in GFR and renal blood flow.**

•**This influence is little except under extreme conditions, such as severe hemorrhage (as sympathetic system).**
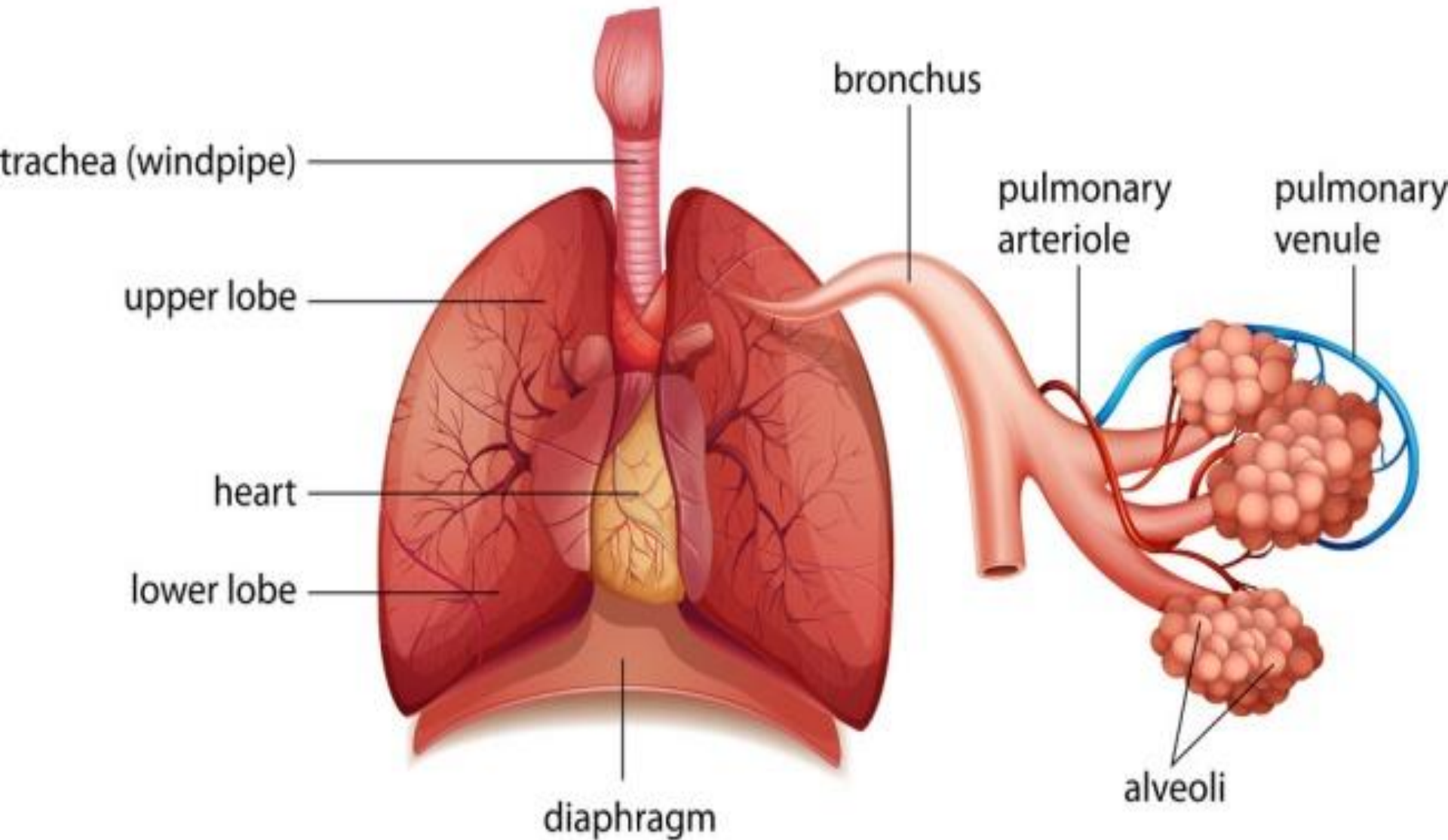

Adrenal glands

Cortex

Medulla

Kidneys

THANK YOU

RESPIRATORY SYSTEM

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

Human Respiratory System

trachea (windpipe)

bronchus

upper lobe

pulmonary arteriole

pulmonary venule

heart

lower lobe

alveoli
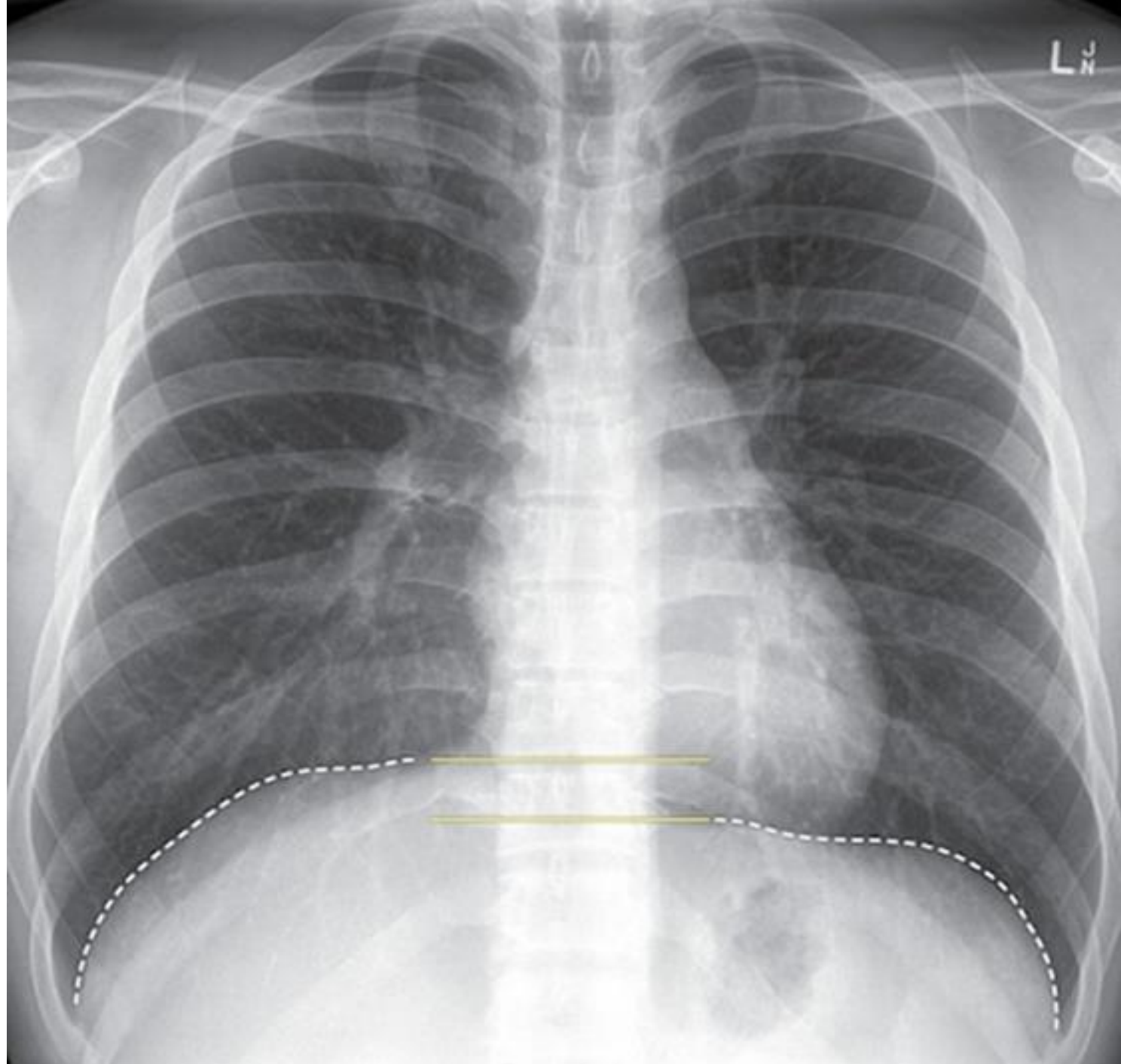
diaphragm

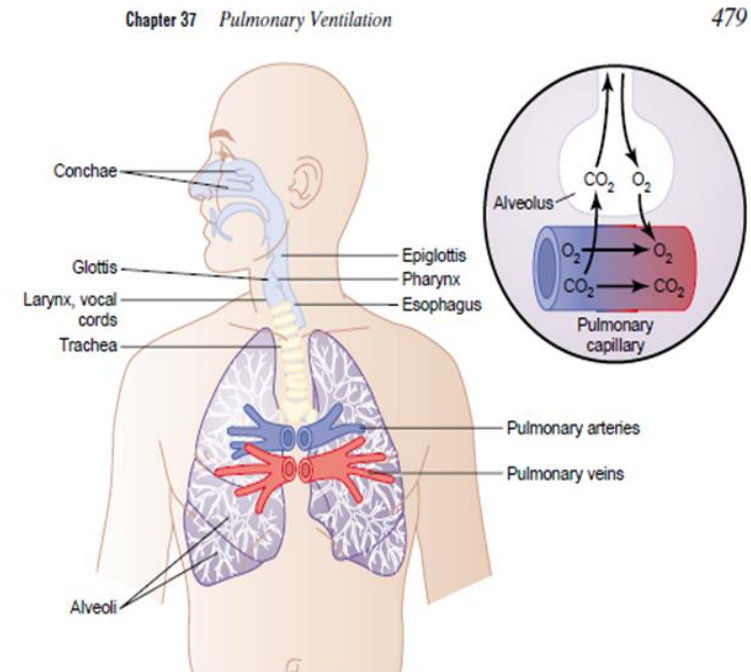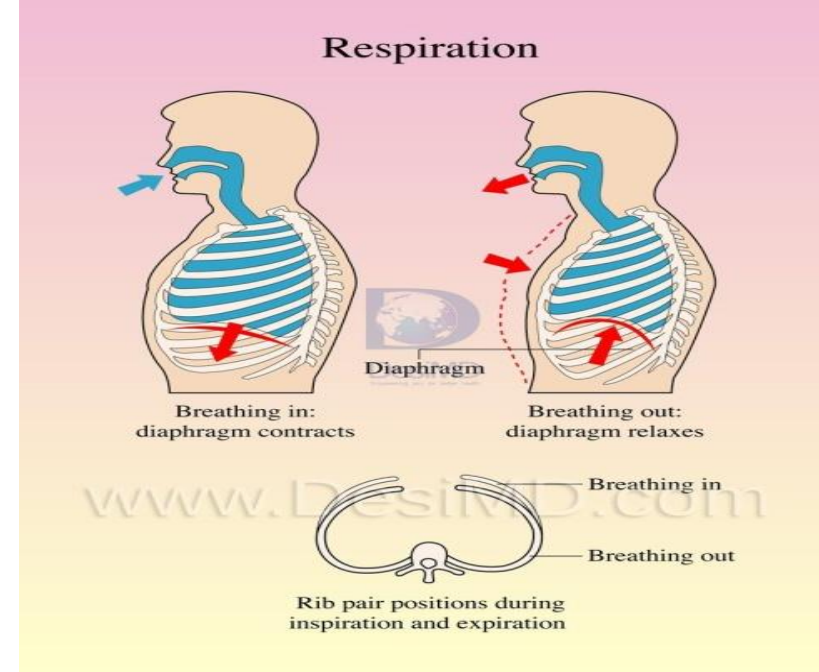## ❖Goals of respiration are:

- To provide oxygen to the tissues and to remove carbon dioxide.
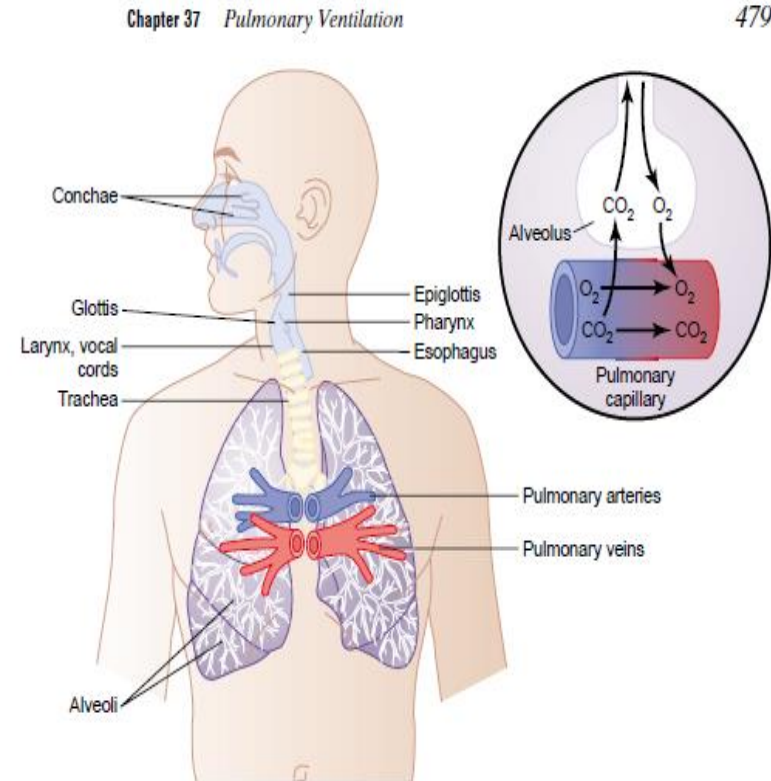
- **Respiration can be divided into four major functions:**

(1) Pulmonary ventilation: which means the inflow and outflow of air between the atmosphere and the lung alveoli.

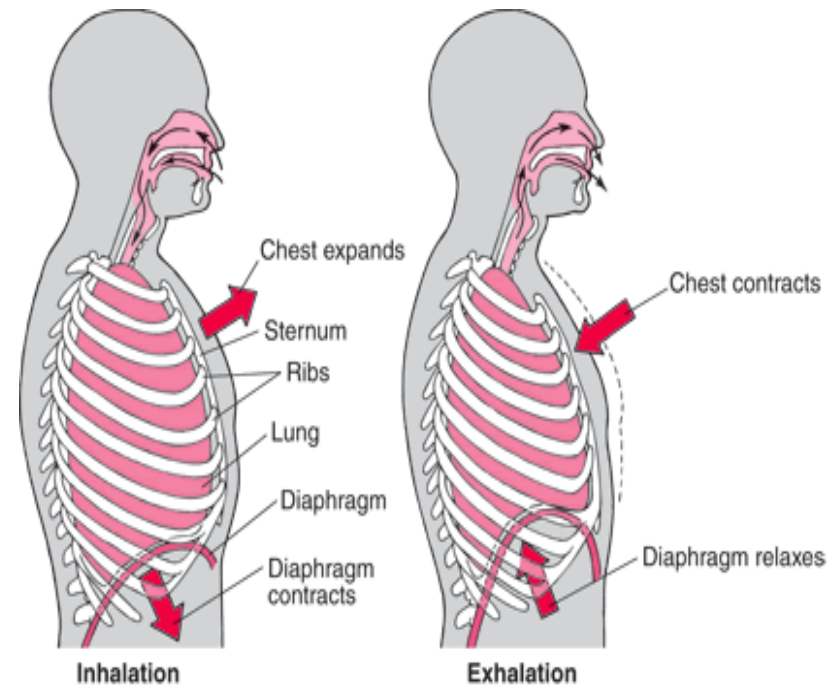**(2) Diffusion of oxygen and carbon dioxide between the alveoli and the blood.**

(3) Transport of oxygen and carbon dioxide in the blood and body fluids to and from the body's tissue cells.

(4) Regulation of ventilation and other facets of respiration.

Conchae

Glottis

Larynx, vocal cords

Trachea

Alveoli

Epiglottis

Pharynx

Esophagus

Alveolus

CO_2 O_2

O_2 O_2

CO_2 CO_2

Pulmonary capillary

Pulmonary arteries

Pulmonary veins

## ❖ Mechanics of Pulmonary Ventilation:

(1) Downward and upward movement of the diaphragm to lengthen or shorten the chest cavity.

(2) Elevation and depression of the ribs to increase and decrease the antero-posterior diameter of the chest cavity.

- **Normal quiet breathing is accomplished almost entirely by the first method; by movement of the diaphragm.**

Chest expands — Sternum — Ribs — Lung — Diaphragm — Diaphragm contracts — Inhalation

Chest contracts — Diaphragm relaxes — Exhalation

1) First method:

During inspiration, contraction of the diaphragm plus the lower surfaces of the lungs downward.
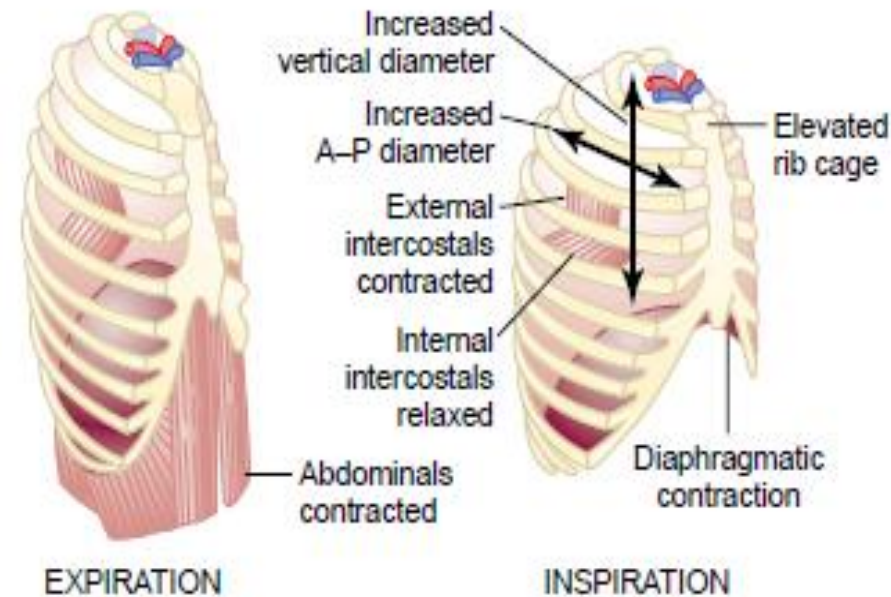
- During expiration, the diaphragm simply relaxes (so the *elastic recoil* of the lungs, chest wall, and abdominal structures compresses the lungs and expels the air).
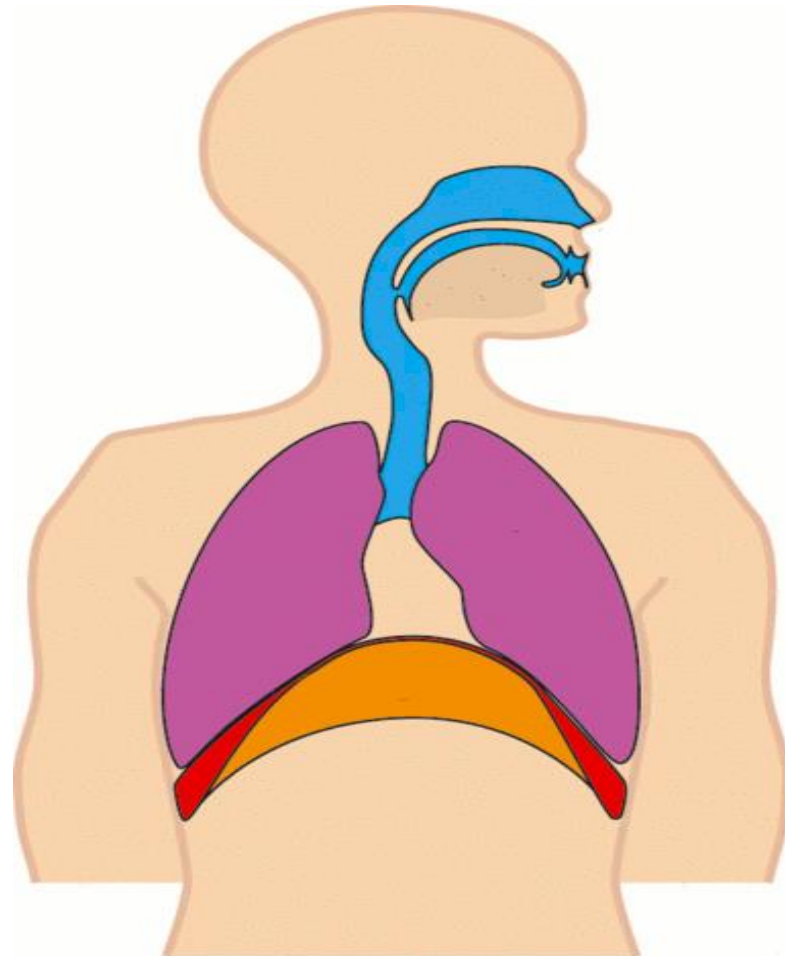
2) The second method:

The expanding of the lungs is to raise the rib cage.

- In the natural resting position, the ribs slant downward, thus allowing the sternum to fall backward toward the vertebral column.

- But when the rib cage is elevated, the ribs project almost directly forward, so that the sternum also moves forward, away from the spine, making the antero-posterior thickness of the chest about **20%** greater during maximum inspiration than during expiration.
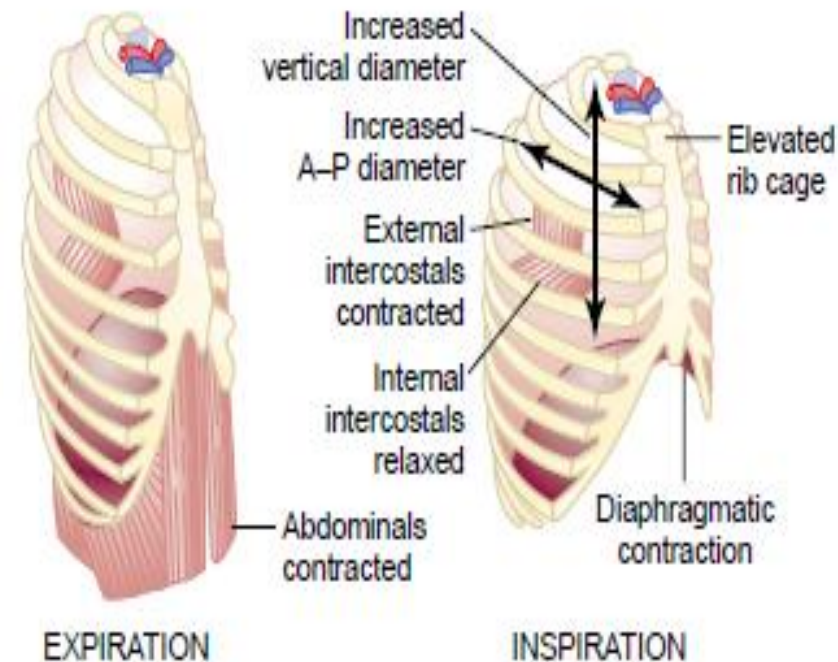

Increased vertical diameter
Increased A–P diameter
External intercostals contracted
Internal intercostals relaxed
Abdominals contracted
Elevated rib cage
Diaphragmatic contraction

EXPIRATION   INSPIRATION

- **All the muscles that** elevate **the chest cage are classified as:**

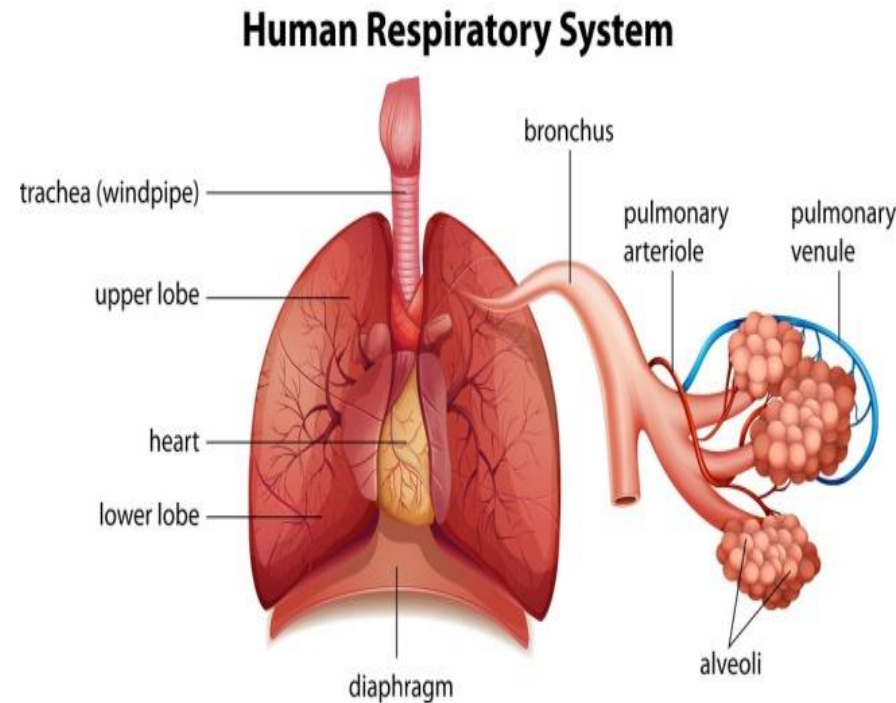➢ **muscles of inspiration.**

- **and those muscles that** depress **the chest cage are classified as:**

➢ **muscles of expiration.**

Increased vertical diameter

Increased A–P diameter

External intercostals contracted

Internal intercostals relaxed

Abdominals contracted

Elevated rib cage

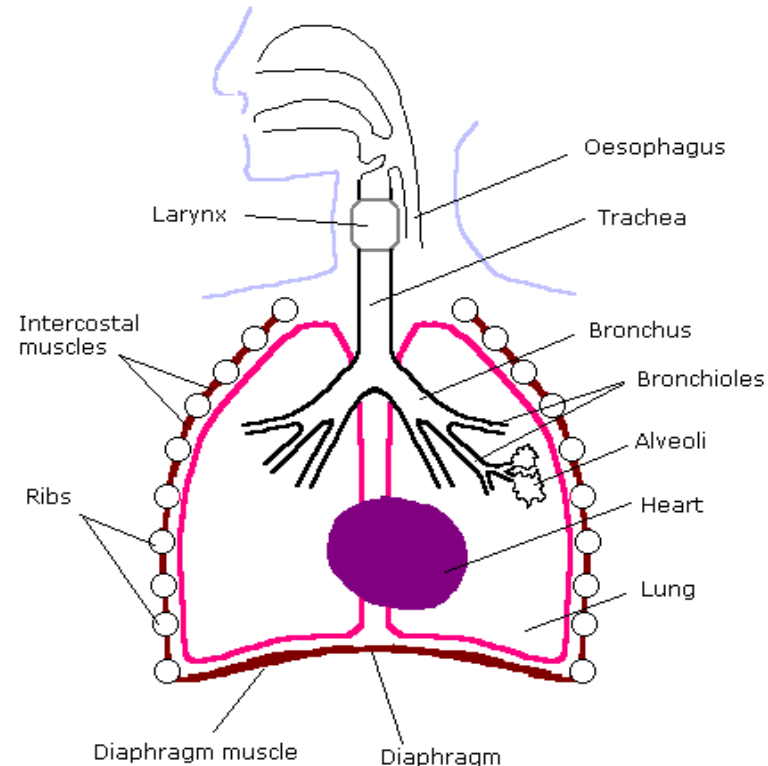Diaphragmatic contraction

EXPIRATION

INSPIRATION

❖ **Movement of air in and out of the lungs and the pressures that cause the movement:**

- **The lung is an elastic structure that collapses like a balloon and expels all its air through the trachea whenever there is no force to keep it inflated.**

- **Also, there are no attachments between the lung and the walls of the chest cage, except where it is suspended at its hilum from the mediastinum.**

- **The lung "floats" in the thoracic cavity.**

- **It surrounded by a thin layer of pleural fluid that lubricates movement of the lungs within the cavity.**

Human Respiratory System

trachea (windpipe)
bronchus
pulmonary arteriole
pulmonary venule
upper lobe
heart
lower lobe
alveoli
diaphragm

❖ Pleural Pressure and Its Changes During Respiration

- It is the pressure of the fluid in the thin space between the lung pleura and the chest wall pleura.

- This is normally a slight suction, which means a slightly negative pressure.

- The normal pleural pressure at the beginning of inspiration is about (–5 centimeters of water) which is the amount of suction required to hold the lungs open to their resting level.

- Then, during normal inspiration, expansion of the chest cage pulls outward on the lungs with greater force and creates more negative pressure, to an average of about (–7.5 centimeters of water).

Schematic diagram of lungs and thorax

Oesophagus

Larynx

Trachea

Intercostal muscles

Bronchus

Bronchioles

Alveoli

Ribs

Heart

Lung

Diaphragm muscle

Diaphragm

- **There is increasing negativity of the pleural pressure from –5 to –7.5 during inspiration.**

- **There is increase in lung volumeof 0.5 liter (500ml).**

- **Then, during expiration, the events are essentially reversed.**
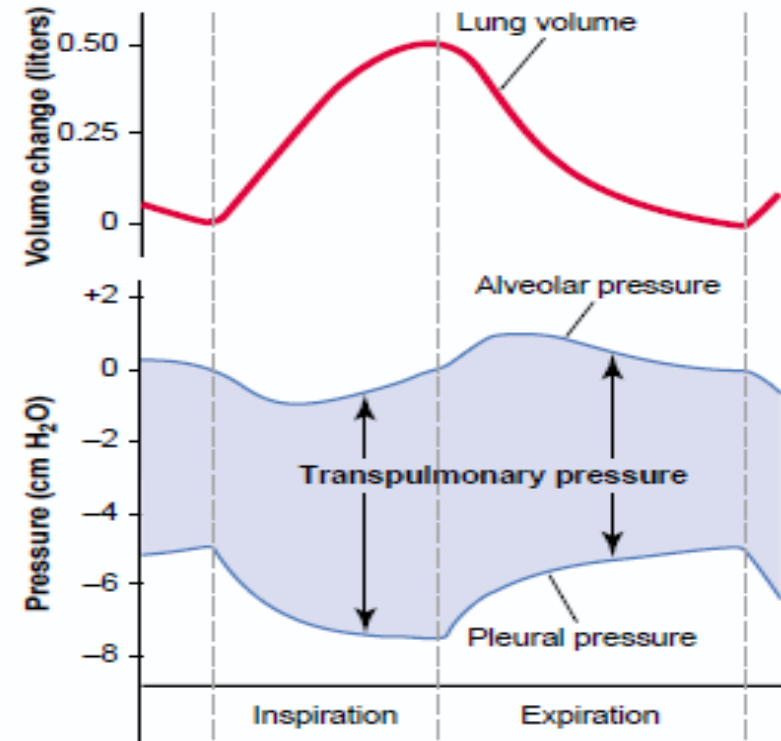
❖ Alveolar Pressure:

- **Alveolar pressure is the pressure of the air inside the lung alveoli.**

- **When the glottis is open and no air is flowing into or out of the lungs, the pressures in all parts of the respiratory tree, all the way to the alveoli, are equal to atmospheric pressure, which is considered to be zero reference pressure in the airways—that is, 0 centimeters water pressure.**

- **To cause inward flow of air into the alveoli during inspiration, the pressure in the alveoli must fall to a value slightly below atmospheric pressure (below 0).**
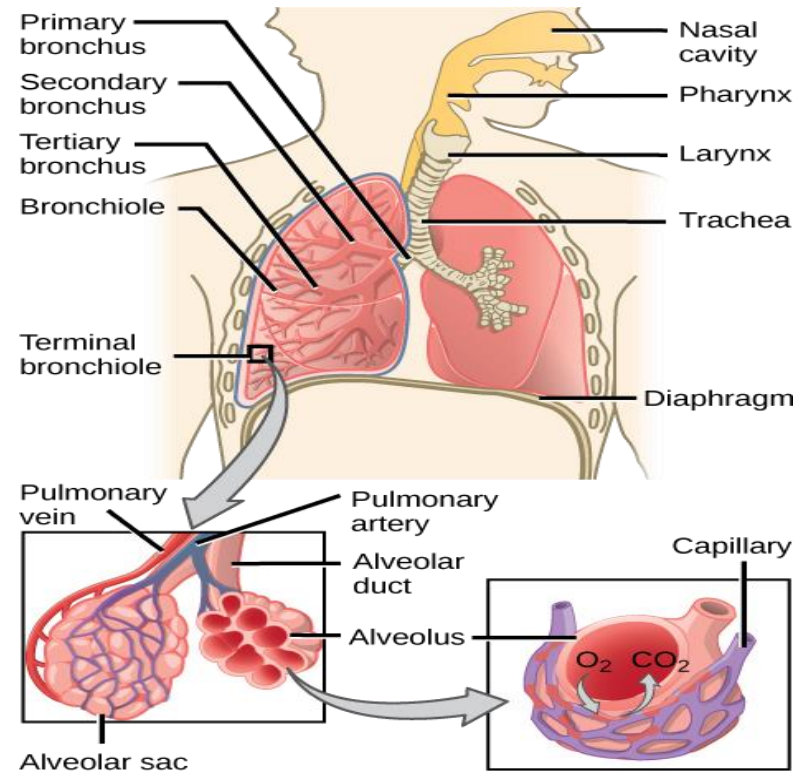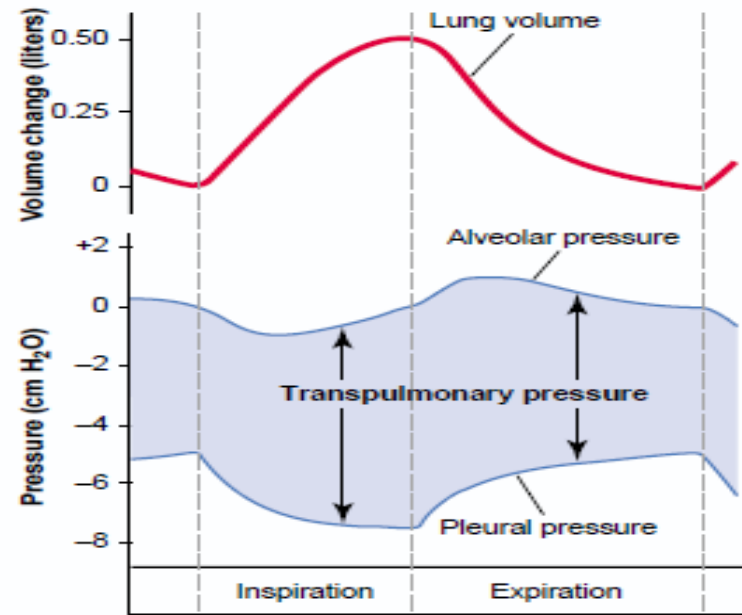
- **During normal inspiration, alveolar pressure decreases to about –1 centimeter of water.**

- **This slight negative pressure is enough to pull 0.5 liter of air into the lungs in the 2 seconds required for normal quiet inspiration.**
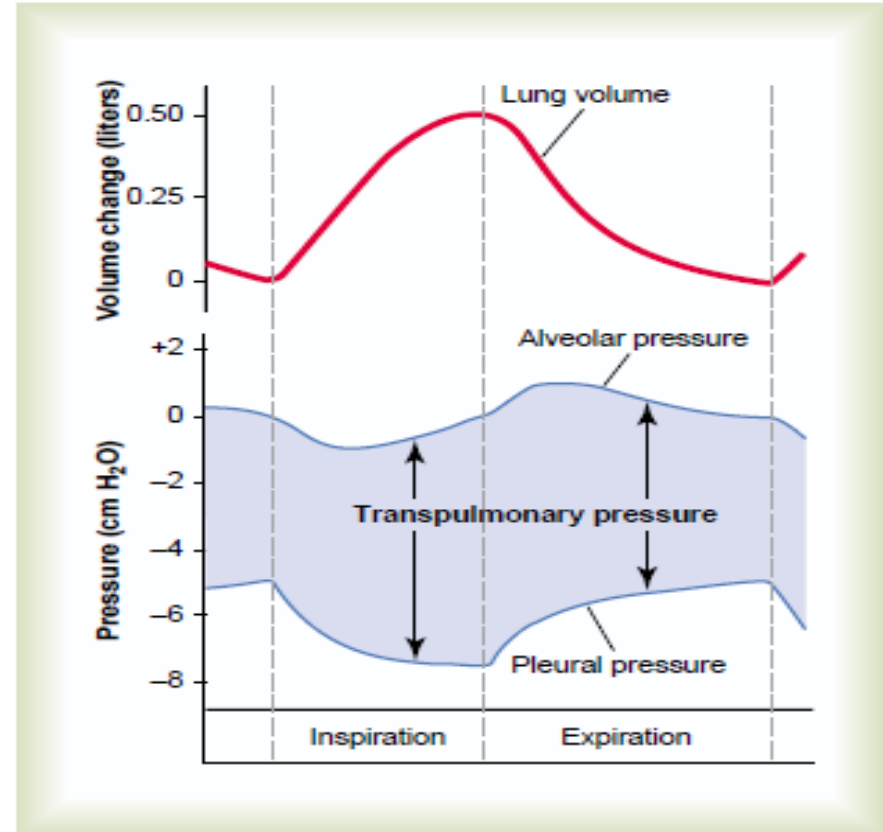
❖**During expiration, opposite pressures occur:**

- **The alveolar pressure rises to about +1 cm. of water, and this forces the 0.5 liter of inspired air out of the lungs during the 2 to 3 seconds of expiration.**

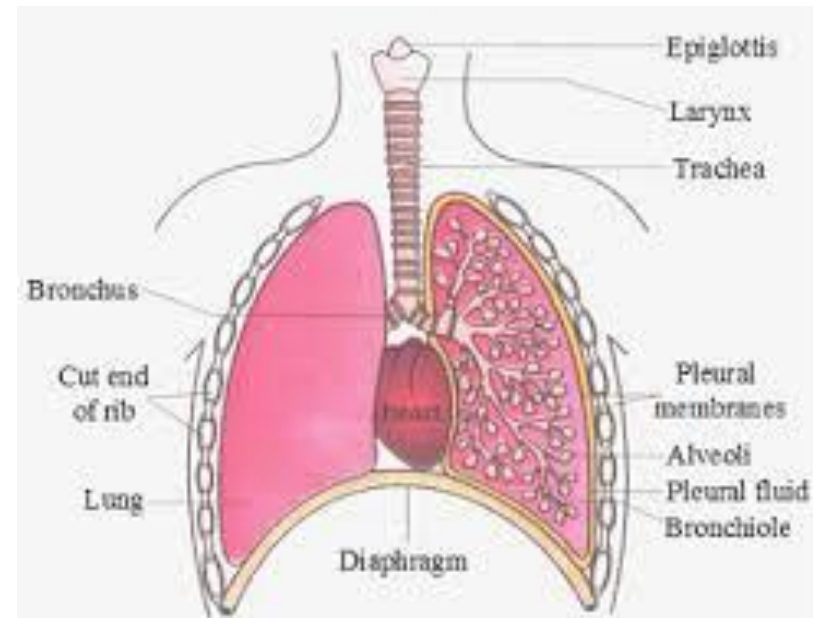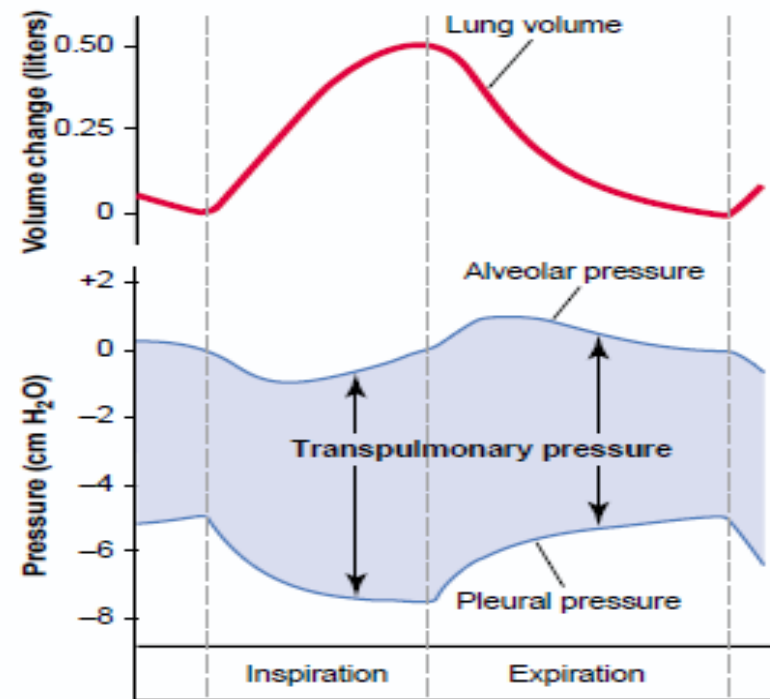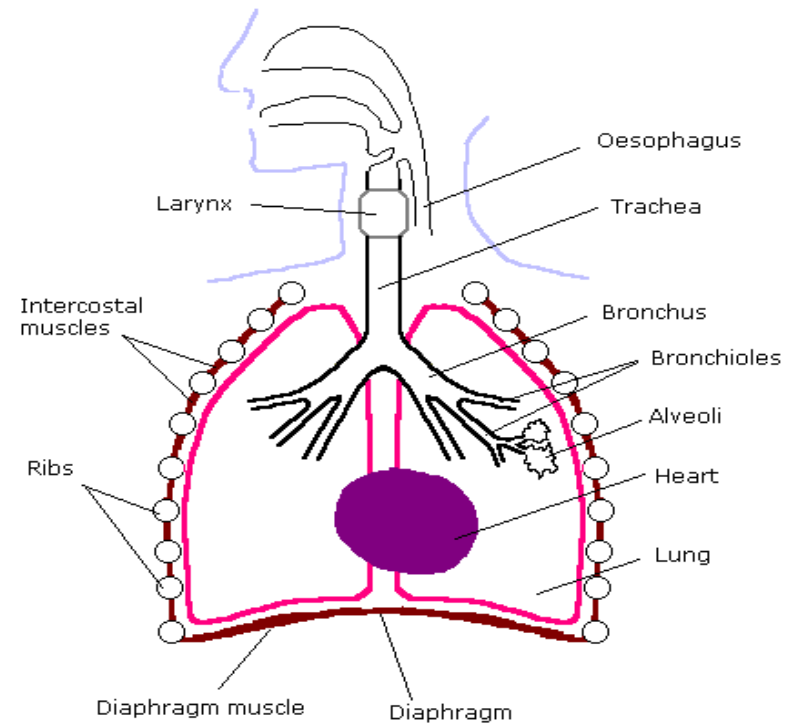Figure : HUMAN RESPIRATORY SYSTEM

❖"Work" of Breathing

- **During normal quiet breathing, all respiratory muscle contraction occurs during inspiration.**

- **Expiration is almost entirely a passive process caused by elastic recoil of the lungs and chest cage.**

- **Thus, under resting conditions, the respiratory muscles normally perform "work" to cause inspiration but not to cause expiration.**

Schematic diagram of lungs and thorax

Oesophagus
Larynx
Trachea
Intercostal muscles
Bronchus
Bronchioles
Alveoli
Ribs
Heart
Lung
Diaphragm muscle
Diaphragm

❖ **The work of inspiration can be divided into three fractions:**

(1) that required to expand the lungs against the lung and chest elastic forces, called *compliance work* or *elastic work.*

(2) that required to overcome the viscosity of the lung and chest wall structures, called *tissue resistance work.*

(3) that required to overcome airway resistance to movement of air into the lungs, called *airway resistance work.*
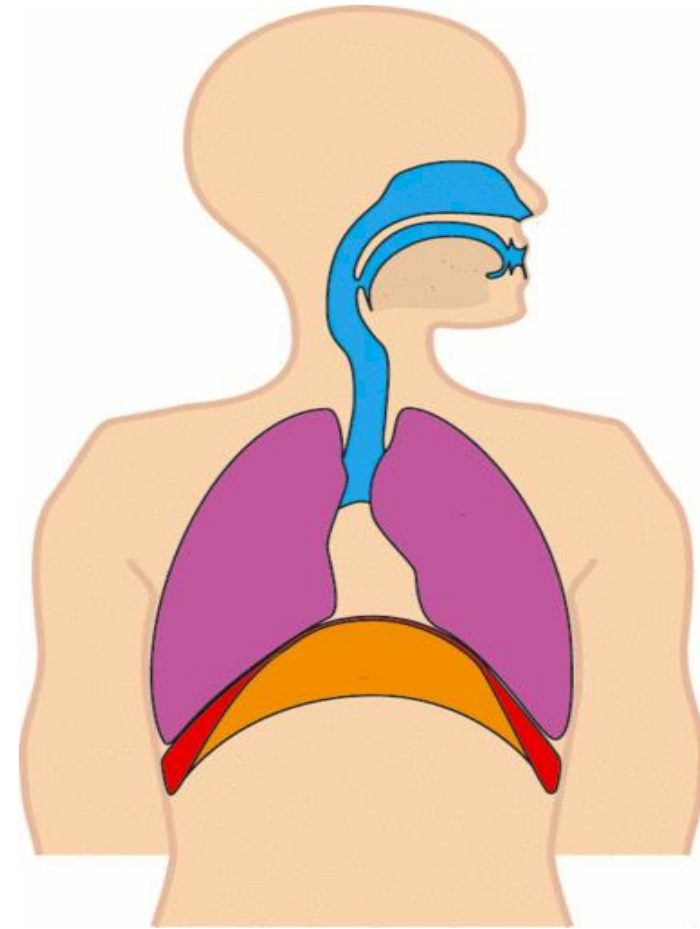
❖ Energy Required for Respiration.

- During normal quiet respiration, only **3 to 5 %** of the total energy expended by the body is required for pulmonary ventilation.

- But during heavy exercise, the amount of energy required can increase as much as **50-fold,** especially if the person has any degree of increased airway resistance or decreased pulmonary compliance.
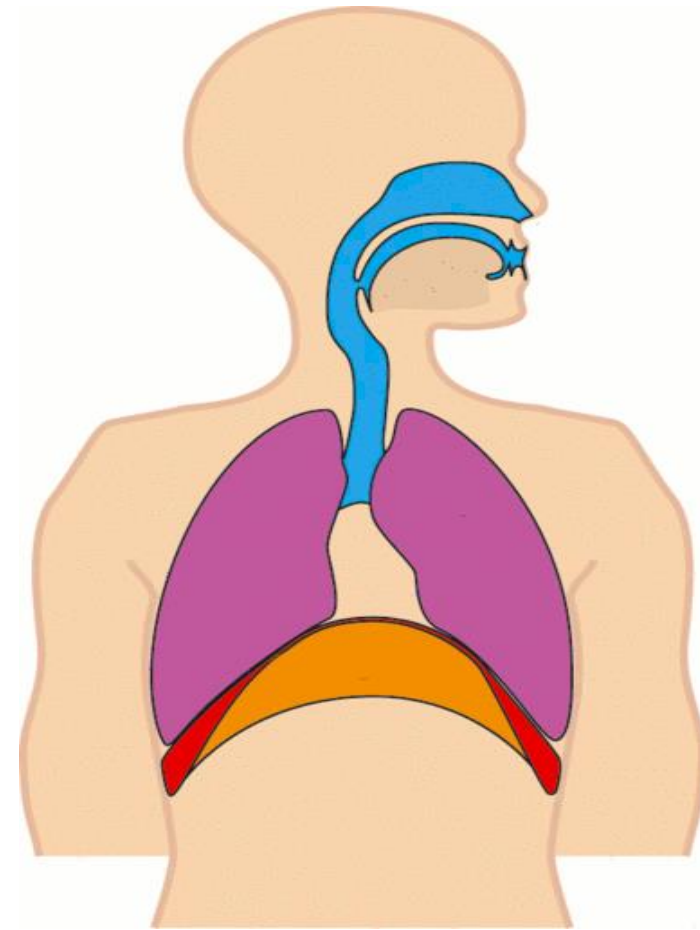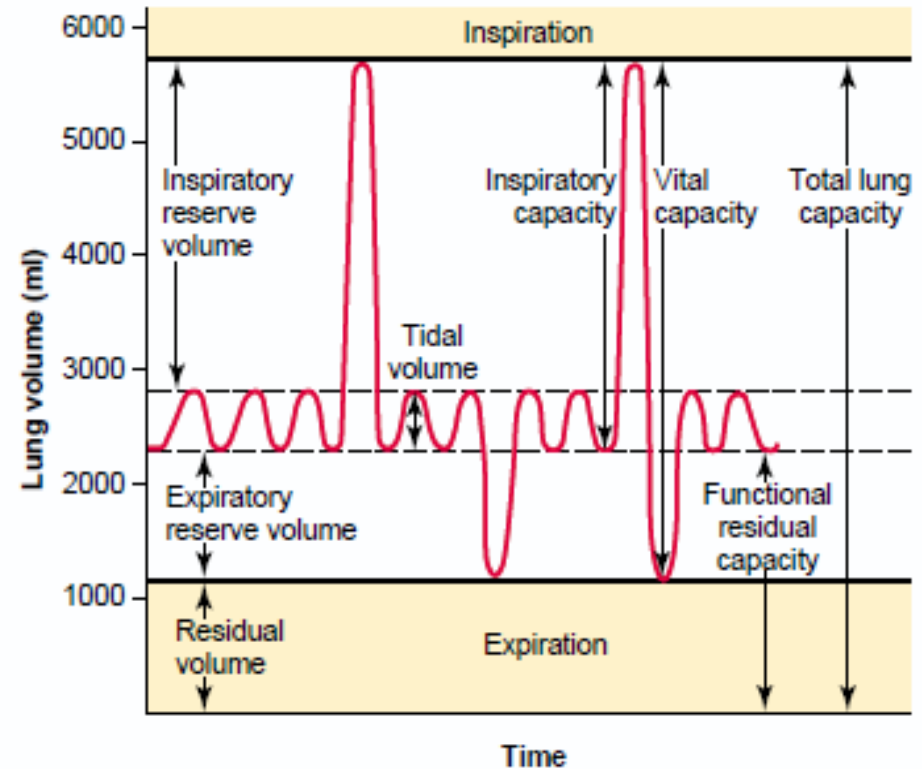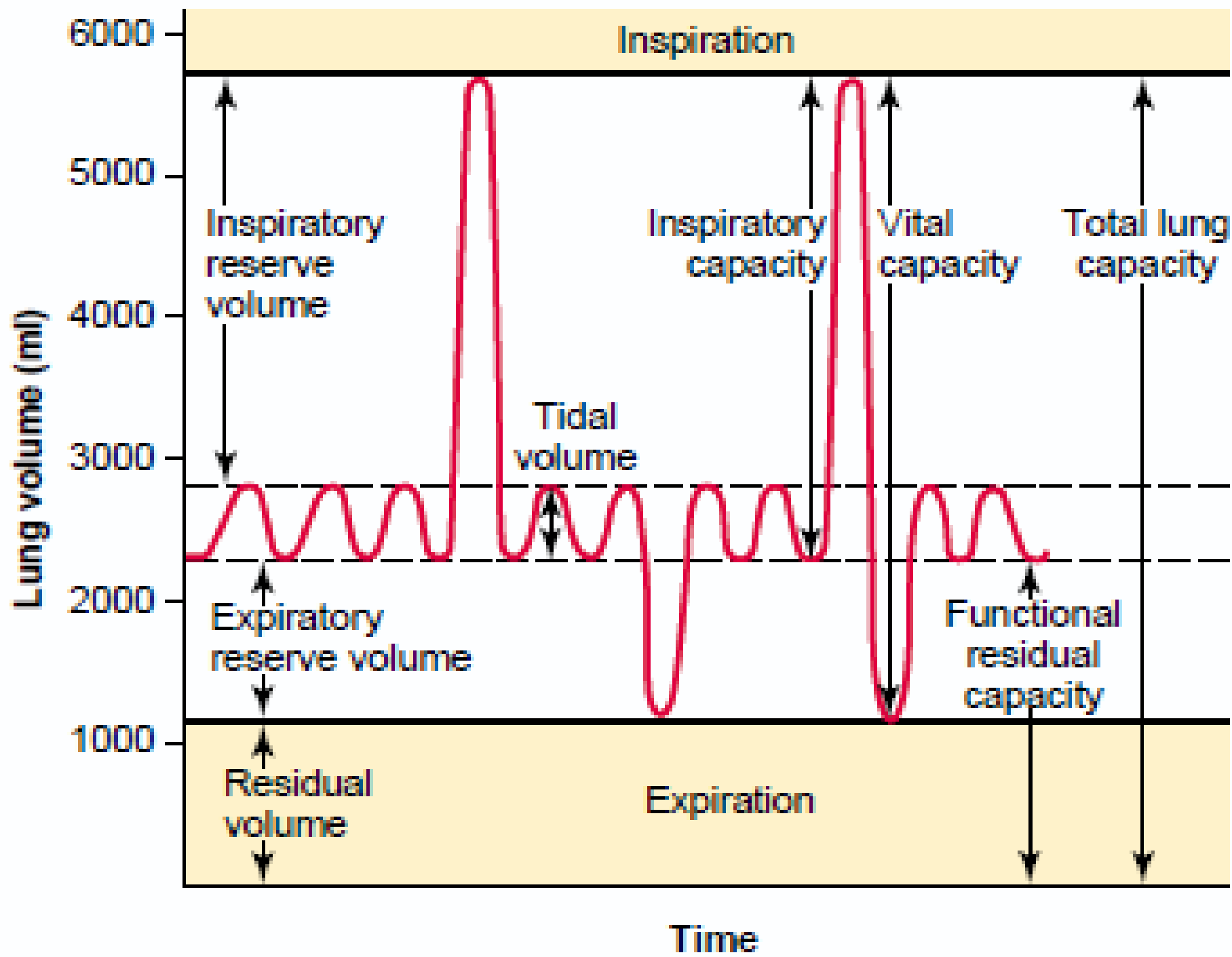
❖ Pulmonary Volumes:

1. The *tidal volume:*

- **Is the volume of air inspired or expired with each normal breath; it's amounts; (500 ml) in the adult male.**

2. The inspiratory reserve volume:

- **Is the extra volume of air that can be inspired over and above the normal tidal volume when the person inspires with full force; it is usually equal to about (3000 milliliters).**

3. The *expiratory reserve volume*:

- Is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration; this normally amounts to about **(1100 milliliters)**.

4. The *residual volume*:

- Is the volume of air remaining in the lungs after the most forceful expiration; this volume averages about **(1200 milliliters)**.
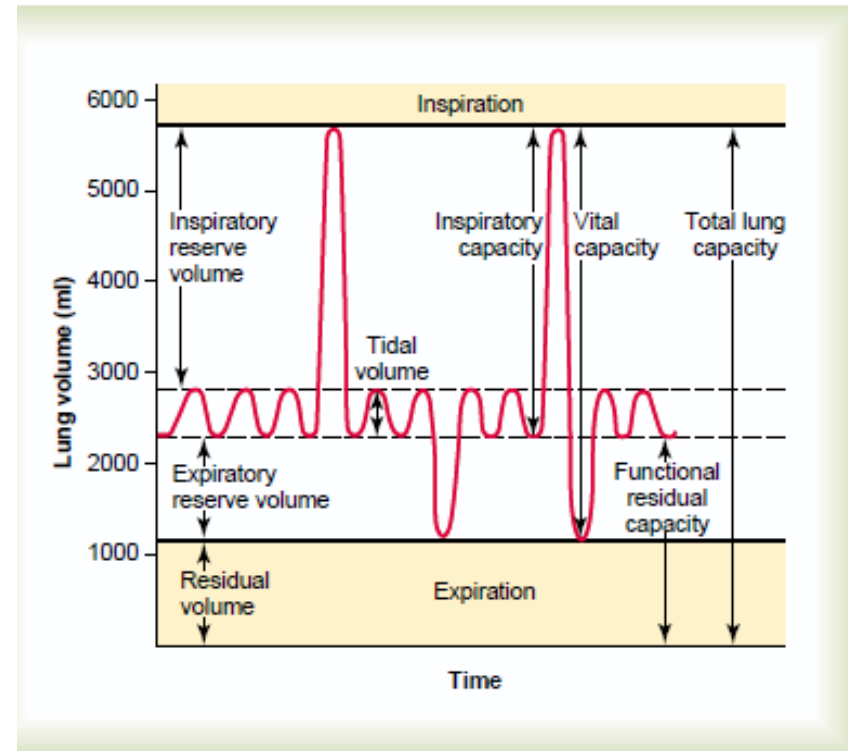
THANK YOU

REPIRATORY SYSTEM

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

❖ Pulmonary Capacities

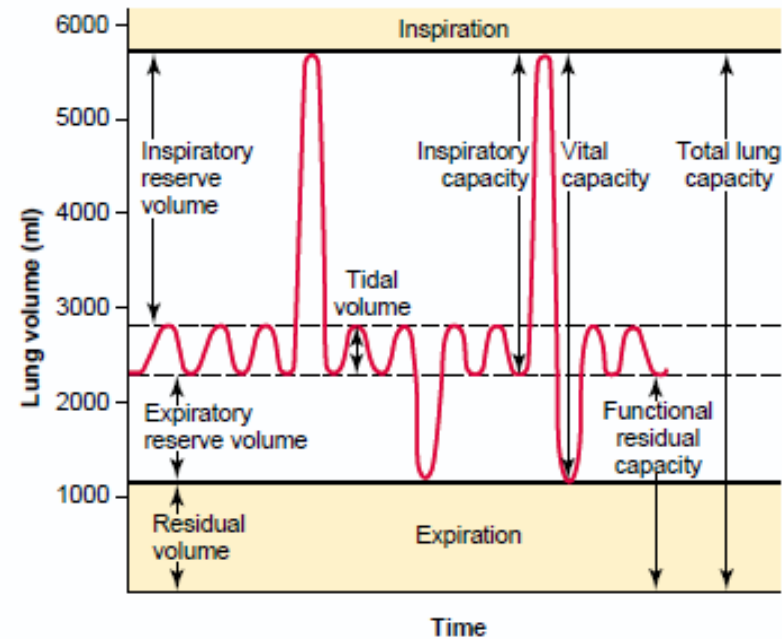**1. The *inspiratory capacity:***

- **equals the *tidal volume* plus the *inspiratory reserve volume.* This amount of air (about 3500 milliliters) a person can breathe in.**

2. The functional residual capacity:

- **equals the *expiratory reserve volume* plus the *residual volume.* This is the amount of air that remains in the lungs at the end of normal expiration (about 2300 milliliters).**

3.The *vital capacity:*

- **Equals to the *inspiratory reserve volume* plus the *tidal volume* plus the *expiratory reserve volume.***

- **This is the maximum amount of air a person can expel from the lungs after first filling the lungs to their maximum extent (4600 milliliters).**
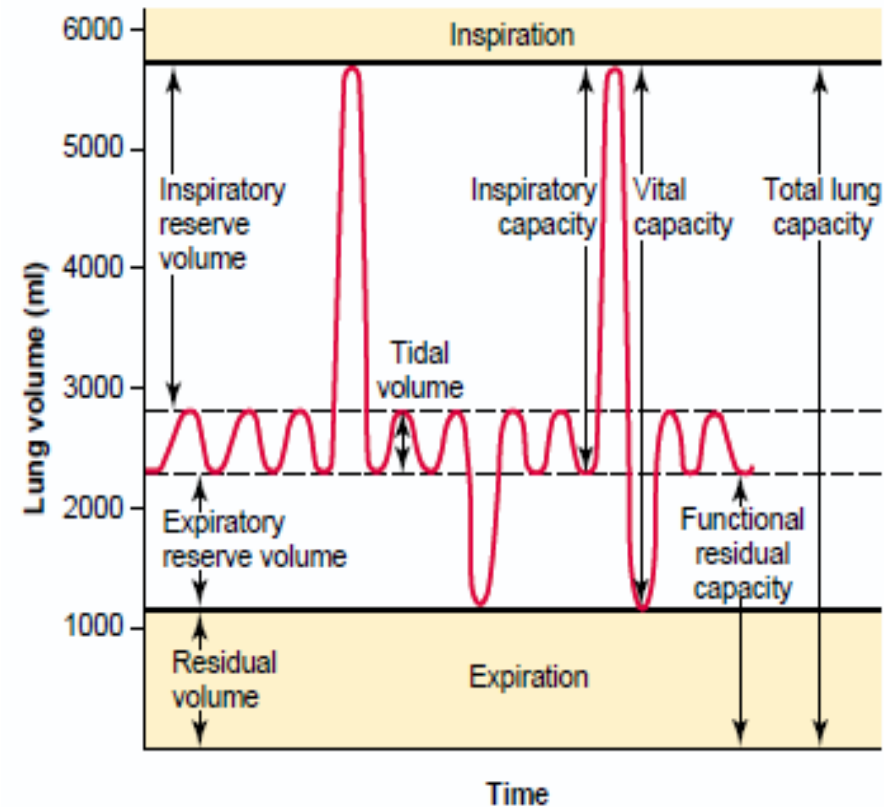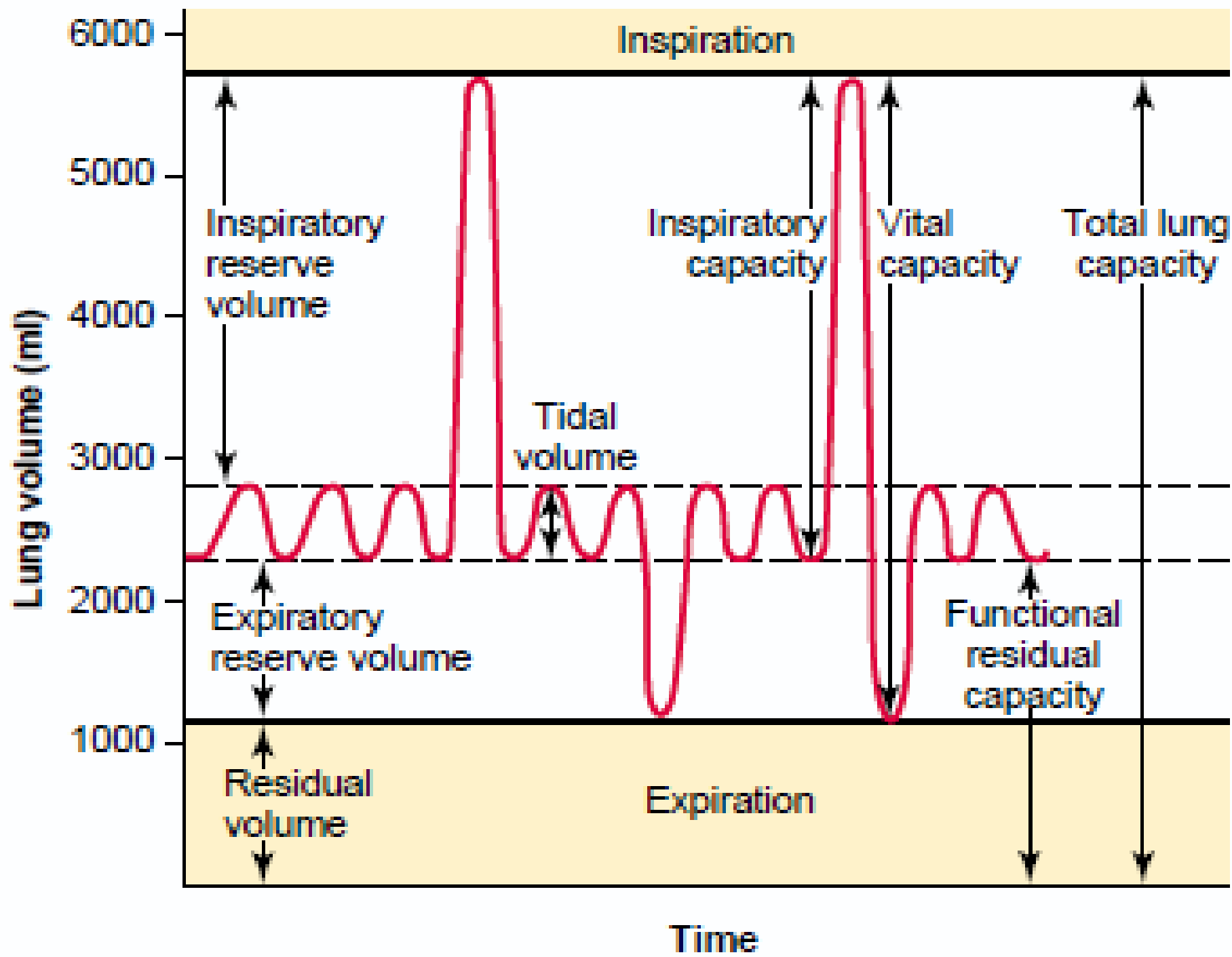
❖Physical Principles of Gas Exchange:

- **After the alveoli are ventilated with fresh air, the next step in the respiratory process is:**

1) **Diffusion of oxygen from the alveoli into the pulmonary blood.**

2) **Diffusion of carbon dioxide in the opposite direction, out of the blood.**

Epithelial
Alveolar basement
epithelium membrane

Fluid and
surfactant
layer

Alveolus

Capillary

Diffusion — Oxygen
Diffusion — Carbon dioxide

Red blood
cell

Interstitial space — Capillary endothelium
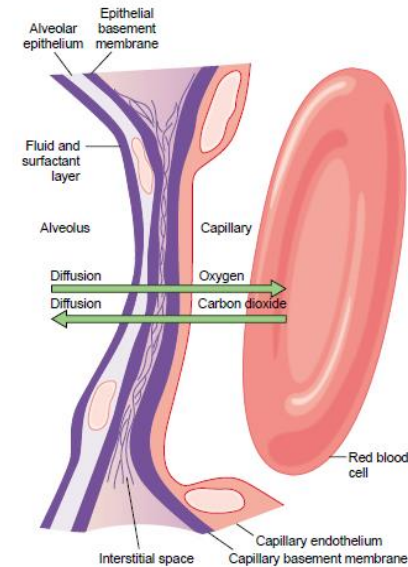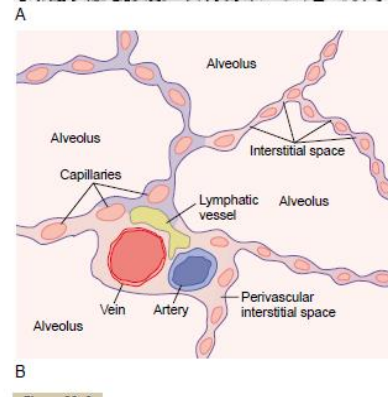Capillary basement membrane

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

5. A capillary basement membrane that in many places fuses with the alveolar epithelial basement membrane

Alveolus

Alveolus

Interstitial space

Capillaries

Lymphatic   Alveolus
vessel

Vein   Artery   Perivascular
interstitial space

Alveolus

❖ **Diffusion of Gases Between the Gas Phase in the Alveoli and the Dissolved Phase in the Pulmonary Blood.**

- **The partial pressure of each gas in the alveolar respiratory gas mixture tends to force molecules of that gas into solution in the blood of the alveolar capillaries.**

- **Conversely, the molecules of the same gas that are already dissolved in the blood are bouncing randomly in the fluid of the blood, and some of these bouncing molecules escape back into the alveoli.**

- **The rate at which they escape is directly proportional to their partial pressure in the blood.**
- **The net diffusion is determined by the difference between the two partial pressures.**
- **If the partial pressure is greater in the gas phase in the alveoli, as is normally true for oxygen, then more molecules will diffuse into the blood than in the other direction.**
- **Alternatively, if the partial pressure of the gas is greater in the dissolved state in the blood, which is normally true for carbon dioxide(CO_2); then net diffusion will occur toward the gas phase in the alveoli.**

Epithelial basement membrane
Alveolar epithelium
Fluid and surfactant layer
Alveolus
Capillary
Diffusion
Diffusion
Oxygen
Carbon dioxide
Red blood cell
Interstitial space
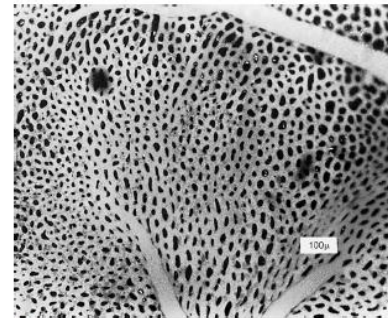Capillary endothelium
Capillary basement membrane

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

5. A capillary basement membrane that in many places fuses with the alveolar epithelial basement membrane

Alveolus
Alveolus
Interstitial space
Capillaries
Lymphatic vessel
Alveolus
Vein   Artery
Perivascular interstitial space
Alveolus

A

B

❖Quantifying the Net Rate of Diffusion in Fluids:

- **Other factors affect the rate of gas diffusion in a fluid:**

(1) Solubility of the gas in the fluid.

(2) Cross - sectional area of the fluid.

(3) Distance through which the gas must diffuse.

(4) Molecular weight of the gas.

(5) Temperature of the fluid.

Epithelial basement membrane
Alveolar epithelium
Fluid and surfactant layer
Alveolus
Capillary
Diffusion — Oxygen
Diffusion — Carbon dioxide
Red blood cell
Capillary endothelium
Interstitial space
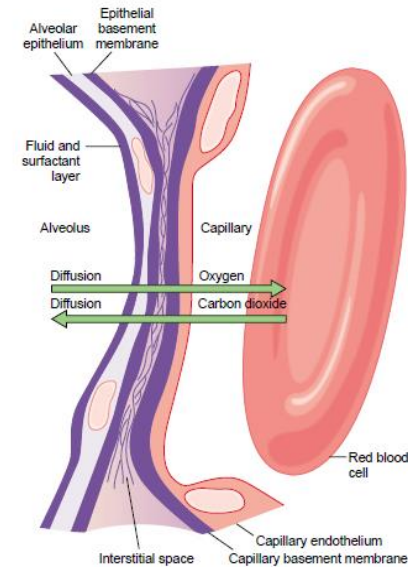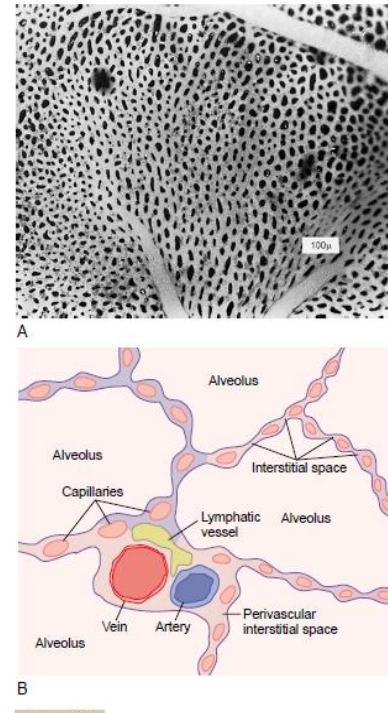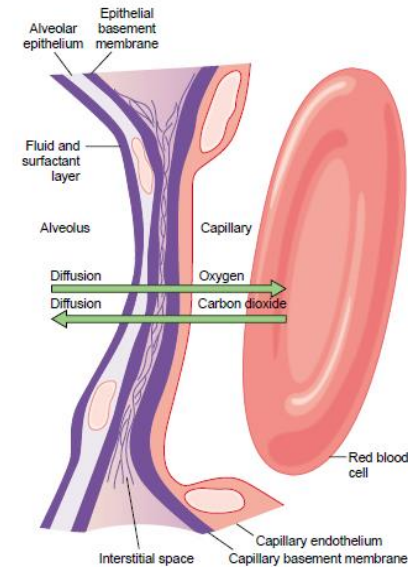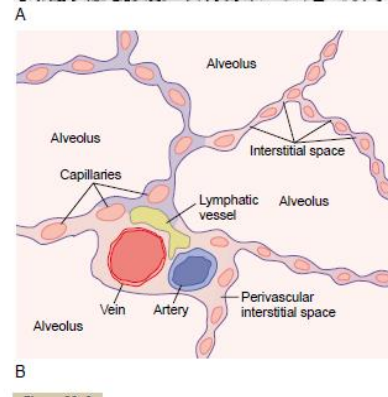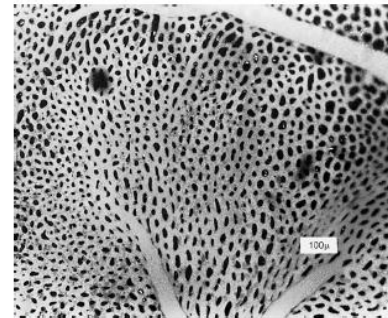Capillary basement membrane

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

5. A capillary basement membrane that in many places fuses with the alveolar epithelial basement membrane

100μ

A

Alveolus
Alveolus
Interstitial space
Capillaries
Lymphatic vessel
Alveolus
Vein
Artery
Perivascular interstitial space
Alveolus

B

❖**Diffusion of gases through the respiratory membrane (respiratory unit).**

- **Respiratory lobule (Respiratory unit): composed of a respiratory bronchiole, alveolar ducts, atria, and alveoli.**

- **There are about 300 million alveoli in the two lungs, and each alveolus has an average diameter of about 0.2 millimeter.**
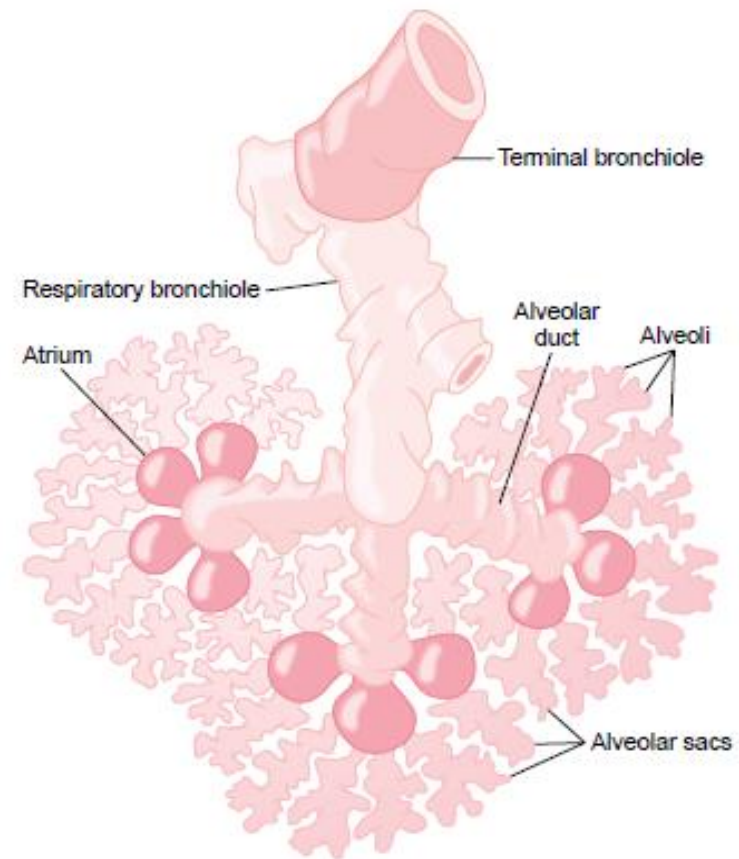

Terminal bronchiole

Respiratory bronchiole

Alveolar duct

Alveoli

Atrium

Alveolar sacs

Figure 39–7

Respiratory unit. (Redrawn from Miller WS: The Lung. Springfield, Ill: Charles C Thomas, 1947.)

- **The alveolar walls are extremely thin, and between the alveoli is an almost solid network of interconnecting capillaries.**

- **Indeed, because of the extensiveness of the capillary plexus, the flow of blood in the alveolar wall has been described as a "sheet" of flowing blood.**

- **Thus, it is obvious that the alveolar gases are in very close proximity to the blood of the pulmonary capillaries.**

Terminal bronchiole

Respiratory bronchiole

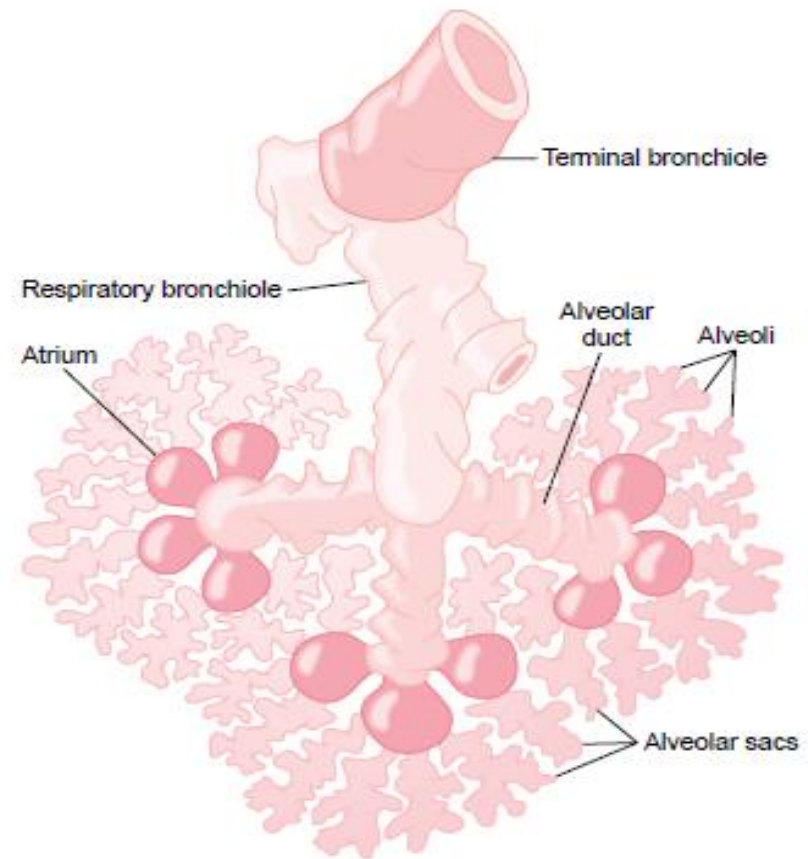Atrium

Alveolar duct

Alveoli

Alveolar sacs

Figure 39–7

Respiratory unit. (Redrawn from Miller WS: The Lung. Springfield, Ill: Charles C Thomas, 1947.)

- **Further, gas exchange between the alveolar air and the pulmonary blood occurs through the membranes of all the terminal portions of the lungs, not merely in the alveoli themselves.**

- **All these membranes are collectively known as the respiratory membrane (pulmonary membrane).**
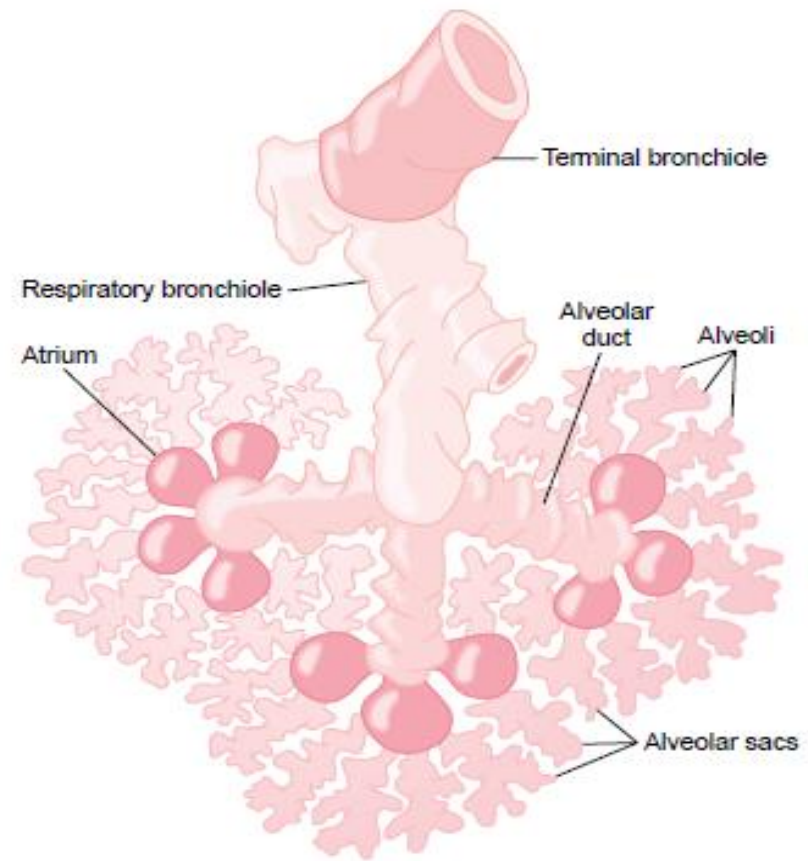

Figure 39–7

Respiratory unit. (Redrawn from Miller WS: The Lung. Springfield, Ill: Charles C Thomas, 1947.)

❖**Layers of the respiratory membrane:**

1. A layer of fluid lining the alveolus and containing surfactant that reduces the surface tension of the alveolar fluid.

2. The alveolar epithelium composed of thin epithelial cells.

3. An epithelial basement membrane.
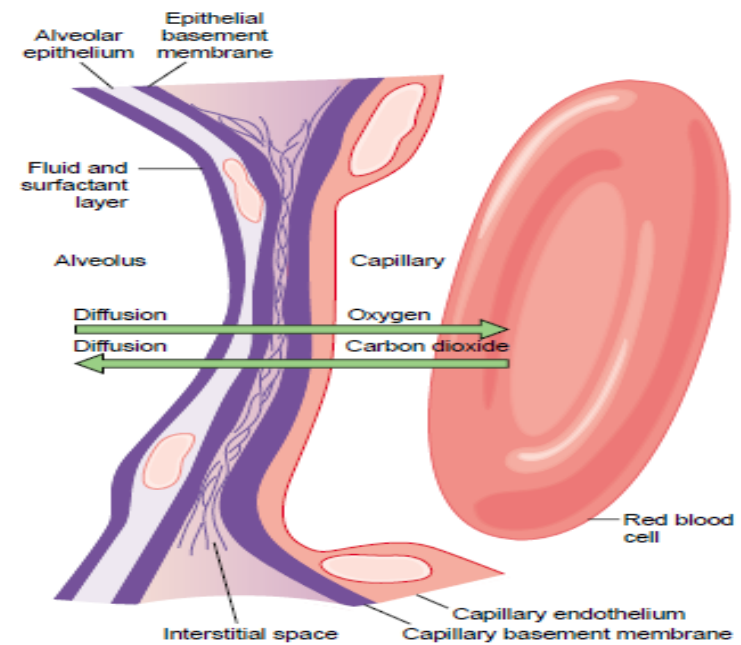
Alveolar epithelium
Epithelial basement membrane
Fluid and surfactant layer
Alveolus
Capillary
Diffusion — Oxygen
Diffusion — Carbon dioxide
Red blood cell
Interstitial space
Capillary endothelium
Capillary basement membrane

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

Alveolus
Alveolus
Interstitial space
Capillaries
Lymphatic vessel
Alveolus
Vein
Artery
Perivascular interstitial space
Alveolus

B
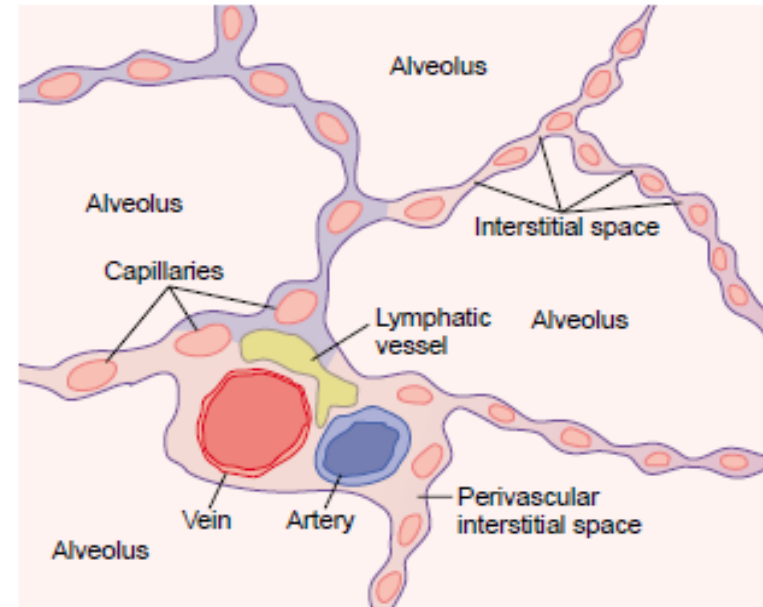
4. A thin interstitial space between the alveolar epithelium and the capillary membrane.

5. A capillary basement membrane that in many places fuses with the alveolar epithelial basement membrane.

6.The capillary endothelial membrane.
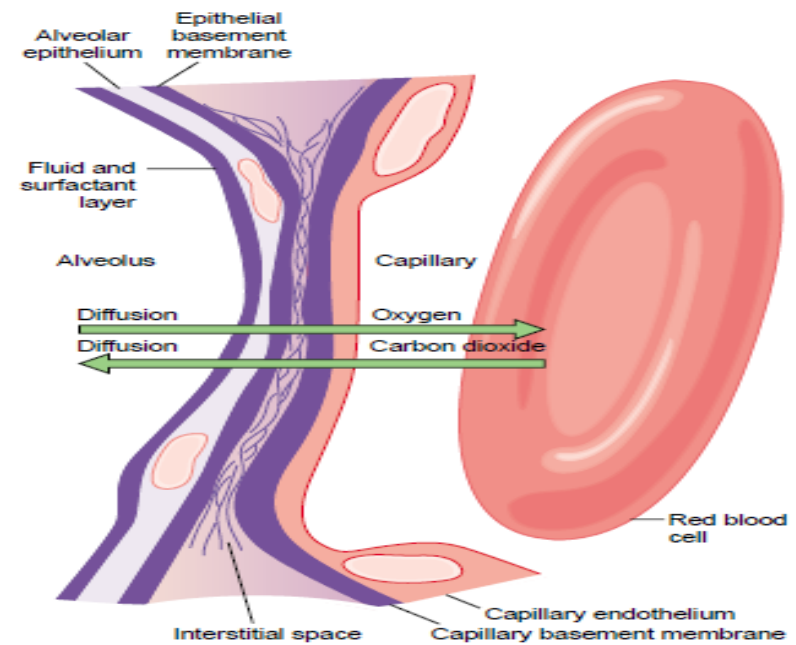
Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

Labels: Alveolar epithelium, Epithelial basement membrane, Fluid and surfactant layer, Alveolus, Diffusion, Diffusion, Oxygen, Carbon dioxide, Capillary, Red blood cell, Capillary endothelium, Capillary basement membrane, Interstitial space

Labels: Alveolus, Alveolus, Alveolus, Alveolus, Interstitial space, Capillaries, Lymphatic vessel, Vein, Artery, Perivascular interstitial space

B
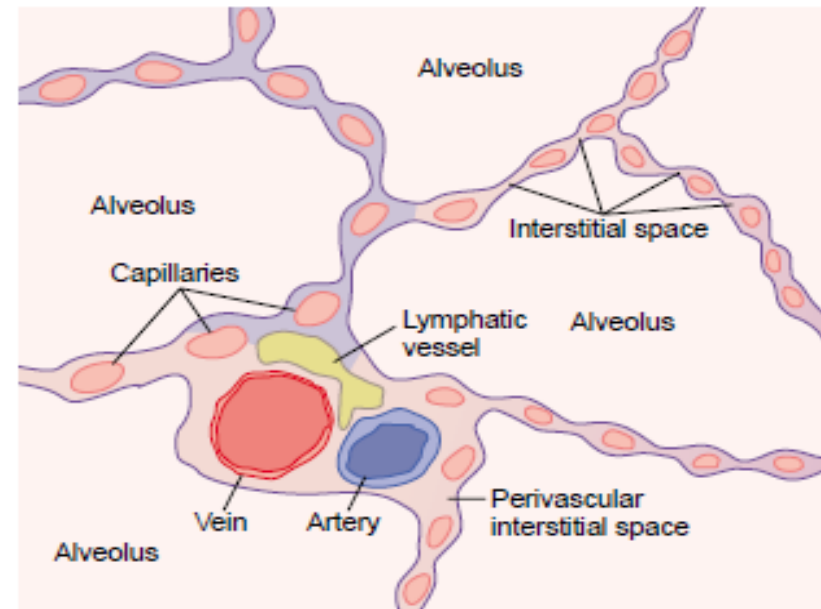
- **Despite the large number of layers, the overall thickness of the respiratory membrane in some areas is as little as** 0.2 **micrometer,** and it averages about 0.6 **micrometer,** except where there are cell nuclei.

- **From histological studies, it has been estimated that the total surface area of the respiratory membrane is about** 70 m² **in the normal adult human male.**

- **This is equivalent to the floor area of a (25 x 30 foot) room.**

Alveolar epithelium
Epithelial basement membrane
Fluid and surfactant layer
Alveolus
Capillary
Diffusion — Oxygen
Diffusion — Carbon dioxide
Red blood cell
Interstitial space
Capillary endothelium
Capillary basement membrane

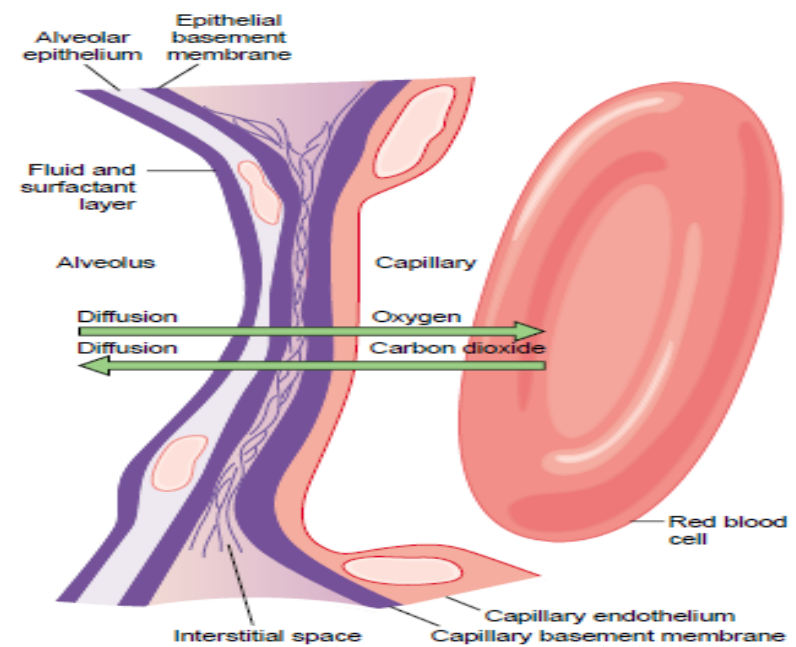**Figure 39–9**

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

Alveolus
Alveolus
Interstitial space
Capillaries
Lymphatic vessel
Alveolus
Vein   Artery
Perivascular interstitial space
Alveolus

B
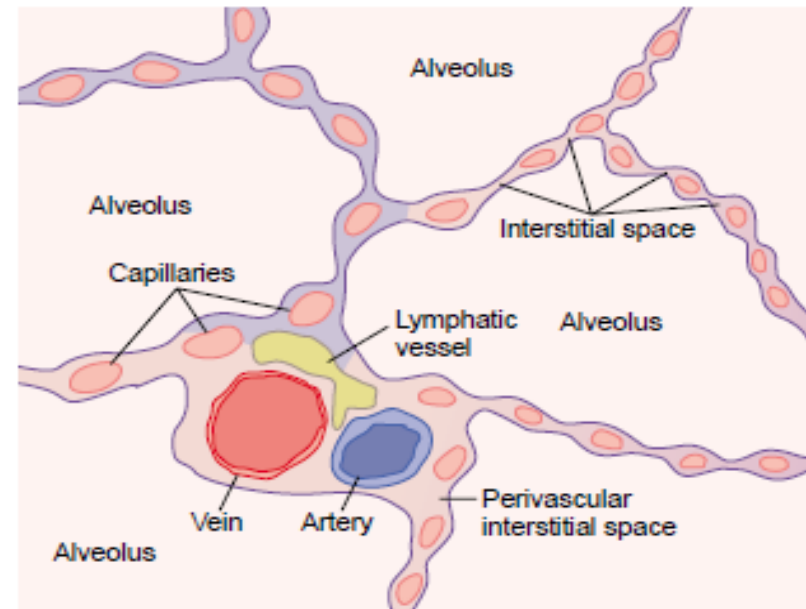
- **The total quantity of blood in the capillaries of the lungs at any given instant is 60 to 140 milliliters.**

- **Now imagine this small amount of blood spread over the entire surface of a (25 x 30 foot floor), and it is easy to understand the rapidity of the respiratory exchange of oxygen and carbon dioxide.**
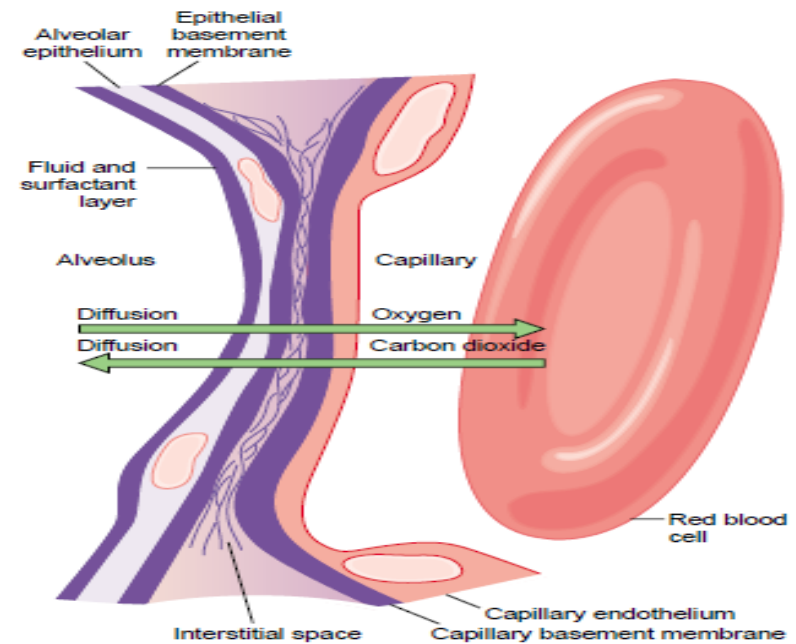

Alveolar epithelium

Epithelial basement membrane

Fluid and surfactant layer

Alveolus

Capillary

Diffusion — Oxygen

Diffusion — Carbon dioxide

Red blood cell

Interstitial space

Capillary endothelium

Capillary basement membrane

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

- **The average diameter of the pulmonary capillaries is only about 5 micrometers, which means that red blood cells must squeeze through them.**

- **The red blood cell membrane usually touches the capillary wall, so that oxygen and carbon dioxide need not pass through significant amounts of plasma as they diffuse between the alveolus and the red cell.**
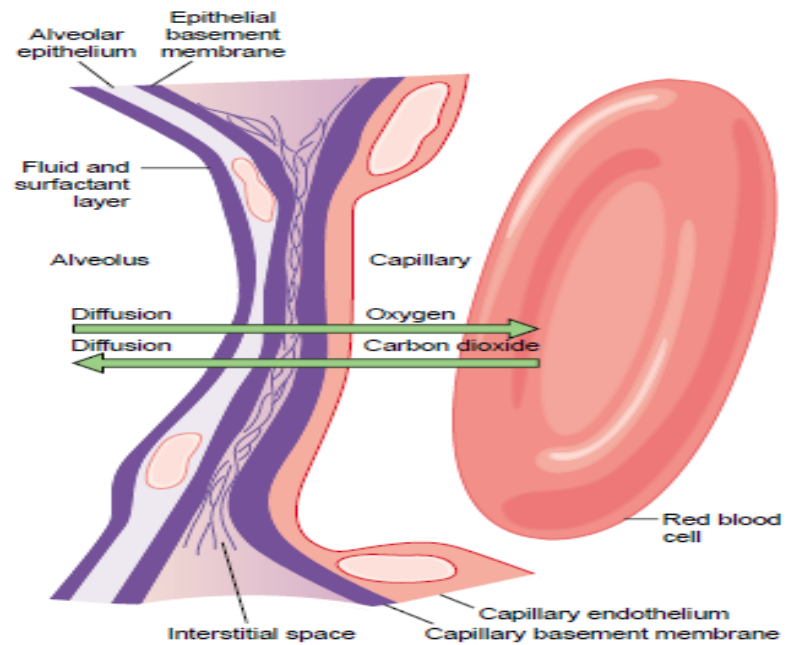
- **This, too, increases the rapidity of diffusion.**

Figure 39—9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

❖ **Factors that affect the rate of gas diffusion through the respiratory membrane:**

• **The factors that determine how rapidly a gas will pass through the membrane are:**

(1) the thickness of the membrane.

(2) the surface area of the membrane.

(3) the diffusion coefficient of the gas in the substance of the membrane.

(4) the partial pressure difference of the gas between the two sides of the membrane.
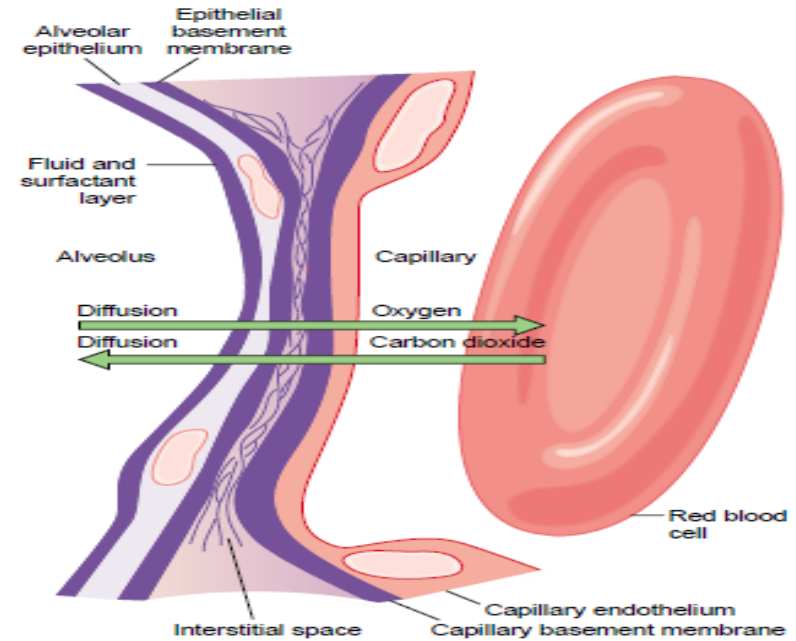

Figure 39-9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

- **The thickness of the respiratory membrane occasionally increases—for instance, as a result of edema fluid in the interstitial space of the membrane and in the alveoli—so that the respiratory gases must then diffuse not only through the membrane but also through this fluid.**
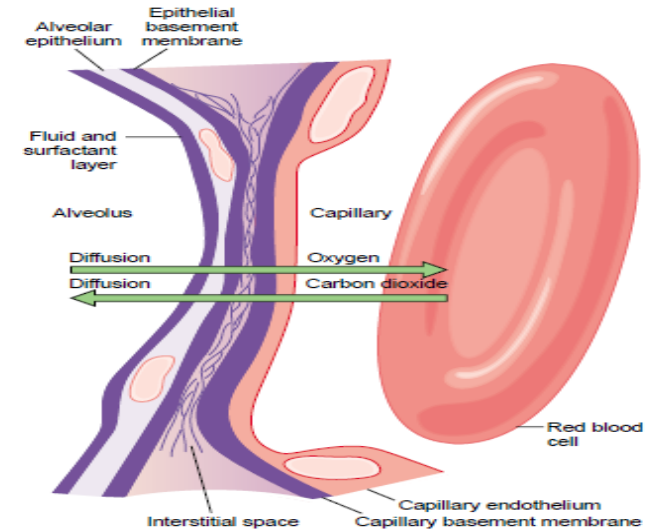

Alveolar epithelium
Epithelial basement membrane
Fluid and surfactant layer
Alveolus
Capillary
Diffusion — Oxygen
Diffusion — Carbon dioxide
Red blood cell
Interstitial space
Capillary endothelium
Capillary basement membrane

Figure 39–9
Ultrastructure of the alveolar respiratory membrane, shown in cross section.

- **Also, some pulmonary diseases cause fibrosis of the lungs, which can increase the thickness of some portions of the respiratory membrane.**

- **Because the rate of diffusion through the membrane is inversely proportional to the thickness of the membrane, any factor that increases the thickness to more than two to three times normal can interfere significantly with normal respiratory exchange of gases.**
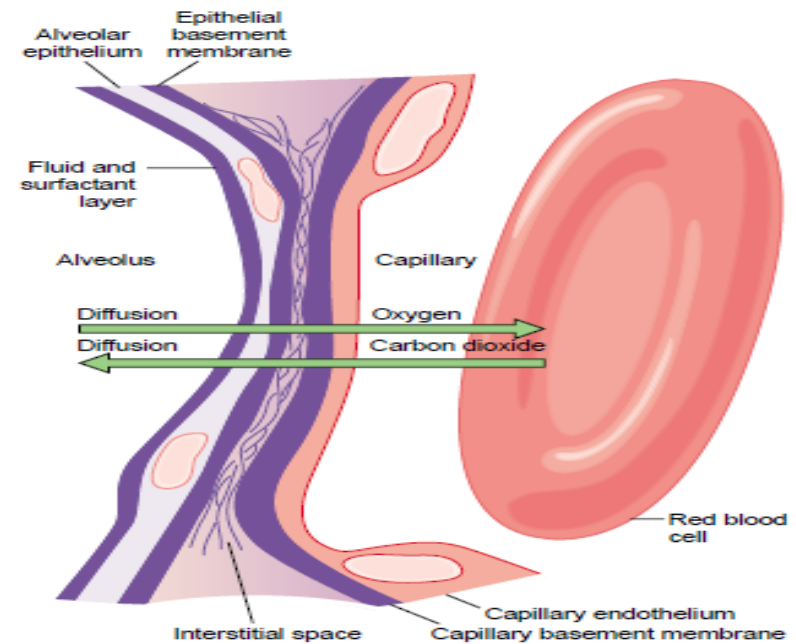

Epithelial basement membrane
Alveolar epithelium

Fluid and surfactant layer

Alveolus   Capillary

Diffusion   Oxygen
Diffusion   Carbon dioxide

Red blood cell

Interstitial space   Capillary endothelium
                            Capillary basement membrane

Figure 39–9
Ultrastructure of the alveolar respiratory membrane, shown in cross section.

- **The surface area of the respiratory membrane can be greatly decreased by many conditions.**
- **For instance, removal of an entire lung decreases the total surface area to one half normal.**
- **Also, in emphysema, many of the alveoli coalesce, with dissolution of many alveolar walls.**
- **Therefore, the new alveolar chambers are much larger than the original alveoli, but the total surface area of the respiratory membrane is often decreased as much as fivefold because of loss of the alveolar walls.**
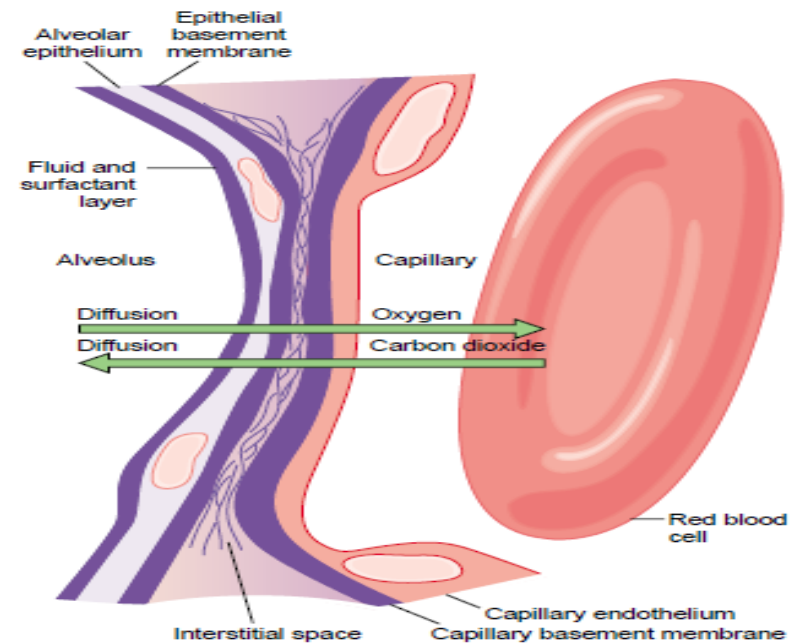

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

- When the total surface area is decreased to about **one third to one fourth** normal, exchange of gases through the membrane is impeded to a significant degree, even under resting conditions, and during competitive sports and other strenuous exercise, even the slightest decrease in surface area of the lungs can be a serious detriment to respiratory exchange of gases.
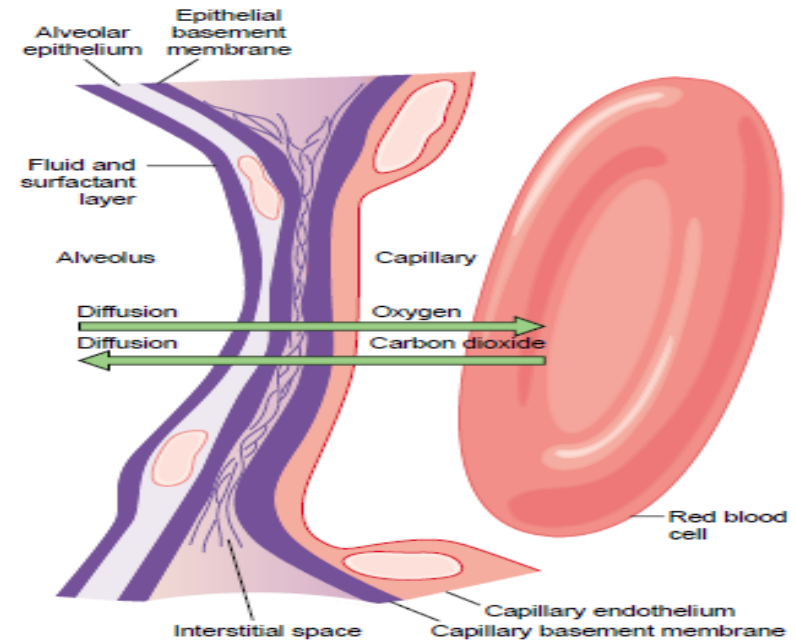

Alveolar epithelium

Epithelial basement membrane

Fluid and surfactant layer

Alveolus

Capillary

Diffusion — Oxygen

Diffusion — Carbon dioxide

Red blood cell

Interstitial space

Capillary endothelium
Capillary basement membrane

Figure 39–9

Ultrastructure of the alveolar respiratory membrane, shown in cross section.

REGULATION OF RESPIRATION

د.محمد عيسى السبعاوي
ماجستير فسلجة طبية

❖Regulation of Respiration

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

- **So that the oxygen pressure (PO$_2$) and carbon dioxide pressure (PCO$_2$) in the arterial blood are hardly altered even during heavy exercise.**
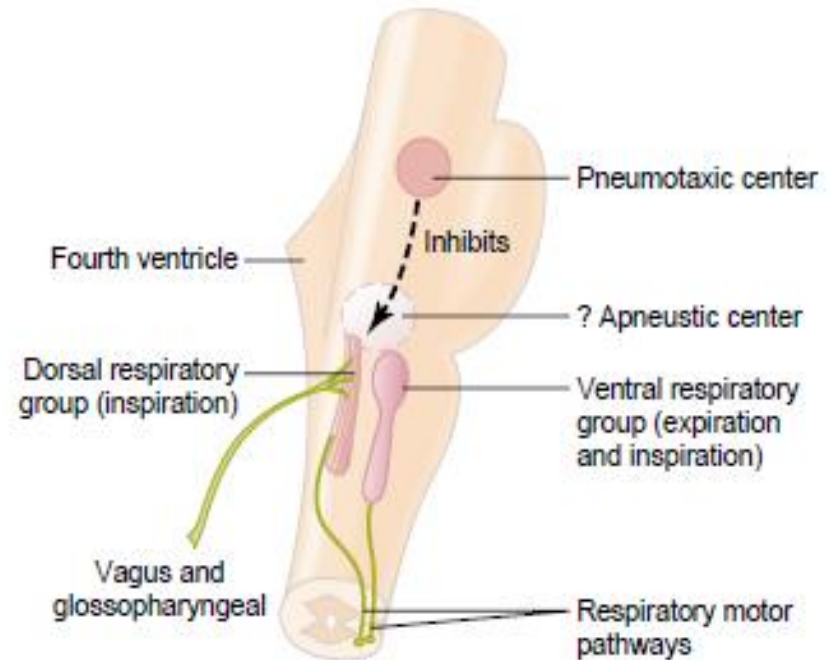

Pneumotaxic center

Fourth ventricle — Inhibits

? Apneustic center

Dorsal respiratory group (inspiration)

Ventral respiratory group (expiration and inspiration)

Vagus and glossopharyngeal

Respiratory motor pathways

Figure 41–1

Organization of the respiratory center.

❖Respiratory Center:

- **The respiratory center is composed of:**

(1) Dorsal respiratory group: located in the dorsal portion of the medulla, which mainly cause inspiration.

(2) Ventral respiratory group: located in the ventrolateral part of the medulla, which mainly causes expiration.

(3) The pneumotaxic center: located dorsally in the superior portion of the pons, which mainly controls rate and depth of breathing.
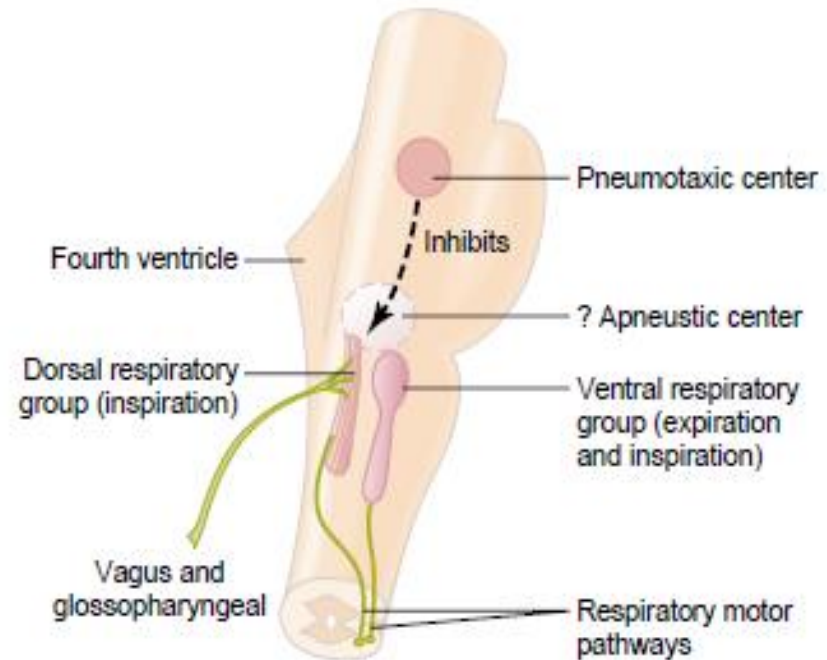

Fourth ventricle

Pneumotaxic center

Inhibits

? Apneustic center

Dorsal respiratory group (inspiration)

Ventral respiratory group (expiration and inspiration)

Vagus and glossopharyngeal

Respiratory motor pathways

Figure 41–1

Organization of the respiratory center.

❑ The Hering-Breuer Inflation Reflex:

- **There is a stretch receptors, located in the muscular portions of the walls of the bronchi and bronchioles throughout the lungs, which transmit signals through the *vegi nerves* into the dorsal respiratory group of neurons when the lungs become over stretched.**

- **When the lungs become overly inflated, the stretch receptors activate an appropriate feedback response that "switches off" the inspiratory ramp and thus stops further inspiration.**
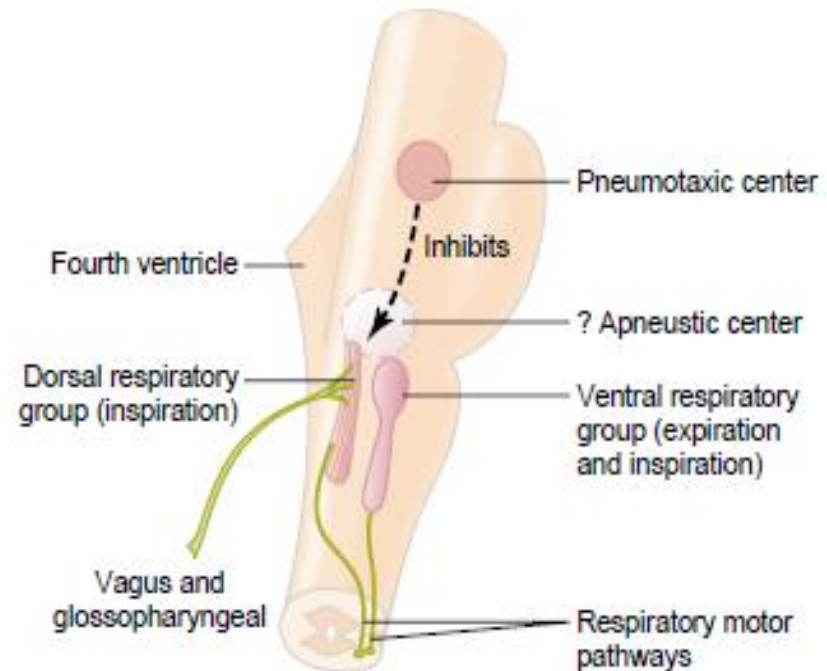

Figure 41-1

Organization of the respiratory center.

- **In human beings, the Hering-Breuer reflex probably is not activated until the tidal volume increases to more than three times normal (greater than about 1.5 liters per breath).**

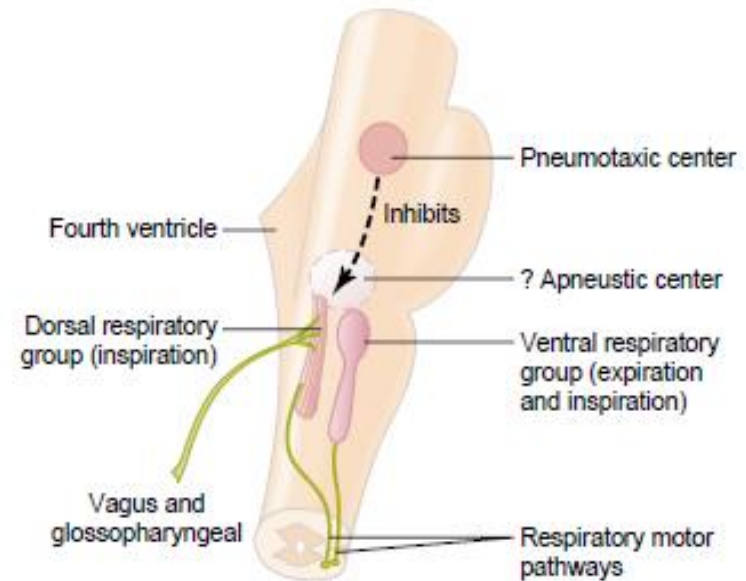- **This reflex; is a protective mechanism for preventing excess lung inflation.**

Figure 41–1

Organization of the respiratory center.

❖ Chemical Control of Respiration:

- **The goal of respiration is to maintain proper concentrations of oxygen, carbon dioxide, and hydrogen ions in the tissues.**

- **The respiratory activity is highly responsive to changes in each of the oxygen, carbon dioxide, and hydrogen ions.**

- **Excess carbon dioxide or excess hydrogen ions in the blood mainly act directly on the respiratory center.**

- **Causing greatly increased strength of both the inspiratory and the expiratory motor signals to the respiratory muscles.**

Peripheral chemoreceptors:

The receptors are present in peripheral portions of the body that's why called as peripheral chemoreceptors.
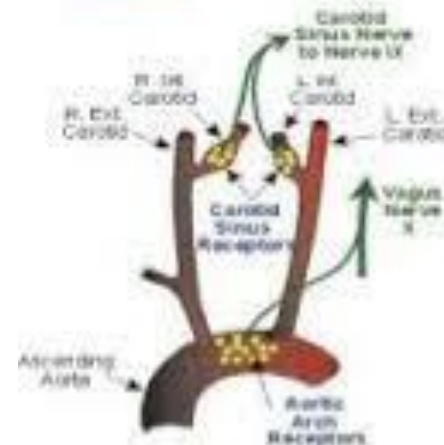
Situation:

Figure 1. Location and innervation of arterial baroreceptors.

Action:

- They are very sensitive to reduction in partial pressure of oxygen.

- Whenever, the partial pressure of oxygen decreases these chemoreceptors become activated and send impulses to inspiratory center and stimulate them.

- Thereby increases rate and force of respiration and rectifies the lack of oxygen.

- **Oxygen, in contrast, does not have a significant *direct* effect on the respiratory center of the brain in controlling respiration.**

- **Instead, it acts almost entirely on peripheral *chemoreceptors* located in the *carotid* and *aortic bodies,* and these in turn transmit appropriate nervous signals to the respiratory center for control of respiration.**
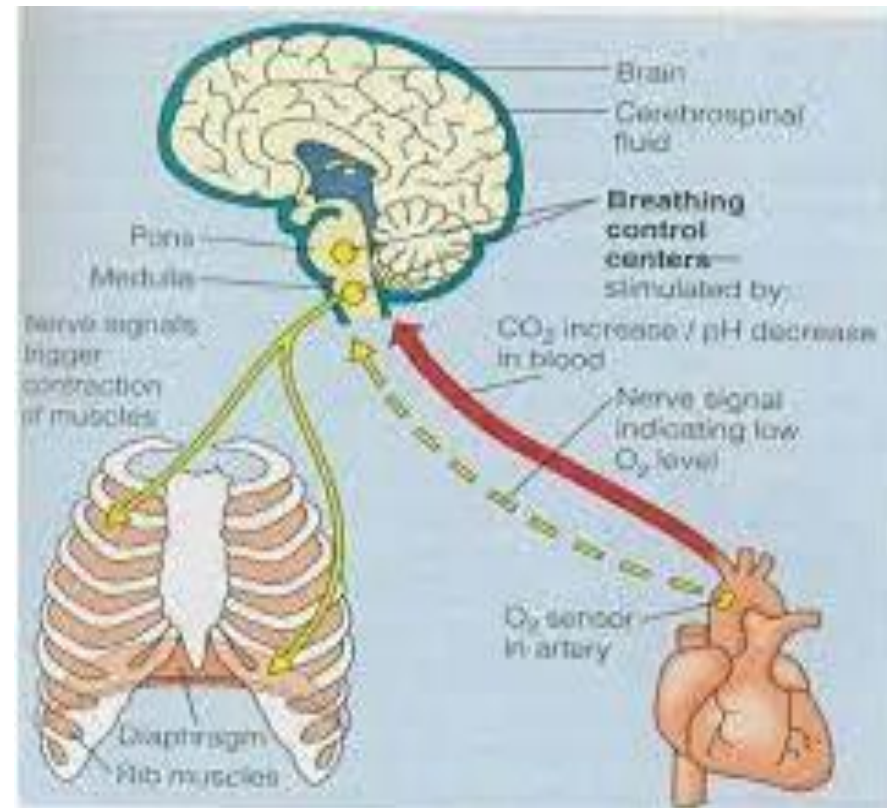
- **Peripheral Chemoreceptor System for Control of Respiratory Activity—Role of Oxygen in Respiratory Control:**

- **In addition to control of respiratory activity by the respiratory center itself, still another mechanism is available for controlling respiration.**

- **This is the peripheral chemoreceptor system, Special nervous chemical receptors, called chemoreceptors, are located in several areas outside the brain.**
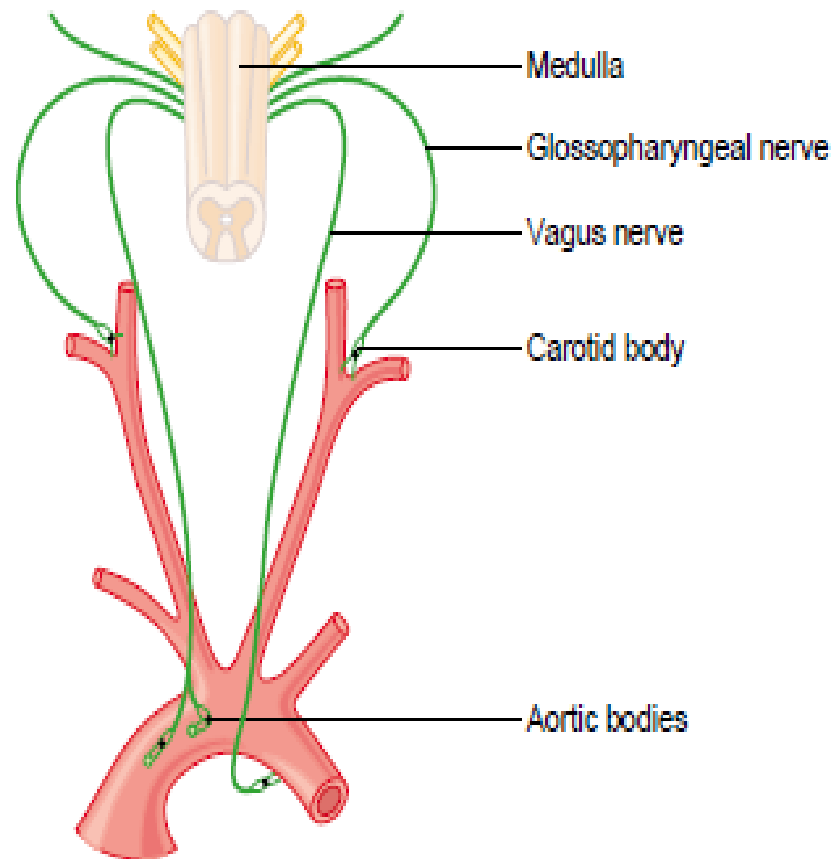

Figure 41–4

Respiratory control by peripheral chemoreceptors in the carotid and aortic bodies.

Labels: Medulla, Glossopharyngeal nerve, Vagus nerve, Carotid body, Aortic bodies

- **They are especially important for detecting changes in oxygen in the blood, although they also respond to <u>a lesser extent</u> to changes in carbon dioxide and hydrogen ion concentrations.**

- **The chemoreceptors transmit nervous signals to the respiratory center in the brain to help regulate respiratory activity.**

Medulla

Glossopharyngeal nerve
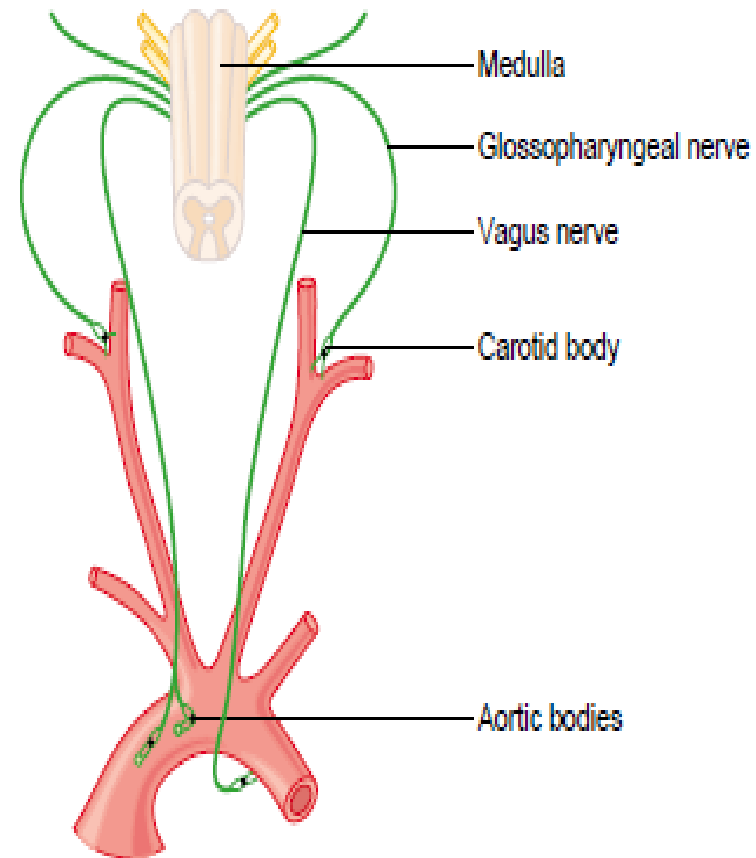
Vagus nerve

Carotid body

Aortic bodies

Figure 41-4

Respiratory control by peripheral chemoreceptors in the carotid and aortic bodies.

- Most of the chemoreceptors are in the carotid bodies.
- However, a few are also in the aortic bodies.
- The carotid bodies are located bilaterally in the bifurcations of the common carotid arteries.
- Their afferent nerve fibers pass through Hering's nerves to the glossopharyngeal nerves and then to the dorsal respiratory area of the medulla.
- The aortic bodies are located along the arch of the aorta; their afferent nerve fibers pass through the vagi, also to the dorsal medullary respiratory area.
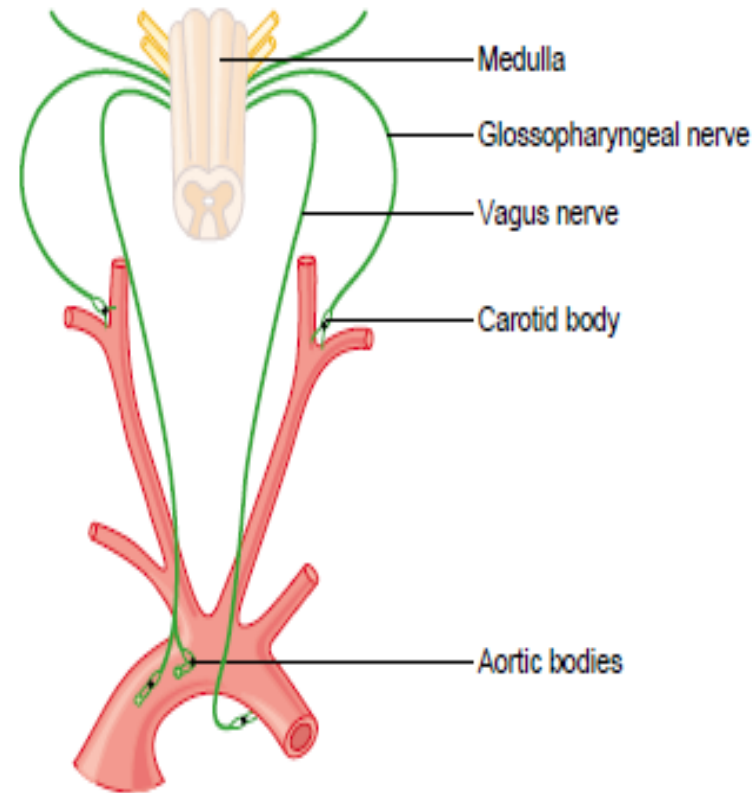

Figure 41–4

Respiratory control by peripheral chemoreceptors in the carotid and aortic bodies.

- **Each of the chemoreceptor bodies receives its own special blood supply through a minute artery directly from the adjacent arterial trunk.**

- **Further, blood flow through these bodies is extreme, 20 times the weight of the bodies themselves each minute.**

- **Therefore, the percentage of oxygen removed from the flowing blood is virtually zero.**

- **This means that the chemoreceptors are exposed at all times to arterial blood, not venous blood, and their PO_2 are arterial PO_2.**
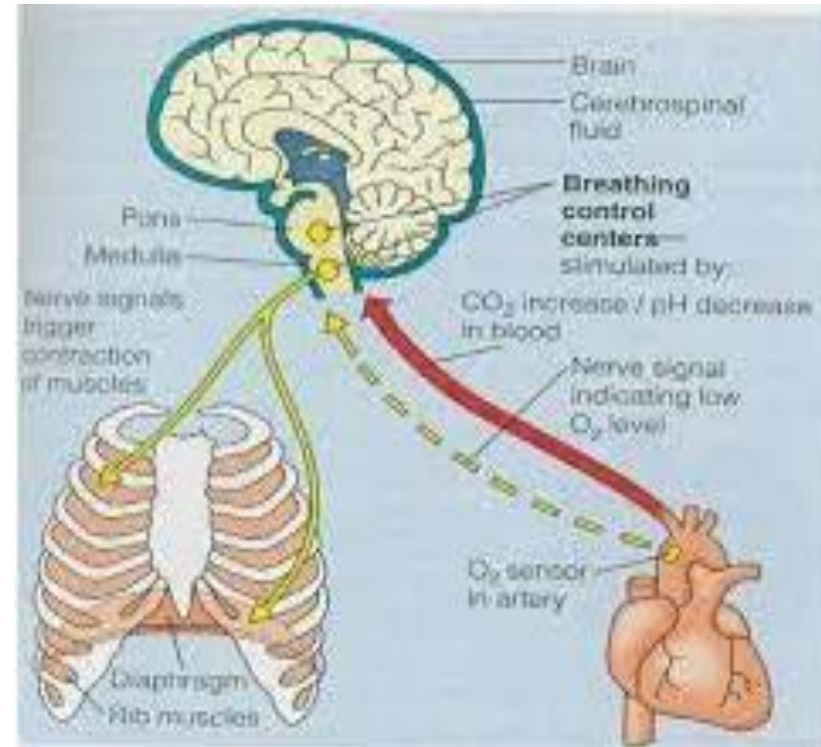
❖ **Stimulation of the Chemoreceptors by Decreased Arterial Oxygen.**

- **When the oxygen concentration in the arterial blood falls below normal, the chemoreceptors become strongly stimulated.**

- **The impulse rate is particularly sensitive to changes in arterial PO$_2$ in the range of 60 down to 30 mm Hg, a range in which hemoglobin saturation with oxygen decreases rapidly.**
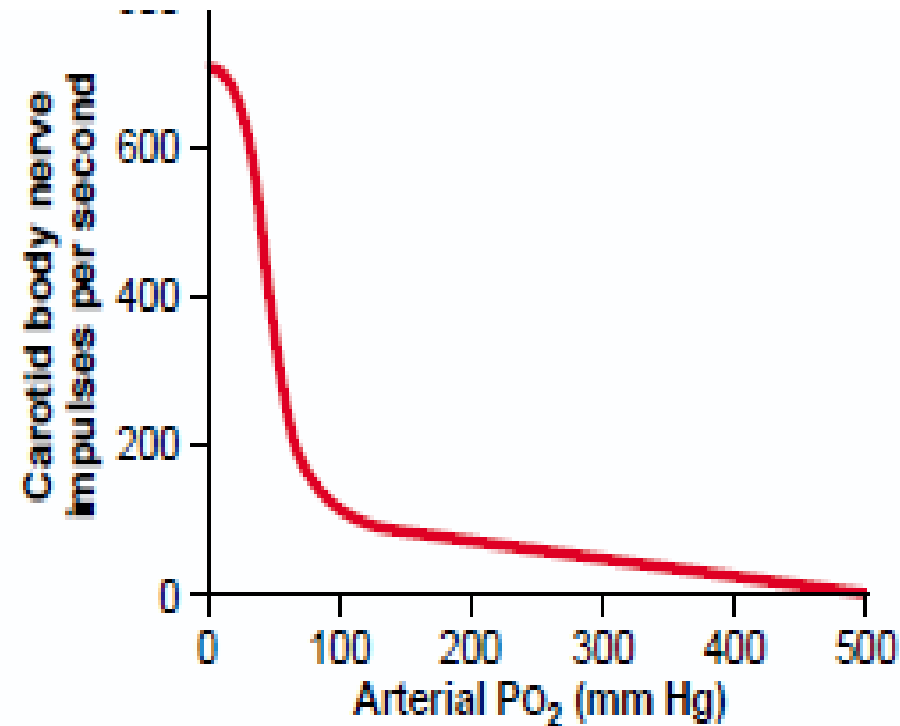

Figure 41–5

Effect of arterial PO$_2$ on impulse rate from the carotid body of a cat.

❖ Effect of Carbon Dioxide and Hydrogen Ion Concentration on Chemoreceptor Activity.

- An increase in either carbon dioxide concentration or hydrogen ion concentration also excites the chemoreceptors; indirectly increases respiratory activity.

- However, the direct effects of both these factors in the respiratory center itself are so much more powerful than their effects mediated through the chemoreceptors (about seven times as powerful) that, for practical purposes, the indirect effects of carbon dioxide and hydrogen ions through the chemoreceptors do not need to be considered.

THANK YOU