Ministry of Higher Education and Scientific Research

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Human Physiology

First stage students

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2020 - 2021

Physiology:

Is the study of the normal functioning of a living organism and its component parts, including all its chemical and physical processes. The term physiology literally means "knowledge of nature." At the level of the organism, physiology is closely tied to anatomy.

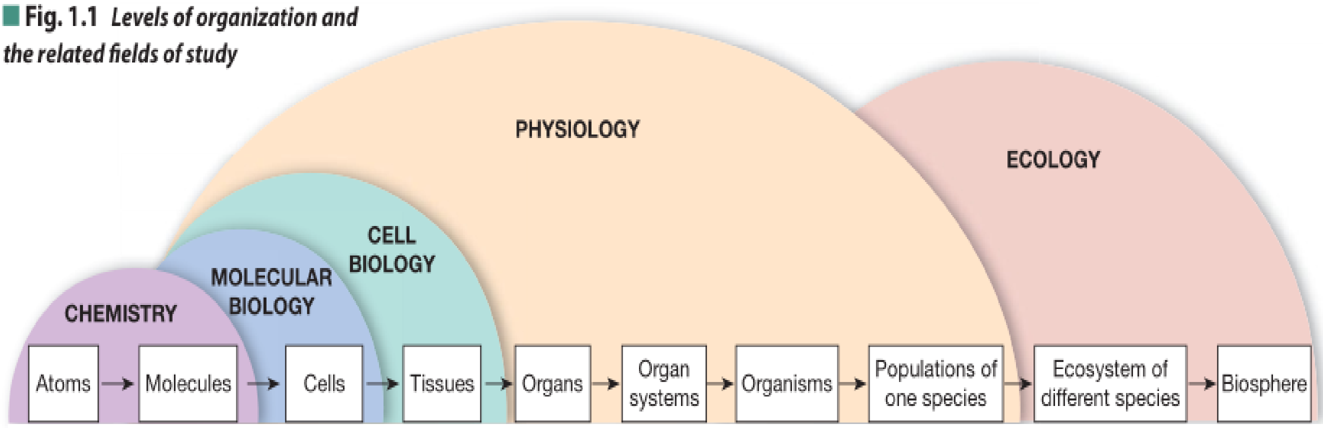


Fig. 1.1 *Levels of organization and the related fields of study*

Homeostasis - maintaining relative constancy in response to internal and external changes, it Dynamic process; changing but relatively constant within limits, Concerns all factors relating to well-being of organism.

Homeostasis refers especially to maintenance of proper conditions for:

a. Oxygen (O_2) and Carbon dioxide (CO_2) levels (brain and respiratory - adjust breathing rate)

b. Levels of nutrients in blood (e.g. glucose (insulin/glucagon) - blood glucose levels

c. Electrolyte /salt balance and osmotic pressure (fluid levels).

d. Acid-base balance (pH).

e. Temperature.

f. Pressure of body cavities (especially lungs).

General characteristics of homeostatic control mechanisms

Nervous and endocrine systems are general controls

Basic Organization of Control Mechanisms

a) **Receptor** - monitors internal/external stimuli sends information to control center via afferent path

b) **Control center** - analyzes info. as it compares to a "set point" for that particular variable

c) **Variables** may include: glucose level, heart rate, blood pressure, urea concentration, oxygen level, tension on a muscle.

d) **Effector** - physiological mechanism acting from the control center via efferent path.

At the simplest level of organization; atoms of elements link together to form molecules. Collections of molecules in living organisms form **cells**, the smallest unit of structure capable of carrying out all life processes. A lipid and protein barrier called the **cell membrane** (also called the plasma membrane) separates cells from their external environment. Simple organisms are composed of only one cell, but complex organisms have many cells with different structural and functional specializations. Collections of cells that carry out related functions are called **tissues**. Tissues form structural and functional units known as **organs**, and groups of organs integrate their functions to create organ systems.

Circulatory system

Blood Physiology

Cardiovascular system has three components: **pumping organ** (heart), **containers** (blood vessels) and **transport medium** (blood).

Blood components:

Blood is composed of: Plasma and cellular components.

1. ***Plasma:*** forms about 55% of total volume of blood. It is composed of:

   A. <u>Water:</u> about 97% of plasma is water, which form the intravascular component of the extracellular fluid.

   B. <u>Plasma proteins:</u> dissolved proteins that serve for different functions as follows:

   ****Albumins:*** the most numerous plasma proteins that serve mainly for transport of hormones, drugs, and biologically active substances.

   ****Globulins:*** that serves for immune functions.

****Fibrinogens:*** that serves for blood clotting and homeostasis.

****Prothrombin:*** also serves for blood clotting and hemostasis.

All plasma proteins are produced in liver except one type of globulin (gama globulin), which is produced in the plasma cells of lymphatic tissue. Plasma proteins also have buffering function and regulatory effect on blood volume (oncotic pressure).

C. **Organic materials**: such as glucose, amino acids, and fat.

D. **Nonorganic materials** such as ions.

E. **Others**: hormones, blood gases and others.

Functions of Plasma:

1- Transport of hormones, vitamins, minerals, and drugs. Examples: albumin is a universal transporter, while other plasma proteins are specific for transport of some substances like transferrin (transport of iron), transcobalamine (transport of Vitamin B_{12}), Apolipoprotein B (transport of lipoproteins).

2- Control of capillary permeability.

3- Contribution to acid-base- balance: Plasma proteins contribute to about 15% of the buffer activity of blood.

4- Contribution to regulation of arterial blood pressure, as follows:

* Plasma proteins contribute to blood viscosity.

* Plasma proteins exert oncotic pressure, which tends to pull water into the blood (at capillary level), which maintains the blood volume.

5- Blood coagulation: Most of clotting factors are plasma proteins.

6- Immune functions.

7- Contribution to gas transport : Plasma proteins participate in CO_2 transport in blood.

2. ***Cellular components:*** Blood cells are subdivided into:

<u>A: Red blood cells</u> (erythrocytes): The most numerous (form 98% of the blood cells), that have the vital function of gas transport (O_2 and CO_2) as well as participating in acid base balance. Erythrocytes have a life span of 120 days after they get destructed by hemolysis in the spleen. They are oval biconcave disk in shape, lack nucleus and many organelles. and full of hemoglobin (Hb forms 34% of the erythrocyte`s weight). Hemoglobin is a pigment (that is, it is naturally colored). Because of its iron content, it appears reddish when combined with O_2 and bluish when deoxygenated.

Red blood cells have no mitochondria; they obtain energy via anaerobic glycolysis. The biconcave disk shape of erythrocytes produces large surface area, as it allows erythrocytes to be squeezed in small capillaries without rupture, due to enhanced cell flexibility.

In addition to their vital function (transport of blood gases), erythrocytes contributes to acid-base balance via the hemoglobin.

<u>2.White blood cells</u> (leukocytes): The blood cells that protect the organism from the foreign invaders such as microorganism. They form 1-2% of blood cells volume. Depending on the presence of staining granules under the microscope, they are subdivided into:

a. Granular leukocytes: such as ***neutrophils*** (62% of leukocytes, fight bacteria and fungi), ***basophils*** (0.4% of leukocytes, produce and release histamine and heparin), and ***eosinophils*** (1-5 % of leukocytes, fight parasites and modulate allergic response).

Neutrophils reach the site of infection, as follows:

1. **Margination**: sticking of neutrophils to capillary wall.

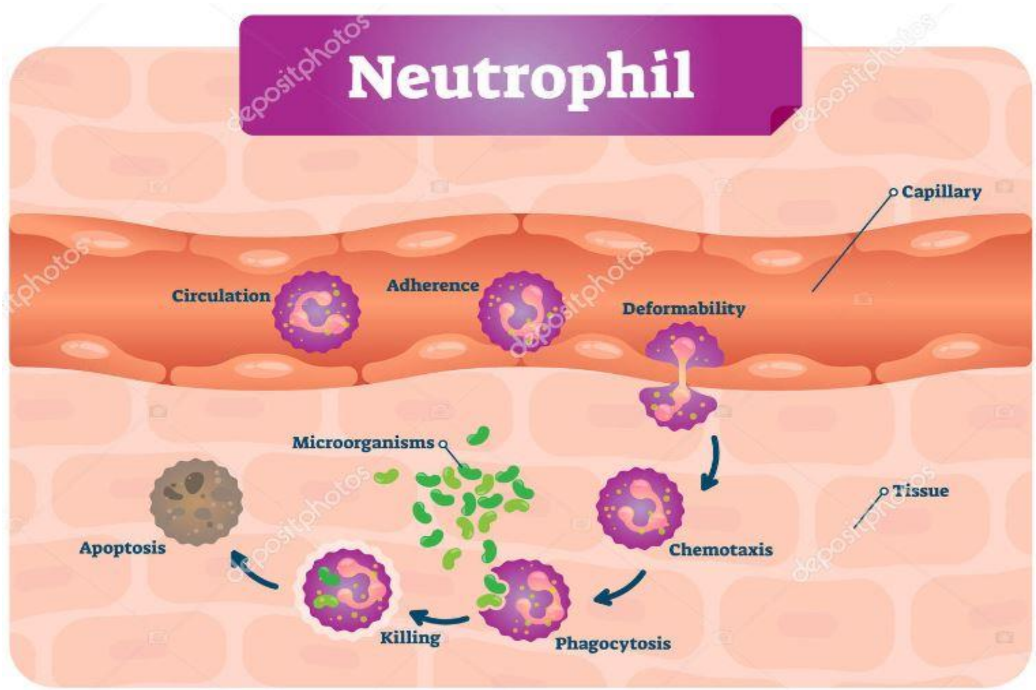
2. **Diapedesis:** neutrophils squeeze themselves through the capillaries to the tissue space.

3. **Amoeboid movement**.

4. **Chemotaxis:** Attraction of neutrophils by chemical substances, such as bacterial toxins, leukotriene, components of the immune compliment and breakdown products of the inflamed tissue.

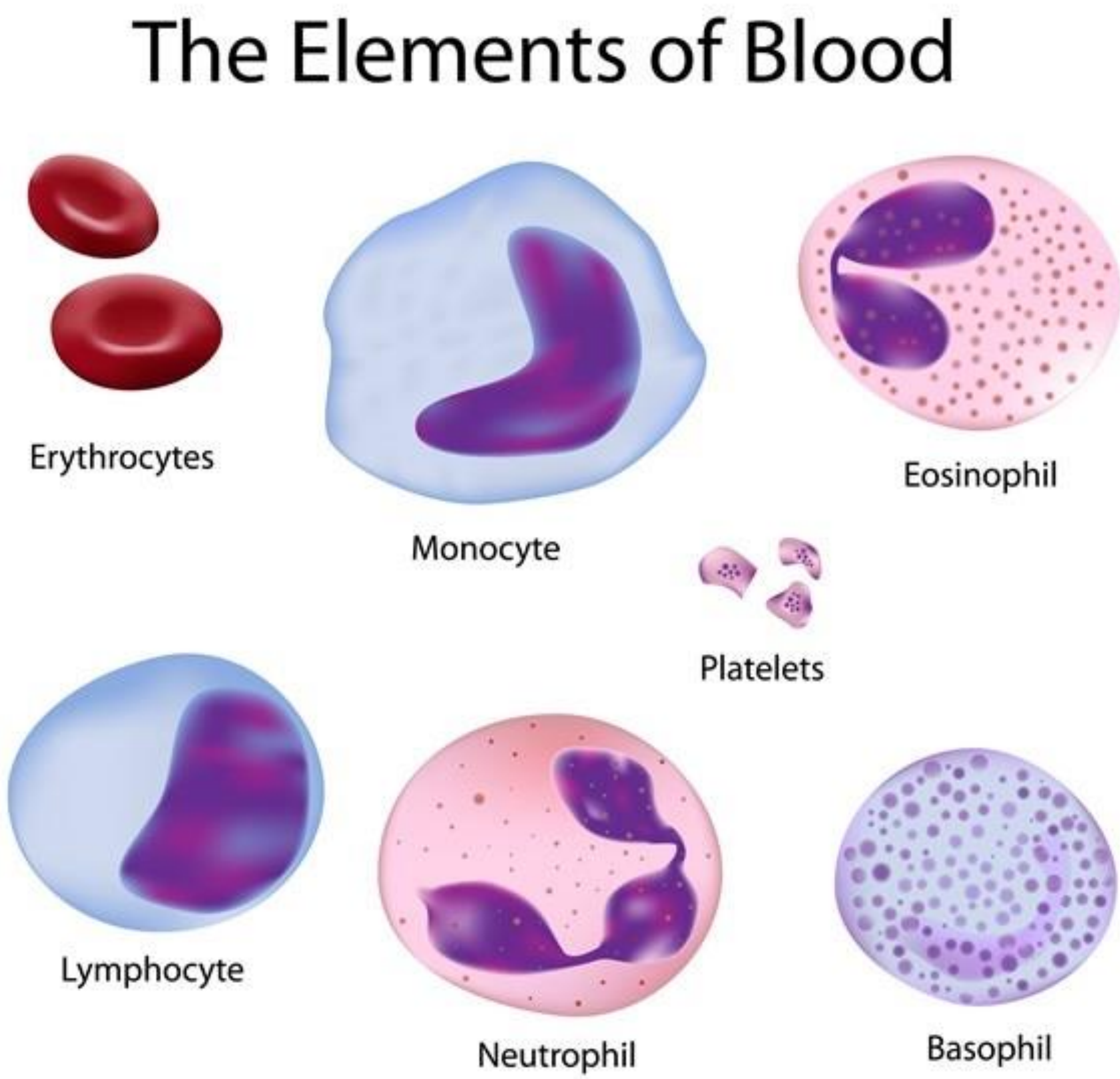
5. **Phagocytosis:** Ingestion of bacteria by the neutrophil. It occurs as follows:

After being phagocytized, the bacteria can be killed either by lysosomal proteolytic enzymes of the neutrophils, or by bactericidal agents formed inside the neutrophils like free radicals and hypochlorite. After phagocyting bacteria the neutrophil will be inactivated and die.



b. **Agranular leukocytes :** such as lymphocytes (30% of white blood cells, subdivided into T and B lymphocytes who have important immune functions), and monocytes (5.3% of white blood cells, migrate into tissues to become macrophages and Kupffer cells in the liver, they have immune function and have the largest life span -months to years).

3. Platelets (thrombocytes): This serves for hemostasis (stopping of bleeding) as for source of growth factors. They are also a nuclear cell fragments. Their life span is 7-9 days.



Blood cells formation (Hematopoiesis)

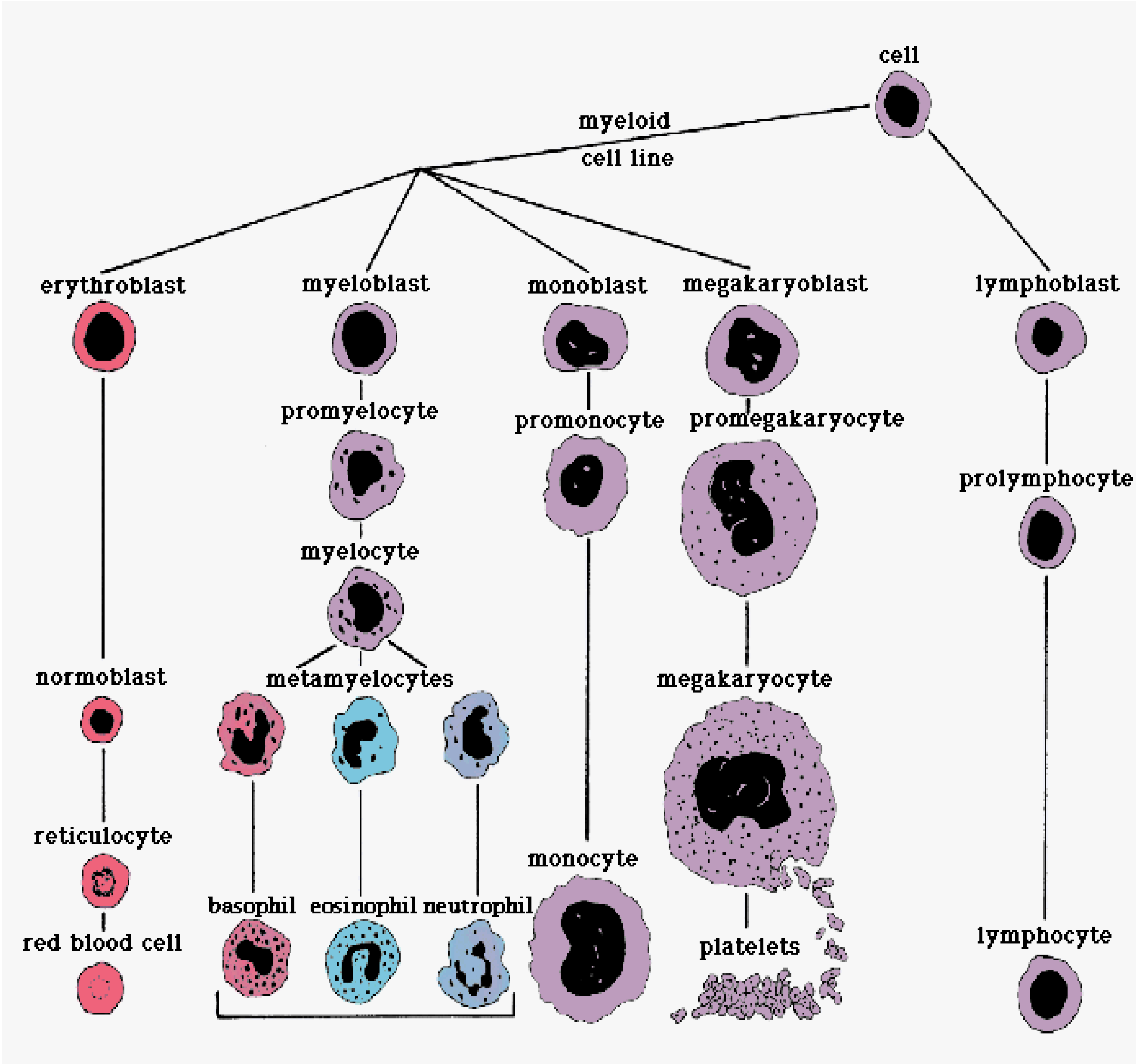
All blood cells are derived from self-renewing hematopoetic stem cells which reside in the bone marrow, after which they proliferate and differentiate in different mature blood cells.

Hematopoiesis occurs in different organs, depending on the stage of development.

- In developing embryo it occurs in the yolk sac.
- After the development progress it occurs in liver, spleen and lymph nodes.

- After birth and maturation of bone marrow , it occurs in the bone marrow of long bones (humerus, femur, tibia, and fibula for example), while in adults it occurs in bone marrow of flat and short bones (pelvis, sternum, vertebrates, and cranium for example).

After the hematopoiesis stops occurring in bone marrow of long bone, the hematopoietic tissue is replaced by fat tissue and is then called yellow bone marrow instead of red bone marrow.



Hematocrit (PCV):

The percentage of red blood cells volume to the total blood volume is called hematocrit. It could be calculated dividing the red blood cells volume by total blood volume and multiplying by 100. The normal average is about 46% in male and 42% in female.

An increase in hematocrit is called **polycythemia**, while a decrease in hematocrit is called **anemia**.

Polycythemia could be physiological as in high altitude or pathological as in polycythemia vera (a neoplastic disease that cause abnormal increase in red blood cells count).

Hematocrit is also increased in dehydration and decreased in overhydration.

Hemostasis of blood:

We mean by hemostasis: prevention of blood loss after injury, causing a cut in blood vessels. The physiological response to cutting or rupturing of blood vessel includes:

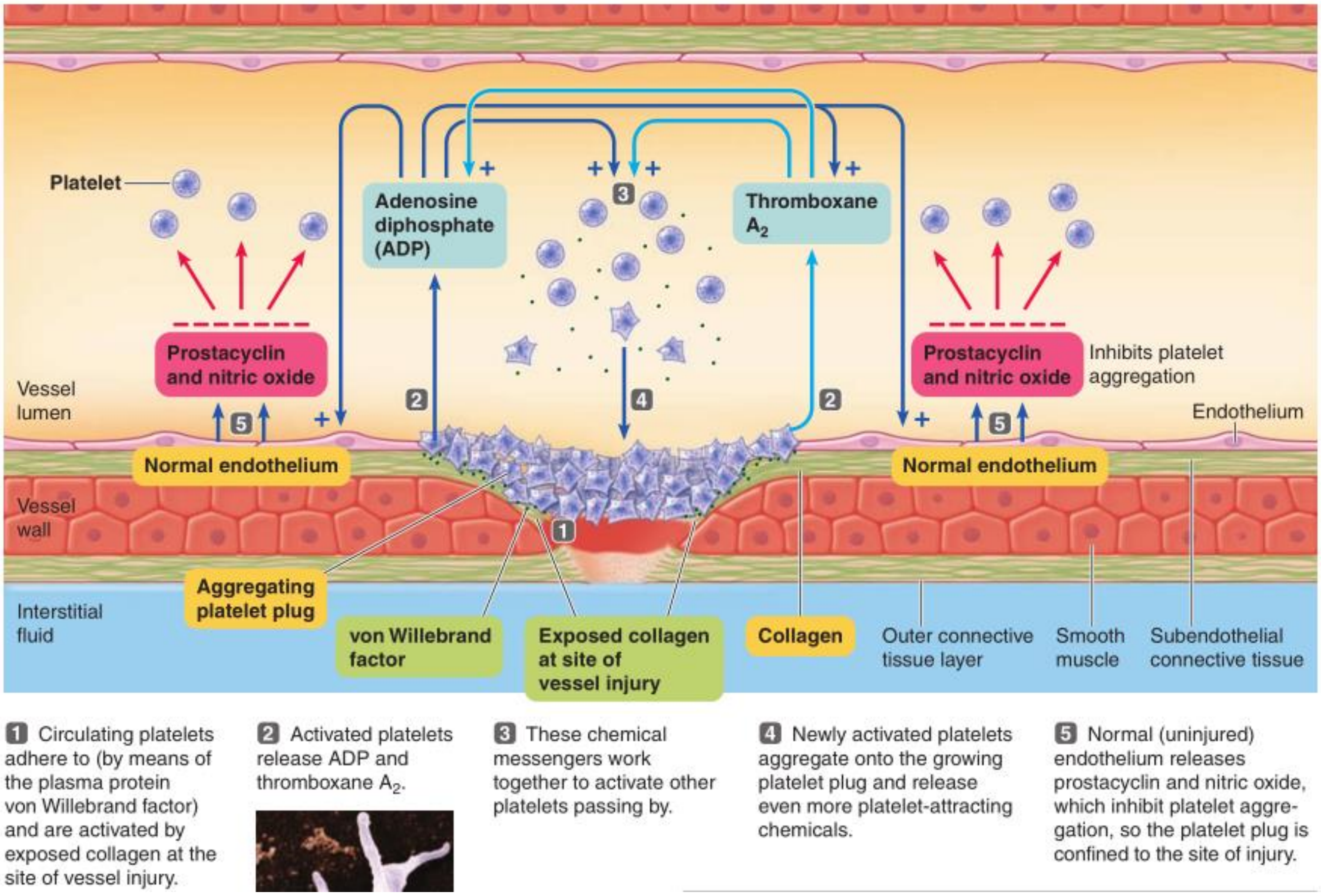
1- Vasospasm: occurs as a result of nerve reflex and myogenic contraction. The nerve reflex usually is stimulated by pain sensation, while the intrinsic myogenic contraction is a result of direct damage.

The more traumatized the vessel, the greater is the degree of the spasm. Vasospasm reduces the blood flow from the vessel rupture.

2- Formation of platelet plug:

- ***platelets adhesion:*** results from adhering of platelets to the exposed subendothelial collagen fibers in the injured blood vessels.
- ***platelets activation:*** This binding initiates platelet activation, which then swell and become sticky and release granules containing ADP and Thromboxane A, which from their side activate the nearby platelets.
- ***platelets aggregation:*** This step will continue in a vicious circle until formation of platelet plug.

Platelet plug is important in closing minute ruptures in the very small vessels of our organism that occurs many thousands of time daily.



3- Formation of blood clot: this occurs by biologically active substances released from the ruptured blood vessel, platelets, and blood proteins. The clot fill the entire hole of ruptured vessel or the broken end of vessel, within 3-6 minutes.

4- Fibrosis of the blood clot to close the hole in the vessel.

Clot formation:

The clot formation starts in 15-20 s. after injury if the trauma was severe and in 1-2 minutes if the trauma was minor.

The opening in the vessel or its broken end will be closed after 3-6 minutes. After being formed the clot retracts.

Mechanism of clot formation:

A blood clotting to occur, clotting factors have to be activated. Clotting factors are mostly plasma proteins in an inactive state.

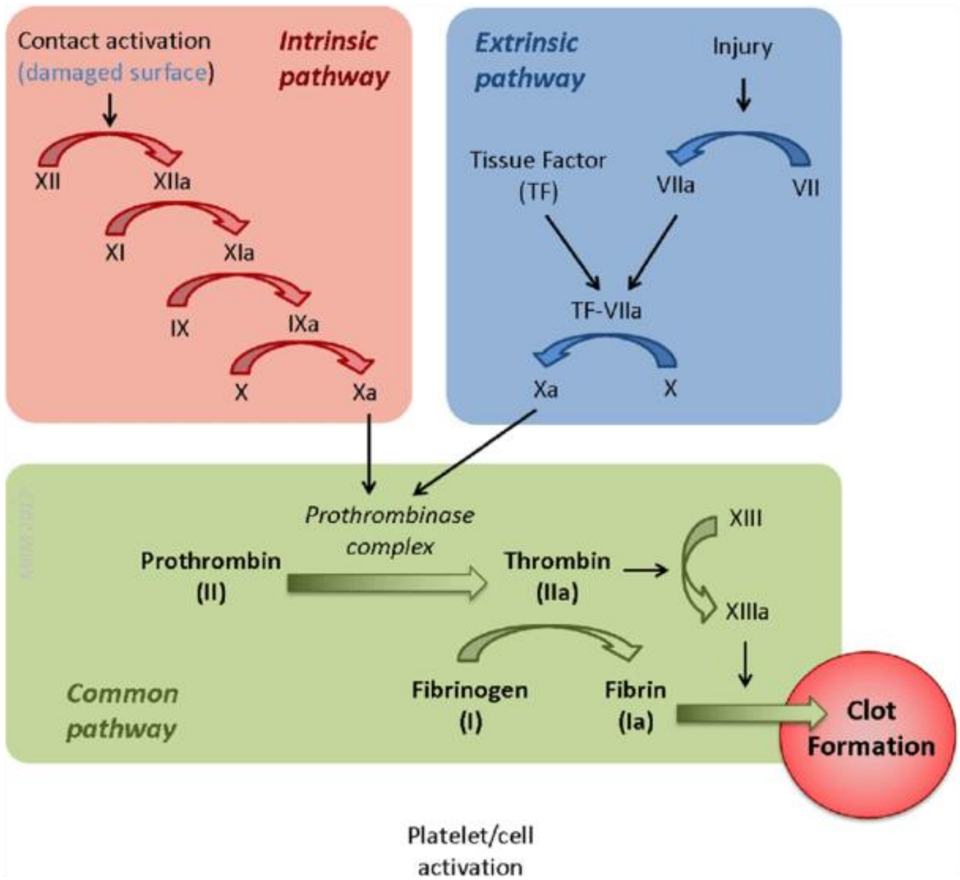
Clot formation starts either by:

1. **Extrinsic pathway:** which begins with trauma in the vascular wall or extravascular tissue:

   A complex of tissue factors released from traumatized tissue activates factor VII. The later activates factor X. Factor X immediately complexes with platelets phospholipids in presence of calcium ions and factor V to form prothrombin activator. Prothrombine activator splits prothrombin to thrombin. Thrombin then acts on soluble fibrinogen to transform it into insoluble fibrin thread.

2. **Intrinsic pathway:** This begins with trauma to the blood itself or contact of blood with water surface. This will lead to activation of factor XII and release of platelets phospholipids.

   Factor XII then activates factor XI, the activated factor XI activates factor IX, which will then activate factor VIII. The activated factors VIII, IX, and the platelets phospholipids will activate factor X. Factor X will combine with factor V, phospholipds and calcium ions to form prothronbine activator.



Fibrin threads form a meshwork, which is weak and breakable. But a factor called fibrin stabilising factor (Factor III) is released from the platelets. Factor XIII after being released will be activated by thrombin. It will add more and more bonds between the fibrin monomer molecules and form multiple cross-linkage between the fibrin threads the strong meshwork entraps blood cells, platelets, and plasma.

Clot retraction: After being formed, the clot then contracts and squeezes most of its fluid (the fluid is plasma protein- free and called serum). As the clot retracts it pulls the edges of the broken blood vessels together.

The clot will be then invaded by fibroblast which forms connective tissue and the clot will completely be organized into fibrous tissue within 1-2 weeks.

Clinical Physiology:

- Aspirin inhibits Thromboxane A2 and thus impair platelets aggregation.
- Vitamin K is very important for liver formation of 5 of clotting factors incluiding Prothrombin, factor VII, factor IX, and factor X. So Vitamin K deficiency may causes serious bleeding tendencies.
- Calcium ions are required for acceleration of most of the clot formation steps, so the blood removed from the body can be prevented from clotting by deionizing of calcium ions by addition of citrate, or by precipitating of calcium with oxalates.

Heart and blood vessels Physiology

Anatomy and Physiology of the Heart

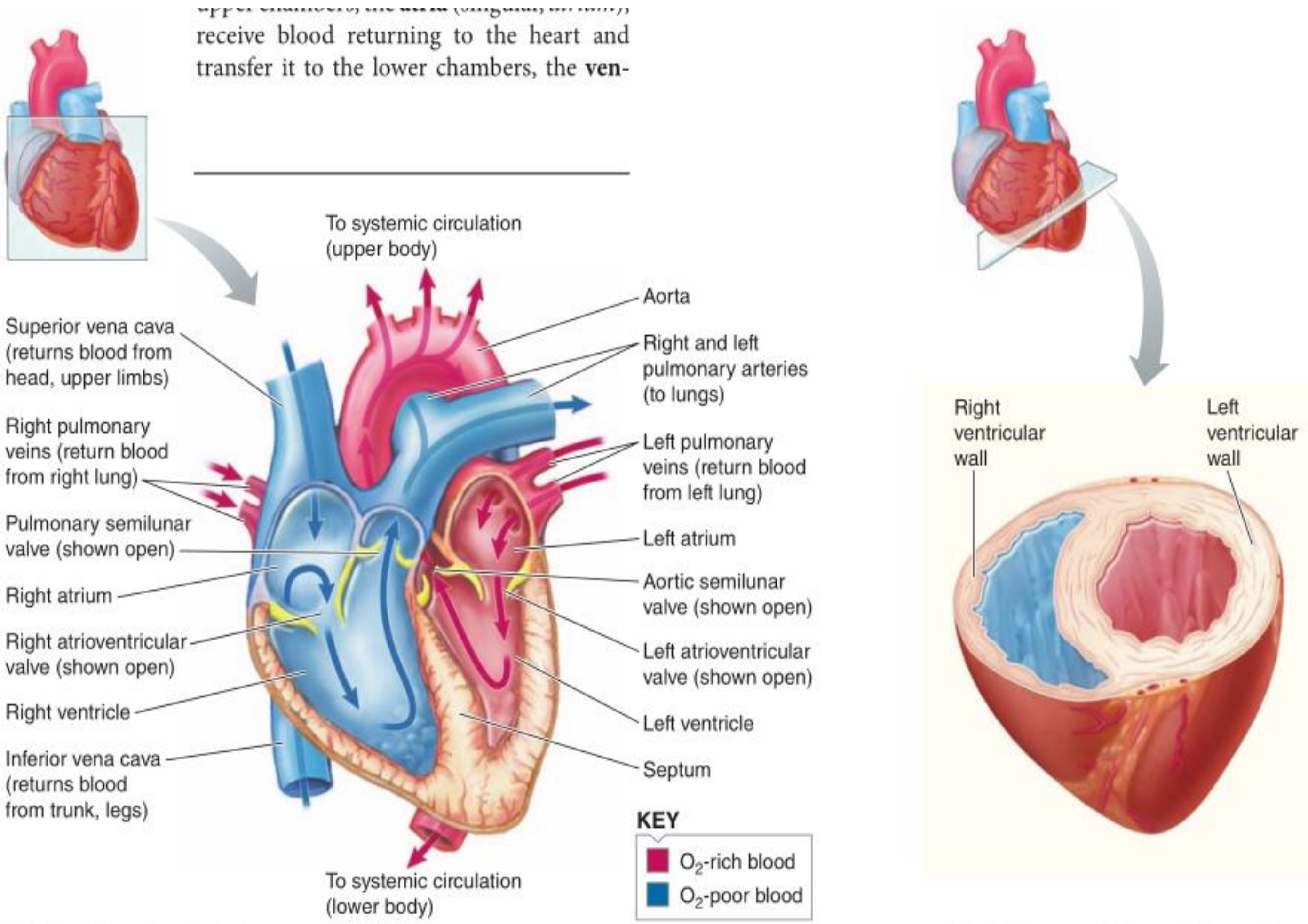
The heart is a funnel -shaped, hollow, muscular organ that is responsible for pumping blood to all parts of the body .The heart is located near the center of the thoracic cavity between the lungs and is contained in the pericardial sac supports the heart and contains some fluid for lubrication. The broad end, or base, of the heart is also supported by large arteries and veins. The pointed end, or apex, of the heart is directed toward the abdomen.

The heart wall is made up of three layers

Epicardium – outer layer of heart, **Endocardium** – inner layer, **Myocardium** – middle layer composed of cardiac muscle.

The cardiac muscle is an involuntary, striated muscle with fibers that intertwine. In mammals and birds, the heart is divided into a right and left side and each side is divided into an **atrium** and **ventricle**. Therefore, the heart is said to have four chambers (right atrium, right ventricle, left atrium, and left ventricle).

The vascular system is made up of three types of blood vessels: **Arteries**, **vein**, and **capillaries**.



(a) Blood flow through the heart **(b)** Thickness of right and left ventricles

Arteries are blood vessels that carry blood, rich in oxygen, from the heart to other parts of the body. The large arteries have thick walls of elastic-like tissue that enables them to withstand the blood pressure created by the heart’s beating.

Veins: are blood vessels that carry the non-oxygenated blood, from the other parts of the body to heart. The large veins contain valves to prevent blood returns.

As the arteries extend away from the heart, they branch out into smaller arteries called

arterioles. The smaller arteries' walls are composed of large amounts of smooth muscle instead of the elastic tissue that carefully controls the amount of blood each capillary receives. Arterioles branch into smaller vessels called **capillaries** which connect arterioles to venules. They allow the exchange of nutrients and wastes between the blood and the tissue cells. Capillaries have a single layer of flattened endothelial cells.

Capillary Exchange

Capillary Exchange: The movement of substances between the blood and interstitial fluid of the tissue. Mainly exchanges, Oxygen, Carbon Dioxide, Glucose, Amino Acids, Hormones.

Filtration: The movement of materials from capillaries into the interstitial fluid.

Reabsorption: The movement of materials from the interstitial fluid into the capillaries.

Diffusion: The movement of materials from high concentration to low concentration. The basic rule states that the more surface area there is for exchange, the faster the gases and nutrients will transfer into the tissue.

Transcytosis: The movement of materials through the cells. Materials are enclosing in vesicles to be transported across the cell. Typically used by large molecules, such as insulin, albumin, & some proteins & fatty acids.

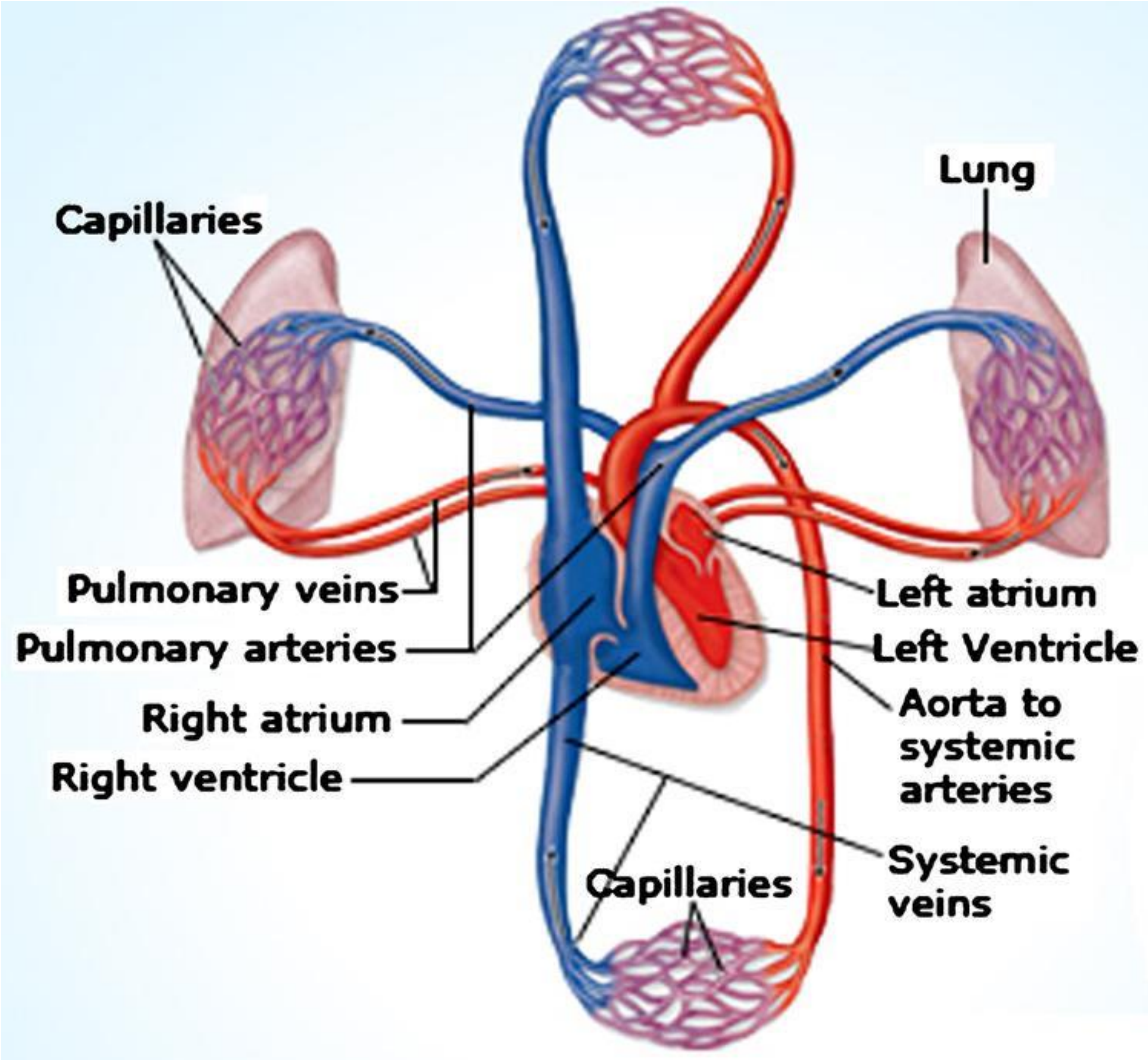
Bulk flow: the process of a large amount of materials moving in the same direction. Movement is driven by pressure mechanisms.

Edema: The increase in interstitial fluid volume caused by filtration rate exceeding reabsorption rate which results in bloated tissue. Can be caused decreased concentrations of the plasma proteins, increased capillary blood pressure, and increased permeability of the capillaries.

The blood Circulation:

Pulmonary circulation: The blood pumped by the ***right ventricle*** enters the pulmonary artery, The deoxygenated blood pumped into the pulmonary artery is passed on to the lungs (where gases exchange occur) from where the oxygenated blood is carried by the pulmonary veins into the ***left atrium***.

systemic circulation: the ***left ventricle*** pumps blood into the aorta. The oxygenated blood entering the aorta is carried by a network of arteries, arterioles and capillaries to the tissues (where gases, nutrients and wastes material exchange) from where the deoxygenated blood is collected by a system of venules, veins and vena cava (superior and inferior) which emptied into the ***right atrium***.

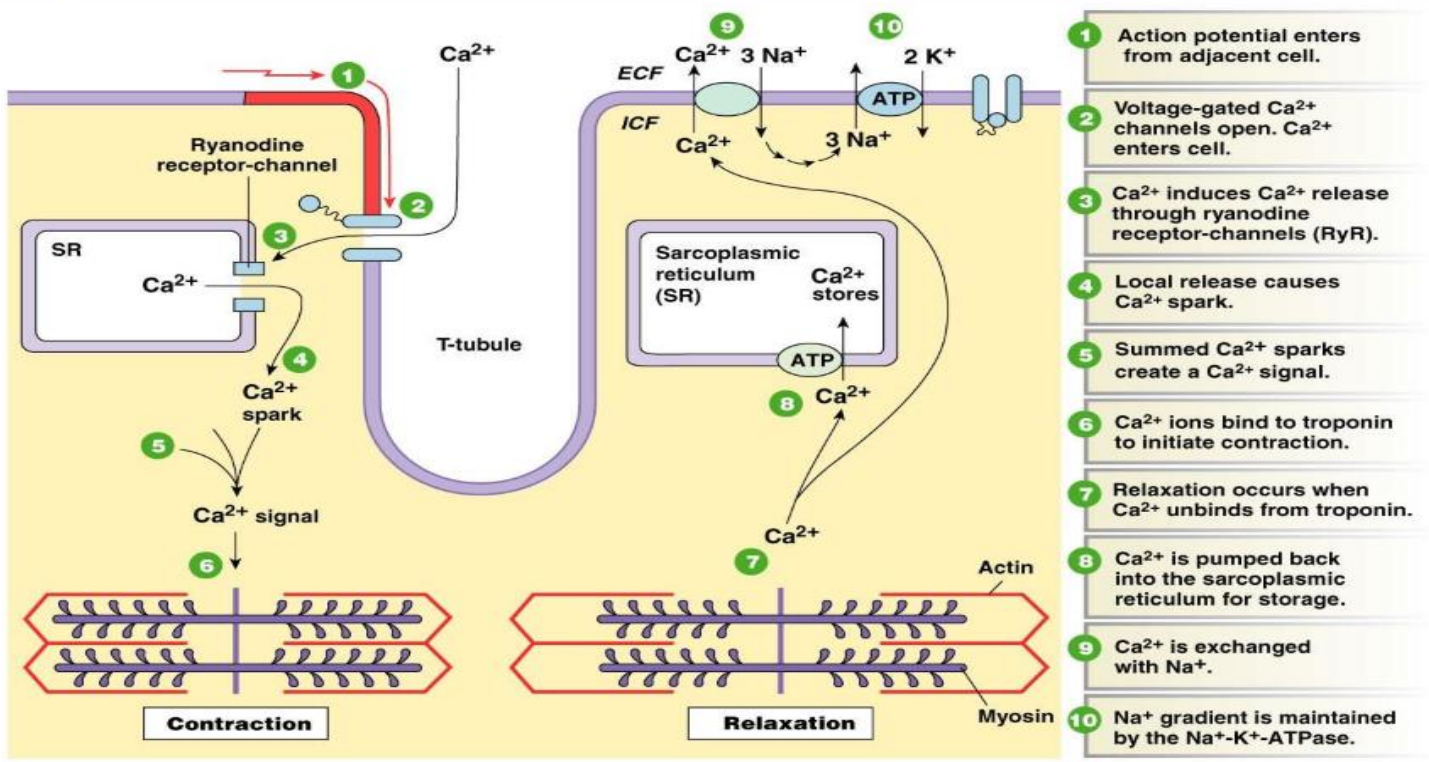


Mechanism of Contraction of Contractile Cardiac Muscle Fibers

1. Sodium ion (Na^+) influx from extracellular space, causes positive feedback opening of voltage-gated Na^+ channels; membrane potential quickly depolarizes (Na^+ channels close within 3 ms of opening.

2. Depolarization causes release of Ca^{++} from sarcoplasmic reticulum (as in skeletal muscle), allowing sliding actin and myosin to proceed.

Depolarization also causes opening of slow Ca^{++} channels on the membrane (special to cardiac muscle), further increasing Ca^{++} influx and activation of filaments. This causes more prolonged depolarization than in skeletal muscle, resulting in a plateau action potential, rather than a "spiked" action potential (as in skeletal muscle cells).



Differences between skeletal & cardiac muscle contraction

1. **<u>All-or-None Law</u>** - Gap junctions allow all cardiac muscle cells to be linked electrochemically, so that activation of a small group of cells spreads like a wave throughout the entire heart. This is essential for "synchronistic" contraction of the heart as opposed to skeletal muscle.

2. **Automicity (Autorhythmicity)** - some cardiac muscle cells are "self-excitable" allowing for rhythmic waves of contraction to adjacent cells throughout the heart. Skeletal muscle cells must be stimulated by independent motor neurons as part of a motor unit.

3**. Length of absolute refractory period** - The absolute refractory period of cardiac muscle cells is much longer than skeletal muscle cells *(*250 ms vs. 2-3 ms), preventing wave summation and tetanic contractions which would cause the heart to stop pumping rhythmically.

General Properties of Conduction

1. Heart can beat rhythmically without nervous input
2. Nodal system (cardiac conduction system) - special autorhythmic cells of heart that initiate impulses for wave-like contraction of entire heart (no nervous stimulation needed for these)
3. Gap junctions_- electrically couple all cardiac muscle cells so that depolarization sweeps across heart in sequential fashion from atria to ventricles

Nodal system\\ Autorhythmic Cell Location & Order of Impulses

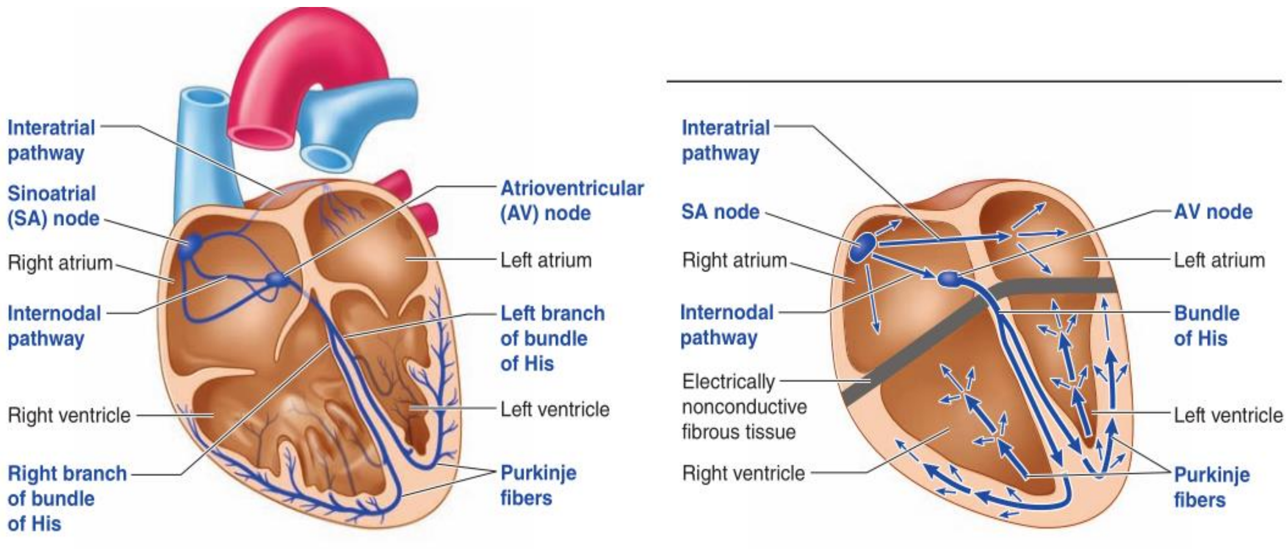
A. **Sinoatrial node (SA node) "the pacemaker"** - has the fastest

autorhythmic rate (70-80 per minute), and sets the pace for the entire heart; this rhythm is called the sinus rhythm; located in right atrial wall, just inferior to the superior vena cava

B. **Atrioventricular node (AV node) -** impulses pass from SA via gap junctions in about 40 ms; impulses are delayed about 100 ms to allow completion of the contraction of both atria; located just above tricuspid valve (between right atrium & ventricle)

C. **<u>Atrioventricular bundle (bundle of His)</u> -** in the inter atrial septum (connects L and R atria) L and R bundle of His branches - within the inter ventricular septum (between L and R ventricles)

D. **<u>Purkinje fibers</u> -** within the lateral walls of both the L and R ventricles; since left ventricle much larger, Purkinjes more elaborate here.



(a) Specialized conduction system of the heart (b) Spread of cardiac excitation

The Normal Cardiac Cycle

A. <u>General Concepts</u>

1. <u>Systole</u> - period of chamber contraction
2. <u>Diastole</u> - period of chamber relaxation
3. <u>Cardiac cycle</u> - all events of systole and diastole during one heart flow cycle

B. <u>Events of Cardiac Cycle</u>

1. <u>Diastole:</u>

* The AV valves are open
* Pressure: **low** in chambers; **high** in aorta/pulmonary trunk
* Aortic/pulmonary semilunar valves **closed**
* Blood flows from vena cavas/pulmonary vein into atria
* Blood flows through AV valves into ventricles (70%)

2. <u>Systole: blood ejected from heart</u>

* Filled ventricles begin to contract, AV valves **close**
* Semilunar valves **open**
* ventricles **closed**
* Contraction of closed ventricles increases pressure
* Ventricular ejection phase - blood forced out (into aorta & pulmonary trunk

Heart Sounds: Stethoscope Listening

1. <u>lub-dub, - , lub, dub.</u>
2. **<u>Lub</u>** - closure of AV valves, onset of ventricular systole
3. **<u>Dub</u>** - closure of semilunar valves, onset of diastole
4. **<u>Pause</u>** - quiescent period of cardiac cycle
5. <u>Tricuspid valve</u> (lub) - right 5th intercostal, medial
6. <u>Mitral valve</u> (lub) - left 5th intercostal, lateral

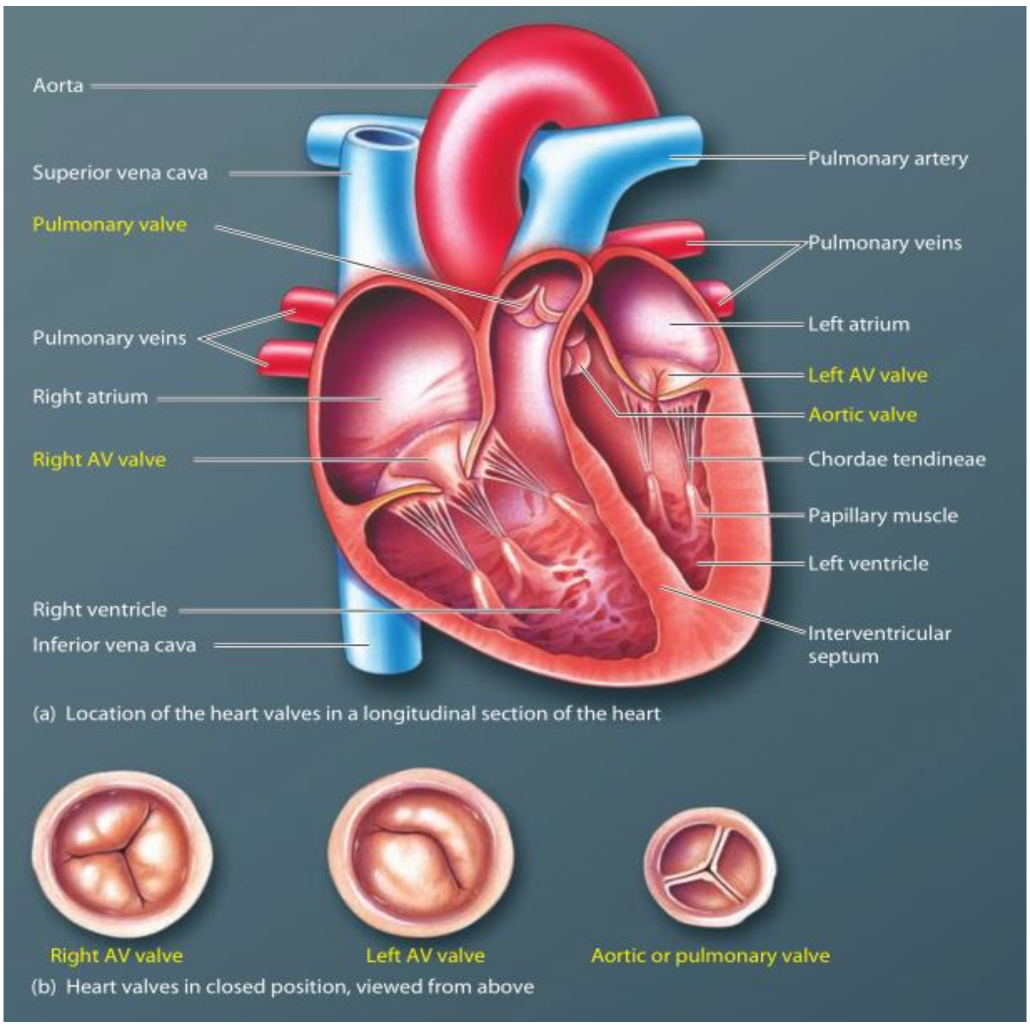
7. Aortic semilunar valve (dub) – right 2nd intercostal

8. Pulmonary semilunar valve (dub) - left 2nd intercostal

Heart Murmurs

Murmur - sounds other than the typical "lub-dub"; typically caused by disruptions in flow

* Incompetent valve - swishing sound just AFTER the normal "lub" or "dub"; valve does not completely close, some regurgitation of blood
* Stenotic valve - high pitched swishing sound when blood should be flowing through valve; narrowing of outlet in the open state.



(a) Location of the heart valves in a longitudinal section of the heart

(b) Heart valves in closed position, viewed from above

General Variables of Cardiac Output

Normal heart rate - fetus 140 - 160 beats/minute, female 72 – 80 beats/minute and male 64 - 72 beats/minute.

1. Cardiac Output (CO) - blood amount pumped per minute
2. Stroke Volume (SV) - ventricle blood pumped per beat
3. Heart Rate (HR) - cardiac cycles per minute

CO (ml/min) = HR (beats/min) X SV (ml/beat)

Normal CO = 75 beats/min X 70 ml/beat = 5.25 L/min

- Increased cardiac output -> increased blood pressure
- Increased stroke volume -> increased blood pressure
- Increased heart rate -> increased blood pressure

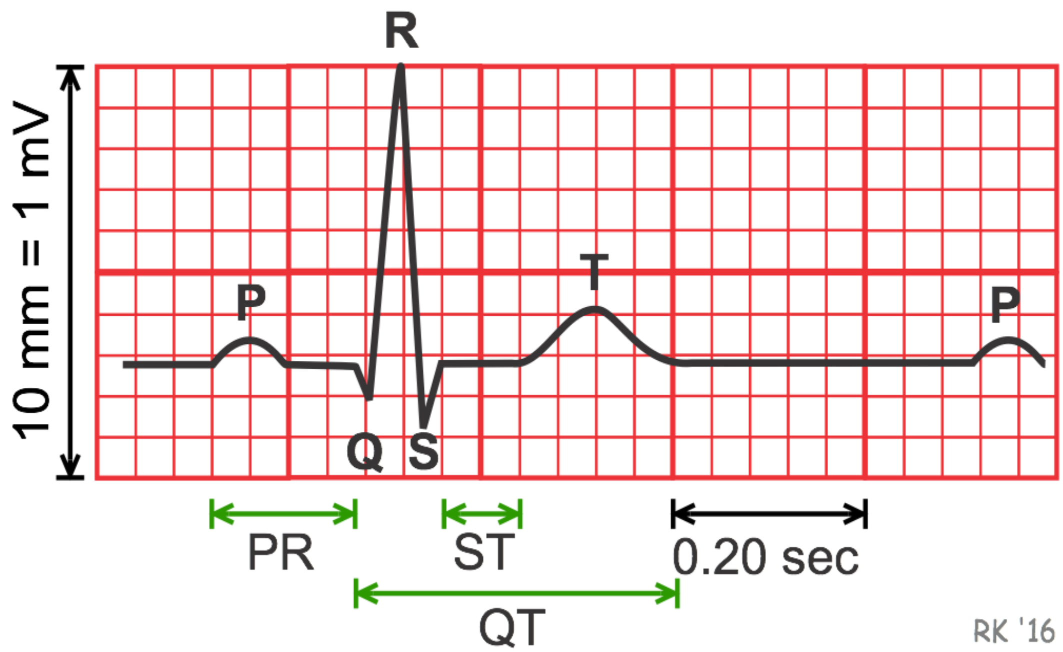
Electrocardiography: Electrical Activity of the Heart

Deflection Waves of ECG

1. **P wave** - initial wave, demonstrates the depolarization from SA Node through both atria; the atria contract about 0.1 s.
2. **QRS complex** - next series of deflections, demonstrates the depolarization of AV node through both ventricles; the ventricles contract throughout the period of the QRS complex, with a short delay after the end of atrial contraction; repolarization of atria also obscured
3. **T Wave -** repolarization of the ventricles (0.16 s)

4. **PR (PQ) Interval** - time period from beginning of atrial contraction to beginning of ventricular contraction (0.16 s)

5. **QT Interval** the time of ventricular contraction (about 0.36 s); from beginning of ventricular depolarization to end of repolarization.



Regulation of Heart Rate (Autonomic, Chemical, Other)

1. **Autonomic Regulation of Heart Rate (HR)**

A. **Sympathetic** - norepinephrine (NE) increases heart rate (maintains stroke volume which leads to increased Cardiac Output)

B. **parasympathetic** - acetylcholine (ACh) decreases heart rate

C. **vagal tone** - parasympathetic inhibition of inherent rate of SA node, allowing normal HR.

Baroreceptors, *pressoreceptors - monitor changes in blood pressure and allow reflex activity with the autonomic nervous system.*

2. Hormonal and Chemical Regulation of Heart Rate (HR)

A. **Epinephrine** - hormone released by adrenal medulla during stress; increases heart rate

B. **Thyroxine** - hormone released by thyroid; increases heart rate in large quantities; amplifies effect of epinephrine

3. Others:

Ca^{++}, K^{+}, and Na^{+} levels very important;

* ***hyperkalemia*** - increased K^{+} level; KCl used to stop heart on lethal injection
* ***hypokalemia*** - lower K^{+} levels; leads to abnormal heart rate rhythms
* ***hypocalcemia*** - depresses heart function
* **hypercalcemia** - increases contraction phase
* ***hypernatremia*** - high Na^{+} concentration; can block Na^{+} transport & muscle contraction

a) **Exercise** - lowers resting heart rate (40-60)

b) **Heat** - increases heart rate significantly

c) **Cold** - decreases heart rate significantly

Tachycardia **-** higher than normal resting heart rate (over 100); may lead to fibrillation

Bradycardia **-** lower than normal resting heart rate (below 60).

Blood pressure = the systemic arterial pressure of large vessels of the body (mm Hg).

Factors Involved in Blood Circulation

A. **Blood Flow** - the actual volume of blood moving through a particular site (vessel or organ) over a certain time period (liter/hour, ml/min)

B. **Blood Pressure** - the force exerted on the wall of a blood vessel by the blood contained within (millimeters of Mercury; mm Hg)

C. **Resistance to Flow** (Peripheral Resistance) - the force resisting the flow of blood through a vessel (usually from friction)

   1. ***Viscosity***
   2. ***Tube length*** **-** the longer the vessel, the greater the drop in pressure due to friction
   3. ***Tube diameter*** **-** smaller diameter = greater friction

Blood Pressure

Hypotension (below normal blood pressure, < 100/60)

1. Factors - age, physical conditioning, illness

3. Chronic hypotension - ongoing low blood pressure

   a. low blood protein levels (nutrition)

   b. Addison's disease (adrenal cortex malfunction)

   c. hypothyroidism

   d. also sign of various types of cancer

Hypertension (above normal blood pressure at rest, > 140/90)

1. Factors - weight, exercise, emotions, stress

2. Chronic hypertension - ongoing high blood pressure

   a. prevalent in obese and elderly

   b. heart disease, renal failure, stroke

   c. arteriosclerosis

   d. primary hypertension

      i. high Na^+, cholesterol, fat levels

      ii. clear genetic component (in families)

      iii. diuretics - promote water removal

   e. secondary hypertension - identifiable disorder

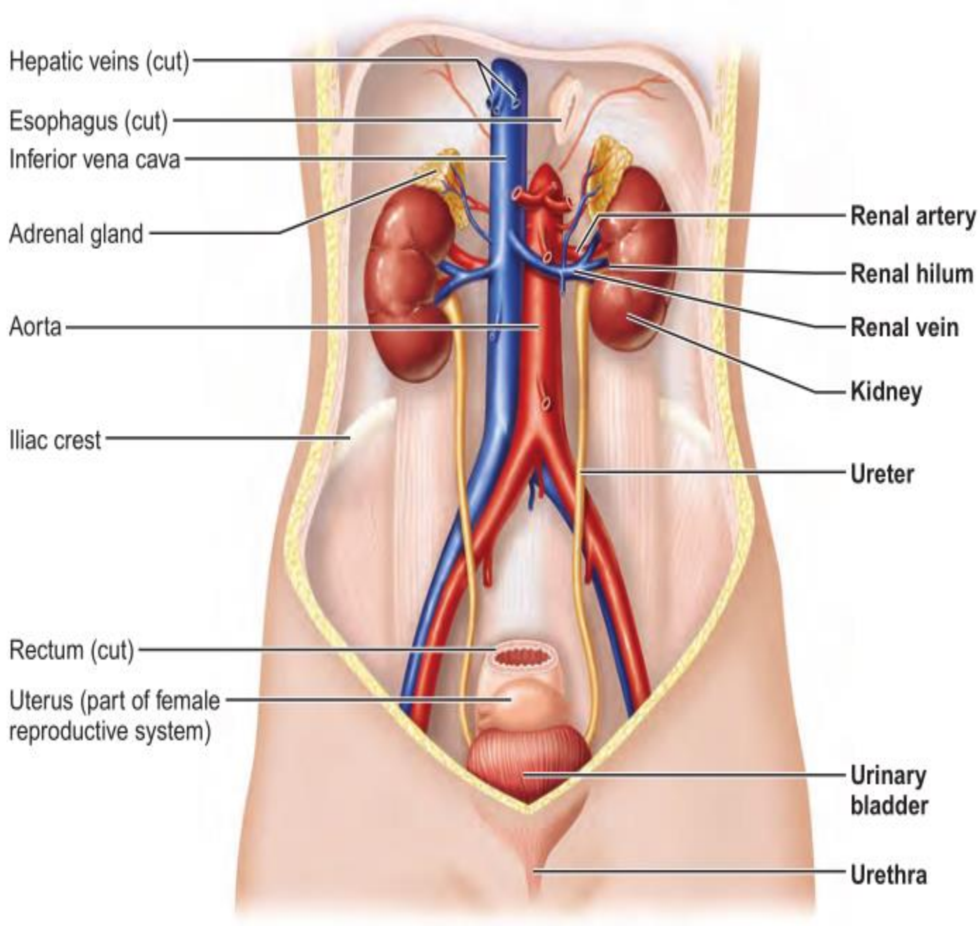
Urinary system

The urinary system play a major role in maintaining homeostasis by regulating the concentration of many plasma constituents, especially electrolytes and water, and by eliminating all metabolic wastes (except CO_2 , which is removed by the lungs).

The urinary system is made-up of the **kidneys, ureters, bladder, and urethra.**

kidneys – a pair of bean – shaped organs located retroperitoneally, it measures 10-12 cm long and covered by renal capsule which is a layer of fibrous connective tissue. There are three major regions of the kidney, **renal cortex**, **renal medulla** and the **renal pelvis**.

Every day the kidneys filter nearly 180 liters of fluid from the blood- stream, allowing toxins, metabolic wastes, and excess ions to leave the body in urine while returning needed substances to the blood. Urine leaves the kidneys by ureters, and collects in the bladder. The bladder can distend to store urine that eventually leaves through the urethra.

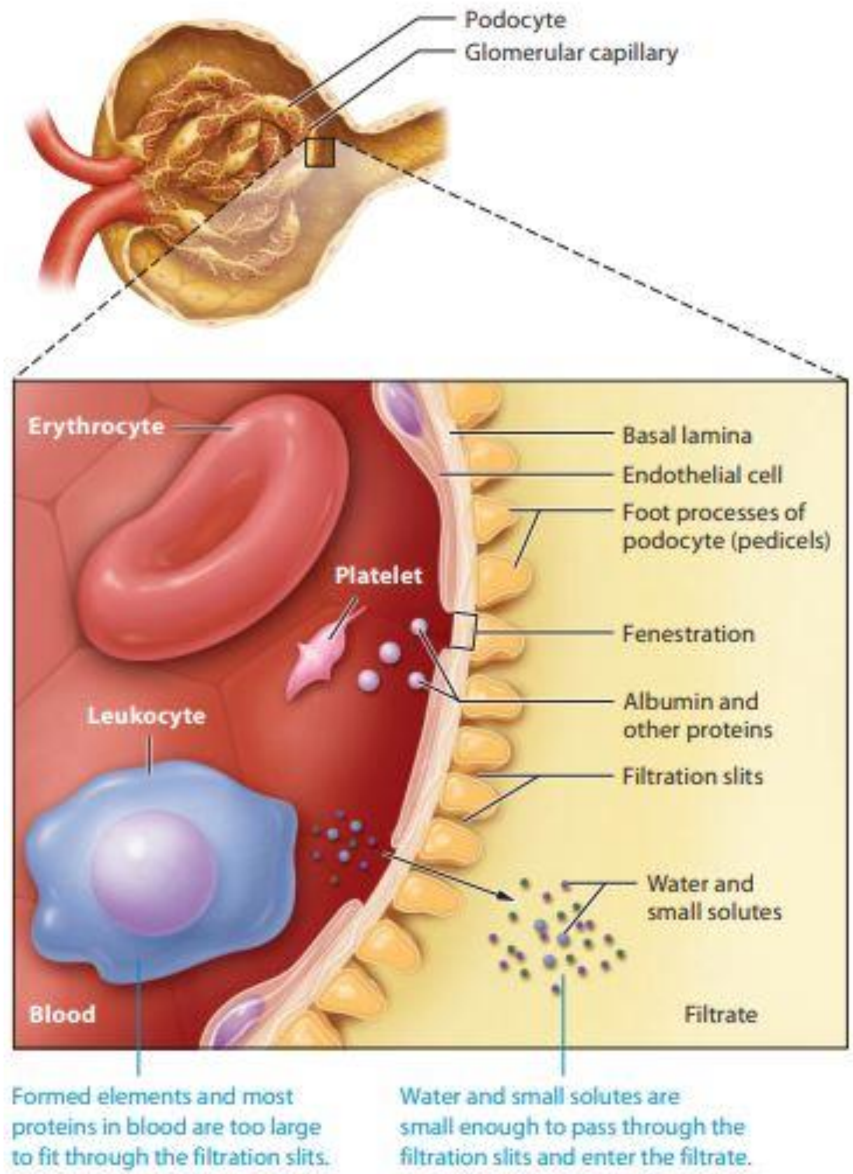


The nephron

A nephron is the basic structural and functional unit of the kidney. and each kidney consists of 1.200.000

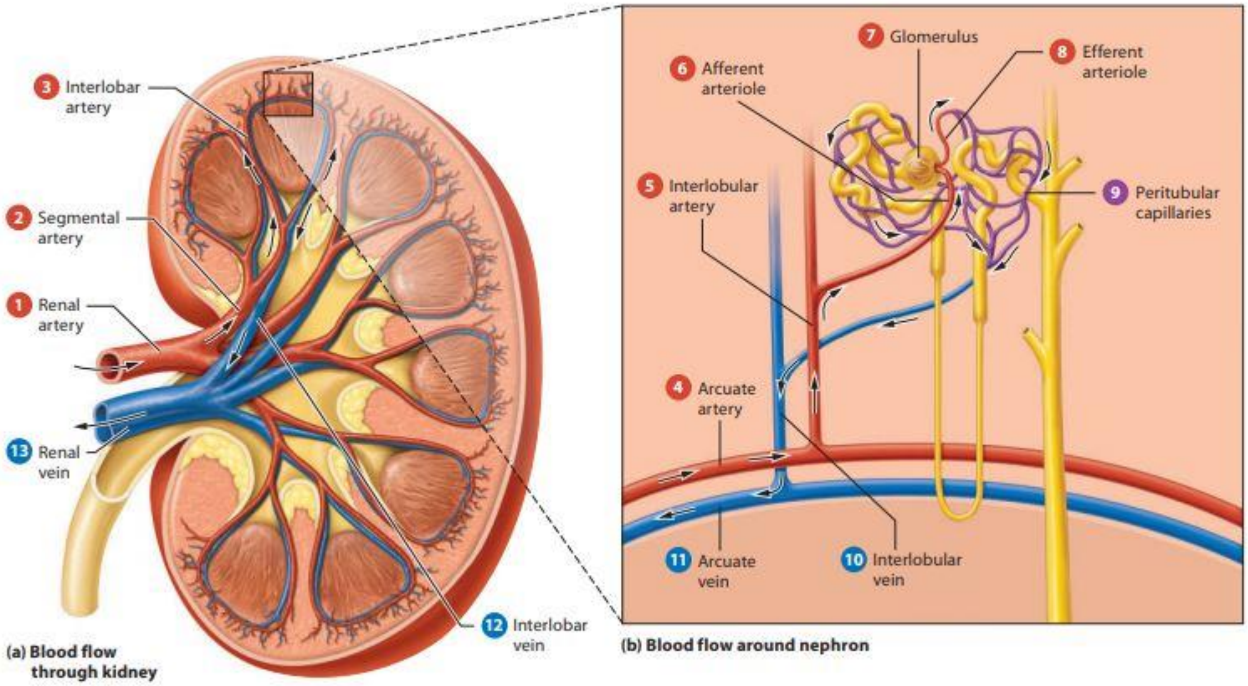
-Each nephron consists of:

- **Bowmans capsule:** Cup-shaped capsule containing capillaries (The glomerulus).
- **The glomerulus:** The glomerulus is a capillary tuft that receives its blood supply from an afferent arteriole of the renal circulation. It mechanically filters blood



- **Long renal tube** which divided into:
    a) ***Proximal convoluted tubule (PCT):*** reabsorbs 75% of the water, salts, glucose, and amino acids
    b) ***Loop of henle:***
    c) ***Distal convoluted tubule(DCT):*** tubular secretion of H ions, potassium, and certain drugs.

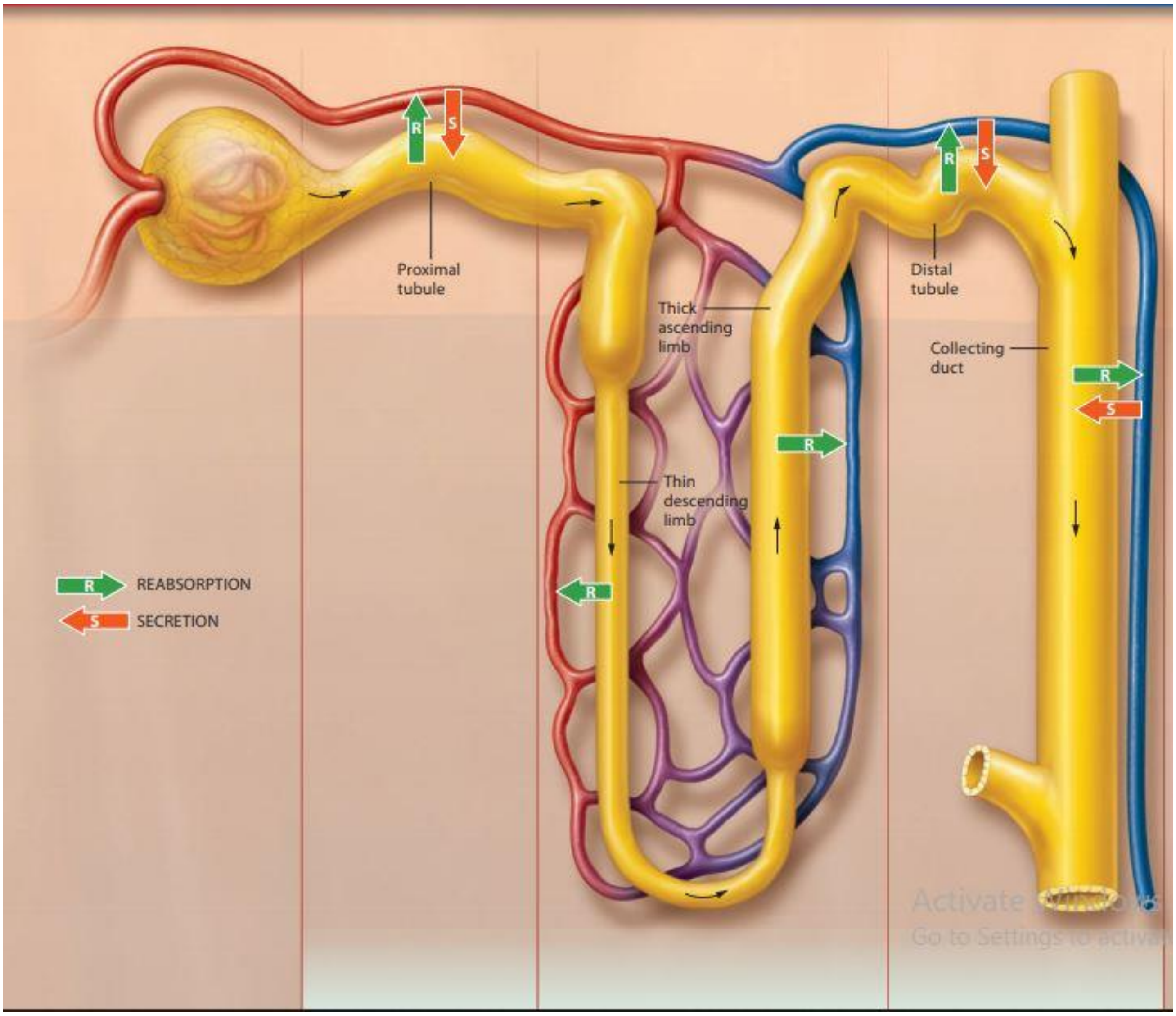
Nephrons filter 125 ml of body fluid per minute; filtering the entire body fluid component 16 time each day. In a 24 hour period nephrons produce 180 liters of filtrate, of which 178.5 liters are reabsorbed. The remaining 1.5 liters forms urine.



Urine Formation

urine formation involves 4 processes:

1. **Filtration**: small molecules are filtered from glomerulus's to bowman's capsule.
2. **Reabsorption**: nutrient molecules are transported from PCT and DCT to per tubular capillaries.
3. **Concentration**:water is reabsorbed from descending limb of loop of handle and from collecting duct into peritubular capillaries.
4. **Secretion**: waste or harmful substances are transported from peritubular capillaries to PCT and DCT.



Kidney function

Kidneys perform a number of homeostatic functions:

1-Maintain volume of extracellular fluid

2- Maintain ionic balance in extracellular fluid

3- Maintain pH and osmotic concentration of the extracellular fluid

4-Excrete toxic metabolic by-products such as urea, ammonia, and uric acid.

5- Vitamin D- Becomes metabolically active in the kidney. Patients with renal disease have symptoms of disturbed calcium and phosphate balance.

6- Renal Hormones such as:

a) **Erythropoietin-** Released by the kidneys in response to decreased tissue oxygen levels (hypoxia).

b) **Renin-** leads to the secretion of aldosterone which is released from the adrenal cortex.

Hormone control of water and salt

1- Antidiuretic hormone (ADH):

water reabsorption is controlled by the antidiuretic hormone (ADH) in negative feedback. ADH is released form the pituitary gland in the brain.

- Dropping levels of fluid in the blood signal the hypothalamus to cause the pituitary to release ADH into the blood.

  ADH acts to increase water absorption in the kidney. This puts more water back in the blood, increasing the concentration of the urine.
- When too much fluid is present in the blood, sensors in the heart signal the hypothalamus to cause a reduction of the amounts of ADH in the blood. This increases the amount of water absorbed by the kidneys, producing large quantities of more dilute urine.

2- Aldosterone, a hormone secreted by the kidneys, regulates the transfer of sodium from the nephron to the blood. When sodium levels in the blood fall, aldosterone is released into the blood, causing more sodium to pass from the nephron to the blood.

Diseases of the Kidney

1. Diabetes Insipidus

This is caused by the deficiency of or decrease of ADH. The person with (DI) has the inability to concentrate their urine, in turn they will void up 3 to 20 liters/day. The cause may be a genetic trait, electrolyte disorder, or side effect of drugs such as lithium.

2. **Urinary tract infections (UTI's)**

The second most common type of bacterial infections seen by health care providers is UTI's. Out of all the bacteria that colonize and cause urinary tract infections the big genus is *Escherichia coli*, and also *Proteus*, *Klebssiela*, *Pseudomonas*, and many others.

3. **Renal Failure**

Uremia is a syndrome of renal failure and includes elevated blood urea and creatinine levels. Acute renal failure can be reversed if diagnosed early. Acute renal failure can be caused by severe hypotension or severe glomerular disease. It is considered to be chronic renal failure if the decline of renal function to less than 25%.

4. **Kidney stones**

also known as nephrolithiases, urolithiases or renal calculi, are solid crystallization of dissolved minerals in urine found inside the kidneys or ureters. They vary in size from as small as a grain of sand to as large as a golf ball.

The Respiratory System

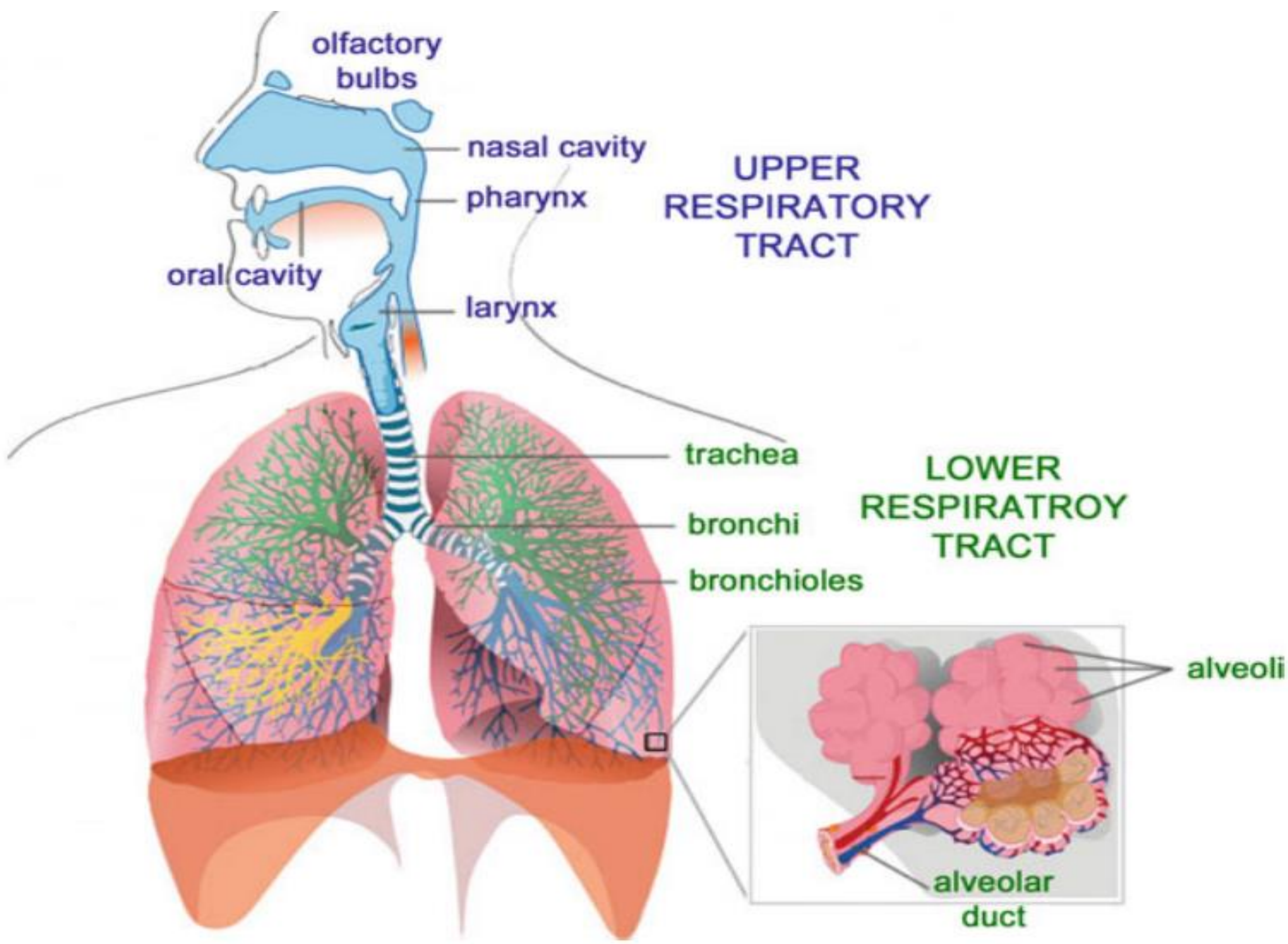
-Energy is essential for sustaining life-supporting cellular activities, such as protein synthesis and active transport across plasma membranes.

-Body cells need a continuous supply of O_2 to support their energy-generating chemical reactions.

-The CO_2 produced during these reactions must be eliminated from the body at the same rate as it is produced.

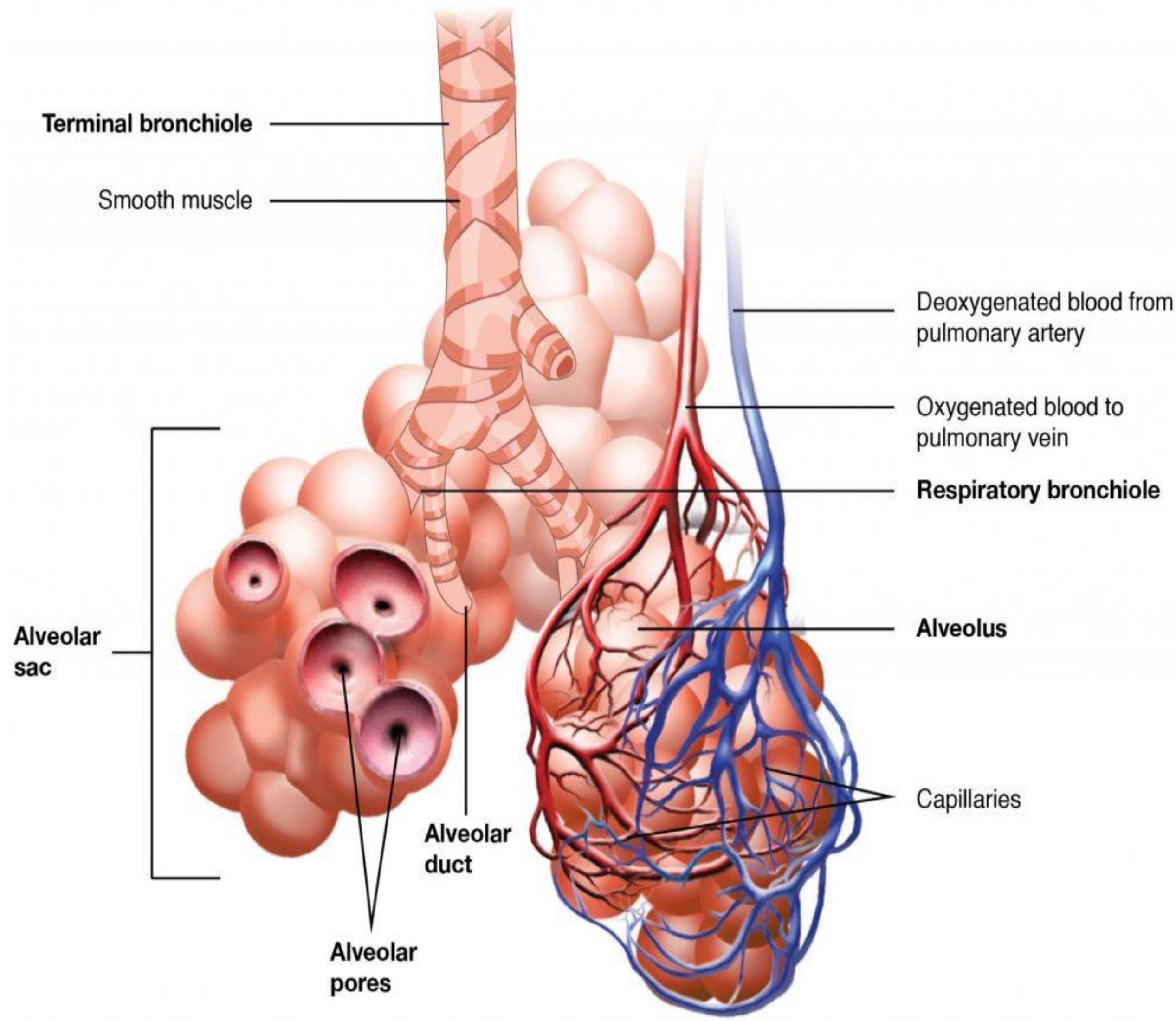
Respiratory System Divisions

- Upper respiratory tract:- Nose (nasal cavity), pharynx and Larynx
- Lower respiratory tract:-, Trachea, bronchi, bronchioles and lungs



Functions of respiratory system

1. Primary function is to obtain oxygen for use by body's cells eliminate or removable carbon dioxide that cells produce
2. Regulation of blood pH altered by changing blood carbon dioxide levels
3. Olfaction: smell occurs when airborne molecules drawn into nasal cavity
4. Protection: against microorganisms by preventing entry and removing them
5. Voice production movement of air past vocal folds makes sound and speech
6. It is a route for water loss and heat elimination.



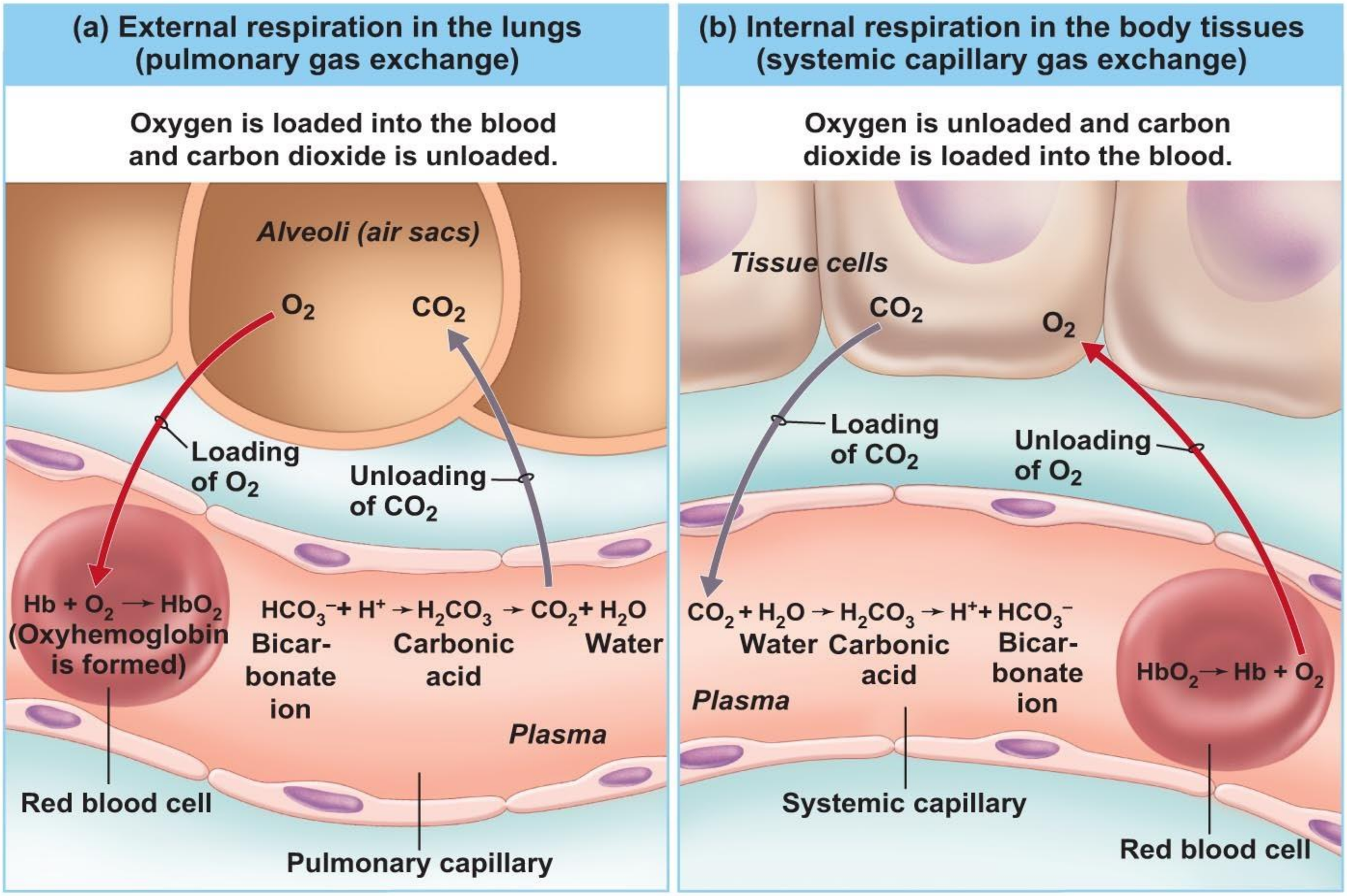
-**Respiration Ventilation**: Movement of air into and out of lungs

-**External respiration**: Gas exchange between air in lungs and blood

-Internal respiration: Gas exchange between the blood and tissues

Mechanism of gas exchange

1) Alveolar PO_2 (Pressure of oxygen) remains relatively high and alveolar PCO_2 (Pressure of carbon dioxide) remains relatively low because continuous exchanged for fresh atmospheric air with each breath.
2) In contrast, the systemic blood entering the lungs (by pulmonary artery) is relatively low in PO_2 and high in PCO_2, having given up O_2 and picked up CO_2 at the systemic capillary level.
3) The blood leaving the lungs is thus relatively high in PO_2 and low in PCO_2.
4) Consequently, gas exchange at the tissue level includes the passive movement of O_2 out of the blood into cells to support their metabolic requirements and also favor the simultaneous transfer of CO_2 into the blood.
5) The blood leaving the tissues is relatively low in O_2 and high in CO_2.
6) The blood then returns to the lungs to once again fill up on O_2 and dump off CO_2



Gas Transport (in blood)

Hemoglobin, an iron-bearing protein molecule contained within the red blood cells, can form a loose, easily reversible combination with O_2. When not combined with O_2, Hb is referred to as reduced hemoglobin, or deoxyhemoglobin; when combined with O_2, it is called oxyhemoglobin (HbO_2):

$Hb + O2 \longleftrightarrow HbO_2$

Oxygen

- 98% of O_2 is transported by binding to hemoglobin in erythrocytes [when O_2 binds with hemoglobin (Hb) oxyhemoglobin (oxy-Hb) is formed which shows are a red pigment].
- 2% of O_2 is dissolved in the blood plasma.

Carbon dioxide

- 7% of CO_2 is dissolved in the blood plasma.

- 23% of CO_2 binds with hemoglobin in erythrocytes. [when CO_2 binds to Hb, carbaminohemoglobin is formed which shows a bluish pigment].
- 70% of CO_2 reacts with water and forms carbonic acid in erythrocytes
  $CO_2 + H_2O \rightarrow H_2CO_3$
- Carbonic acid is immediately broken down by the enzyme carbonic anhydrase (CA), to become hydrogen ion and bicarbonate ion.
  $H_2CO_3 \rightarrow H^+ + HCO_3$
  Where H^+ quickly binds with Hb to prevent it from affecting blood pH and HCO_3 - diffuses into blood plasma and maintains an ionic balance with chloride anion (Cl -).

Respiration: is the sum of the processes included in passive movement of O_2 from the atmosphere to the tissues to support cell metabolism and the continual passive movement of metabolically produced CO_2 from the tissues to the atmosphere.

Breathing is an active process-requiring the contraction of skeletal muscles, the primary muscles of respiration include:

- **The inter costal muscles** (located between the rips)
- **The diaphragm** a sheet of muscles located between the thoracic and abdominal cavities.

1) Inspiration

Inspiration is an active process and is principally mediated by the diaphragm during quiet breathing.

Contraction of the diaphragm enlarges the chest cavity, and expands the lungs. Minimal movement of the diaphragm (a few centimeters) is sufficient to move several liters of gas. *The external intercostal and accessory muscles are not necessary for resting respiration, but they contribute substantially to deep respiration during exercise and respiratory distress.*

2) **Expiration** relaxation of external inter costal muscles and diaphragm and restores thoracic cavity lead to increases pressure in lungs then the air is exhaled.

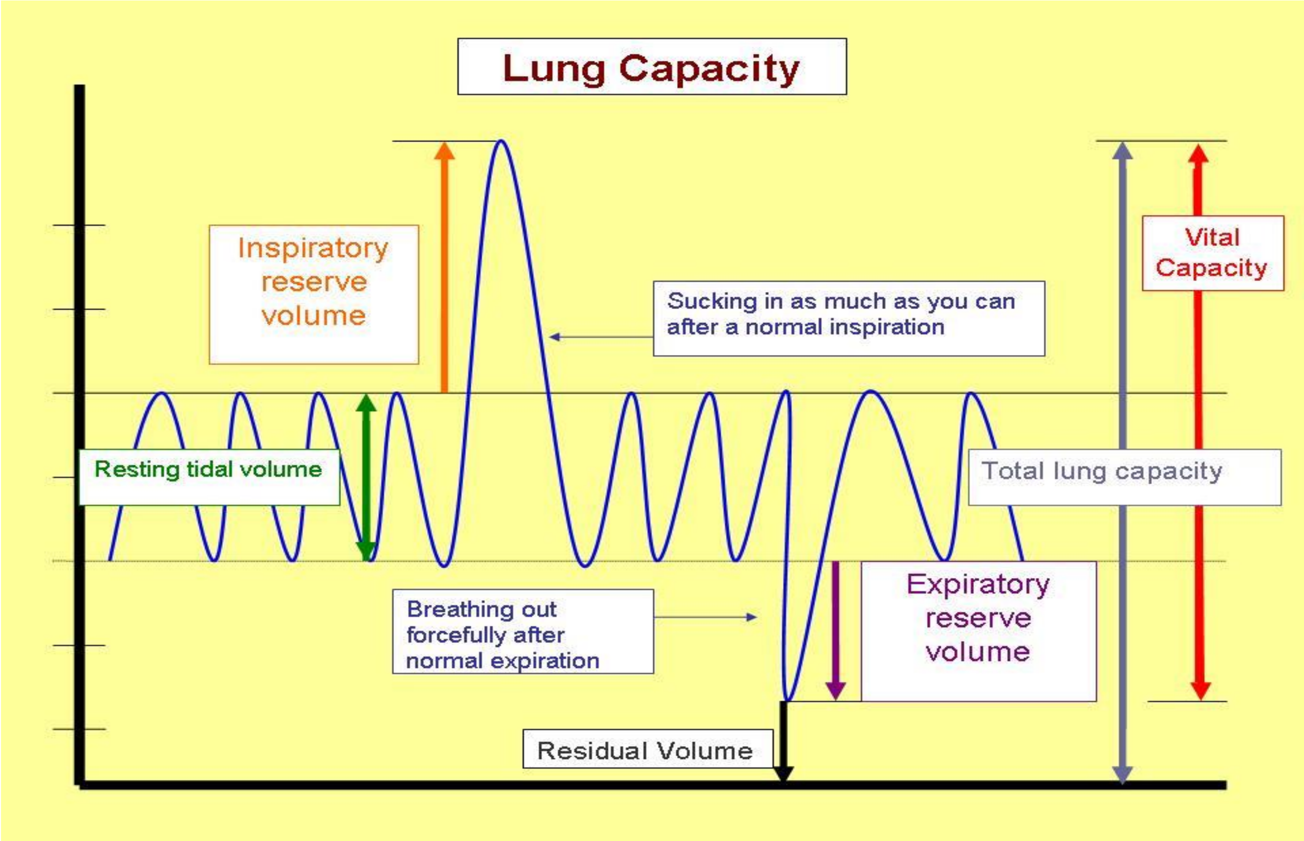
Dead Space: dead space is volume within the bronchial tree that is ventilated but does not participate in gas exchange.

Functions of some respiratory parts:

- **Nose: external nose and nasal cavity:** passageway for air, cleans the air, humidifies, warms air, smell, and speaks
- **Pharynx**: is the common opening for digestive and respiratory system have three regions (nasopharynx, aoropharynx ,laryngopharynx).
- **Larynx**: it's an open passageway for air movement it contains from epiglottis and vestibular folds (prevent swallowing food during moving in digestive tract throw larynx).
- **Vocal folds**: are the primary source of sound production
- **Trachea**: it's also a passageway respiratory air way, It form (primary bronchi, secondary bronchi , tertiary bronchi ,bronchioles)
- **Pleura fluid**: it's the liquid which surround the lungs and act to lubricated the surface of diaphragm and lungs throw movement during

Lung Capacity

- **Tidal volume (TV):** is the normal volume moved in or out of the lungs during quiet breathing. When we are in a relaxed state, only a small amount of air is brought in and out, about 500 mL.
- **Inspiratory Reserve Volume (IRV):** is the inspiratory breathing in very deeply and can increase lung volume by 2900 mL.
- **Expiratory Reserve Volume (ERV):** is the expiratory breathing in very deeply by contracting our thoracic and abdominal muscles and is about 1400 ml of air.
- **Vital capacity (VC):** is the total of tidal, inspiratory reserve and expiratory reserve volumes; it is called vital capacity because it is vital for life, and the more air you can move, the better off you are.



Control of Respiration

Like the heartbeat, breathing must occur in a continuous, cyclic pattern to sustain life processes. inspiratory muscles must rhythmically contract and relax to alternately fill the lungs with air and empty them. Both these activities are accomplished automatically, with-out conscious effort.

1. **The respiratory centers:** Involuntary respiration is controlled by the respiratory centers of the upper brainstem which contain chemoreceptors that detect pH levels in the blood and send signals to the respiratory centers of the brain to adjust the ventilation rate.
2. **The medulla oblongata:** is the primary respiratory control center. Its main function is to send signals to the muscles that control respiration to cause breathing to occur.

The pons: is the other respiratory center and is located underneath the medulla. Its main function is to control the rate or speed

Digestive System

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

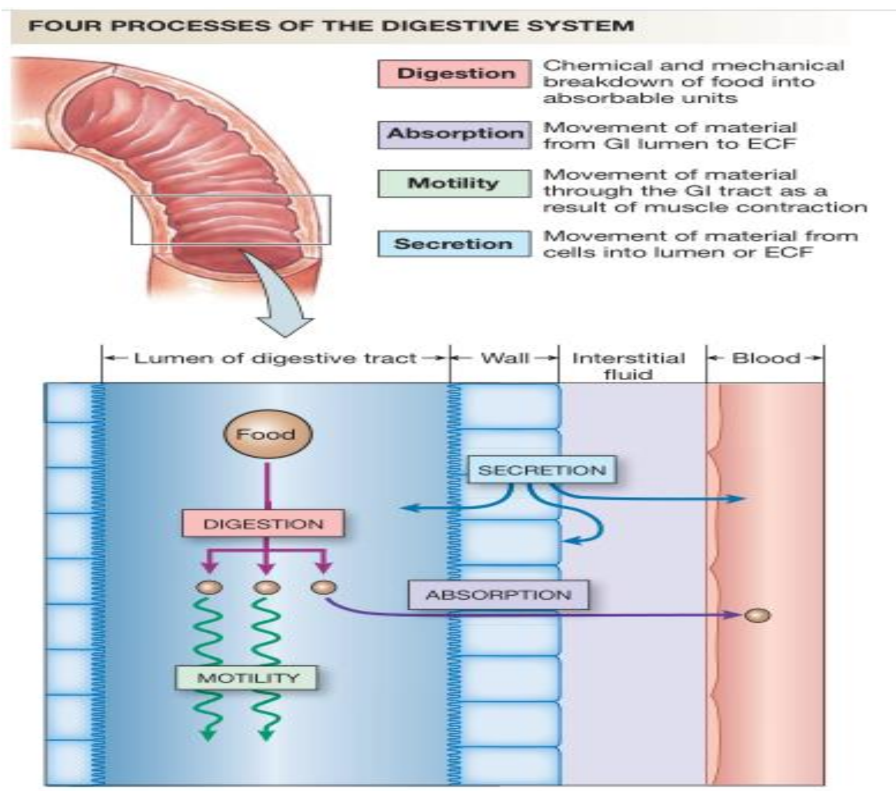
The primary function of the digestive (gastrointestinal or GI) system (*gastro* means "stomach") is to transfer nutrients, water, and electrolytes from the food we eat into the body's internal environment.

Digestive processes: -

1. **Mechanical**

   mastication (chewing), swallowing (deglutition) and movements of the GIT (motor functions)

2. **Chemical** Saliva, gastric juice, pancreatic juice, intestinal juice and bile



The main parts of the digestive tract and functions:

1. **Oral cavity**
   - **A.** *Ingestion*. Solid food and fluids are taken into the digestive tract through the oral cavity.
   - **B.** *Taste*.
   - **C.** *Mastication*. Movement of the mandible cause the teeth to break food down into smaller pieces.
   - **D.** *Digestion*. Amylase in saliva begins carbohydrate (starch) digestion.
   - **E.** *Swallowing*. The tongue forms food into a bolus and pushes the bolus into the pharynx.
2. **Pharynx**
   - **A.** *Swallowing*. Materials are prevented from entering the nasal cavity by the soft palate and from entering the lower respiratory tract by the epiglottis and vestibular folds.
   - **B.** *Breathing*. Air passes from the nasal or oral cavity through the pharynx to the lower respiratory tract.
   - **C.** *Protection*. Mucus provides lubrication.
3. **Esophagus**
   - **A.** *Propulsion*. Peristaltic contractions move the bolus from the pharynx to the stomach. The lower esophageal sphincter limits reflux of the stomach contents into the esophagus.
   - **B.** *Protection*. Glands produce mucus that provides lubrication and protects the inferior esophagus from stomach acid.
4. **Stomach**
   - **A.** *Storage*. Rugae allow the stomach to expand and hold food until it can be digested.
   - **B.** *Digestion*. Protein digestion begins as a result of the actions of hydrochloric acid and pepsin.

C. *Absorption*. Except for a few substances (e.g., water, alcohol, aspirin) little absorption takes place in the stomach.

D. *Protection*. Mucus provides lubrication and prevents digestion of the stomach wall. Stomach acid kills most microorganisms.

5. **Small intestine**

A. *Neutralization*. Bicarbonate ions from the pancreas and bile from the liver neutralize stomach acid to form a pH environment suitable for pancreatic and intestinal enzymes.

B. *Digestion*.

C. *Absorption*. The circular folds, villi, and microvilli increase surface area. Most nutrients are actively or passively absorbed.

D. *Excretion*. Bile from the liver contains bilirubin, cholestrol, fats, and fat-soluble hormones.

E. *Protection*. Mucus provides lubrication, prevents the digestion of the intestinal wall, and protects the small intestine from stomach acid. Peyer's patches protect against microorganisms.

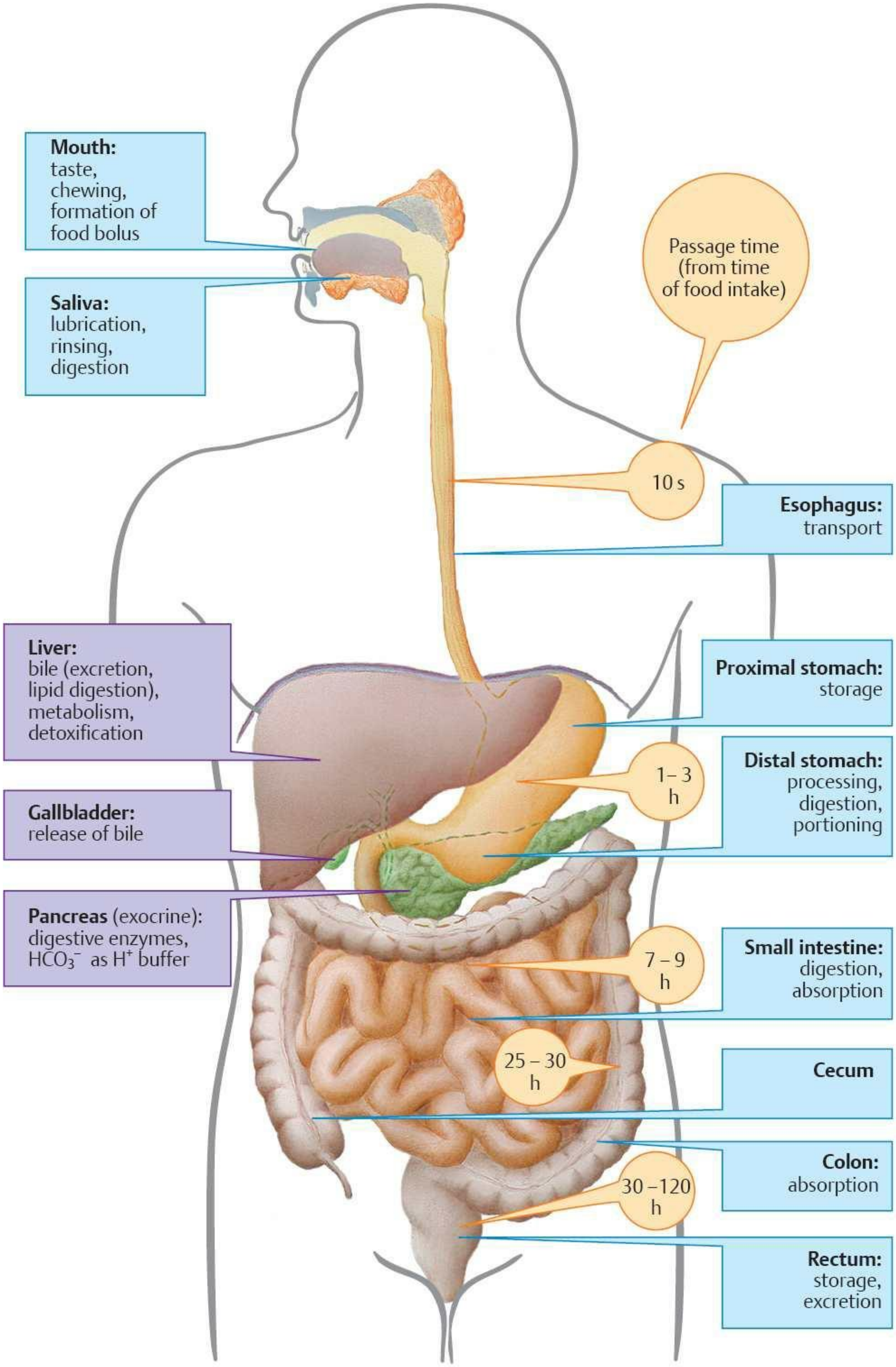
6. **Large intestine**

A. *Absorption*. The proximal half of the colon absorbs salts (e.g., sodium chloride), water, and vitamins (e.g., K) produced by bacteria.

B. *Storage*. The distal half of the colon holds feces until it is eliminated.

Muscular movement of the GI tract

1. **Peristalsis** – wavelike movement that occurs from the oropharynx to the rectum , allowing GI tract to push food particles toward the anus.
2. **Mixing**—mixing motion in the oral cavity and stomach that allows break down food into smaller particles.
3. **Segmentation** – regions of the small intestine contracting and relaxing independently , allowing the small intestine to digestive and absorb more efficiently



(After Kahle, Leonhardt & Platzer)

Stomach

The stomach is an enlarged segment of the digestive tract in the left superior part of the abdomen. Its shape and size vary from person to person.

gastric pits contain four major secretory cells:

1. **<u>chief cells</u>**

   i- secretes **pepsinogen**

   -activation of pepsinogen by low pH to form **pepsin**

   - pepsin is a protease for protein digestion

2. **<u>parietal cells</u>**

   i - secretes HCl

   ii -Intrinsic factor : binds to and allows B_{12} absorption in intestines

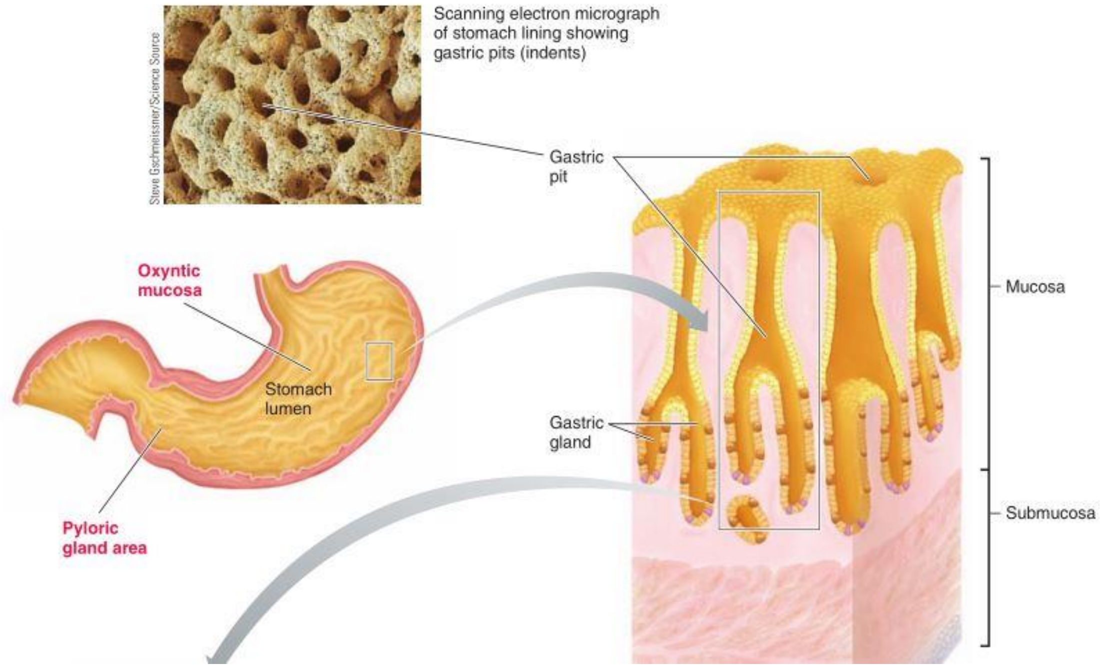
3. **<u>G-cell</u>**

   i - secretes **gastrin hormone**

   - gastrin activates gastric juice secretion and gastric smooth muscle "churning"

4. **<u>mucus cell</u>**

   i. protective role of mucus against acids and digestive enzymes



Chemical digestion & absorption in the stomach:

1. Carbohydrate digestion is continued with gastric amylase, resulting in disaccharides.
2. Protein digestion begins with pepsin, resulting in peptides (small chains of protein).
3. Lipid digestion begins with gastric lipases which can only break down certain lipids.
4. Absorption in the stomach is limited, where only small and fat-soluble substances can be absorbed—water , alcohol, aspirin , and certain drugs .
5. The result of all these mixing , chemical digestion , secretion, and absorption is a yellowish paste called **chyme** , which will be passed on to the small intestine .

Three major mechanisms of gastric regulation

1. **Cephalic phase:** is activated by the smell and taste of food and swallowing.
2. **Gastric phase:** is activated by the chemical effects of food and the distension of the stomach.
3. **Intestinal phase:** blocks the effect of the cephalic and gastric phases.

Small Intestine

1. The small intestine is the site at which the greatest amount of digestion and absorption occur..
2. Approximately 21 ft. long/ 1inch diameter.
3. It divided into three major segments
   A. duodenum ~12 inches
   B. jejunum ~8 ft
   C. ileum ~ 12 ft

Secretions of the Small Intestine

- The mucosa of the small intestine has glands for secretion of intestinal juice that primarily contain mucus, electrolytes, and water.

- Intestinal secretions lubricate and protect the intestinal wall from the acidic chyme and the action of digestive enzymes.
- mucosa also has circular folds, villi & microvilli for increased surface area
- "brush border" has many enzymes embedded in plasma membranes as peptidases, nucleosidases and enterokinase

Hormones secreted from SI (small intestine) mucosa

A. gastric inhibitory peptide (GIP)

i. fatty acids in chyme induce GIP secretion

ii. GIP inhibits gastric secretion

iii. GIP inhibits gastric "churning"

iv. GIP activates insulin secretion

B. secretin

i. inhibits gastric secretion

C. cholecystokinin (CCK)

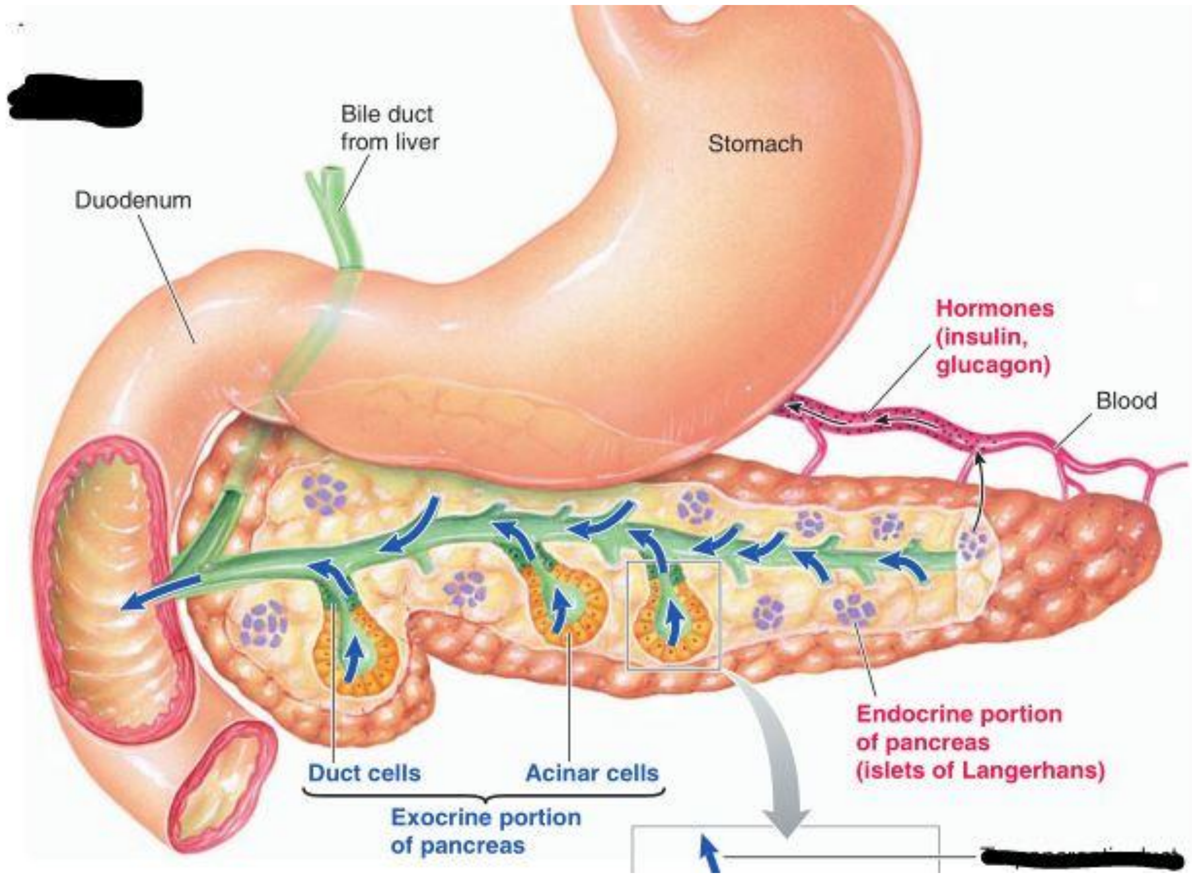
i. CCK fatty acids in chyme induce CCK secretion

ii. CCK slows gastric emptying

The Pancreas

- Is a complex organ composed of both endocrine and exocrine tissues.
- **The endocrine part** of the pancreas consists of pancreatic islets (islets of Langerhans). The islet cells produce insulin and glucagon, which are very important in controlling blood levels of glucose.
- **The exocrine part** of the pancreas is a compound acinar gland produce digestive enzymes.
- Approximately 1.5L/day pancreatic secretions produced.
- Secretions enter duodenum via two pancreatic ducts
- Many different components in these secretions
    - $NaHCO_3$ – buffers pH of chyme

- pancreatic amylase
- trypsinogen, chymotrypsinogen, trypsin acts on other proteases to activate them
- lipases



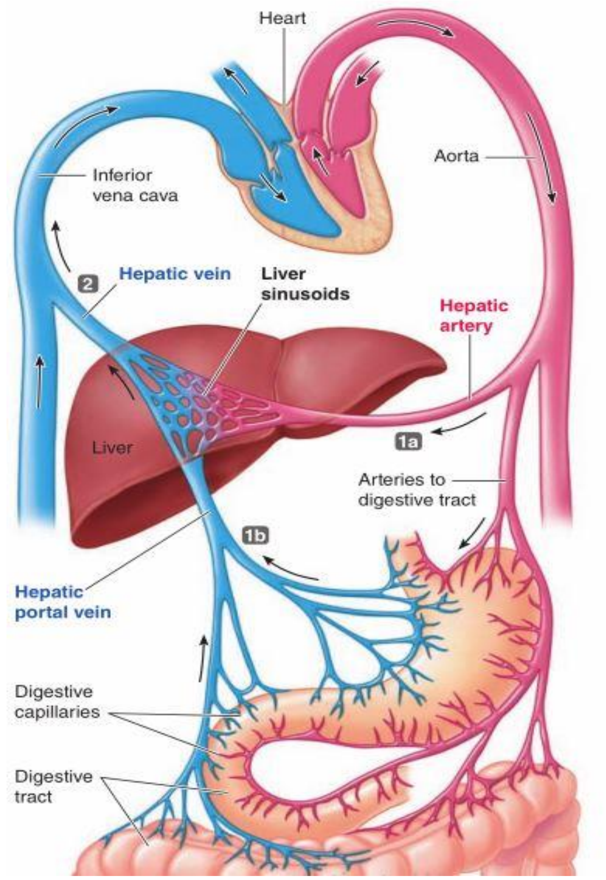
The Liver

- Liver is largest internal organ in body.
- Receives nutrient-rich blood from SI via the hepatic portal vein.
- Many functions to liver besides aiding in digestion

  1. **Bile synthesis** (approximately 1L/day):
     - Bile contains no digestive enzymes, but it plays a role in digestion because it neutralizes and dilutes stomach acid and emulsifies fats.
     - Bile salts (cholesterol derivatives) function to emulsify fats to aid enzymatic digestion

- Bile salts are recycled (are not excreted) from colon back into liver for reuse
- Main bile pigment is bilirubin – derived from RBC heme
- Bile is synthesized in liver, stored in gall bladder
- "gallstones" are concentrated precipitates of cholesterol (gallstones form when bile is too rich in cholesterol or lacking bile salts)

2. **Storage:** hepatocytes can remove sugar from the blood and store it in the form of glycogen.
3. **Nutrient Interconversion:** Ingested nutrients are not always in the proportion needed by the tissues. If this is the case, the liver can convert some nutrients into others. If, for example, a person is on a diet that is excessively high in protein, and an undersupply of lipids and carbohydrates, the hepatocytes break down the amino acids and cycle many of them through metabolic pathways so they can be used to produce adenosine triphosphate, lipids, and glucose.
4. **Detoxification:** It detoxifies many substances by altering their structure to make them less toxic or make their elimination easier.
5. **Synthesis:** produces many blood proteins, such as albumins, fibrinogen, globulins, heparin, and clotting factors.



Large Intestine

- Major function to absorb water, electrolytes and some vitamins .and eliminate indigestable matter
- The major structures of the LI

a) cecum with vermiform appendix

b) ascending, transverse, descending colon

c) sigmoid colon, rectum

- Haustra are pouches in wall of large intestine, its churning is sequential movement of contents from one haustra to the next
- Normal bacterial flora colonize colon where they break down certain indigestible substances and synthesize certain vitamins . (vitamin K synthesis by *E. coli* bacterium).

The Reproductive System

Reproduction describes processes that maintain the species rather than the individual. These processes help to assure that a viable egg meets a viable sperm. The physiology of reproduction is largely about endocrine control.

Normal functioning of the reproductive system is not aimed at homeostasis and is not necessary for survival of an individual, but it is essential for survival of the species.

The primary reproductive organs, or gonads, consist of a **pair of testes in the male** and **a pair of ovaries in the female**. In both sexes, the mature gonads perform the dual function of

(1) Producing gametes (**gametogenesis**), that is, spermatozoa (sperm) in the male and ova (eggs) in the female.

(2) Secreting sex hormones, specifically, testosterone in males and estrogen and progesterone in females.

Puberty

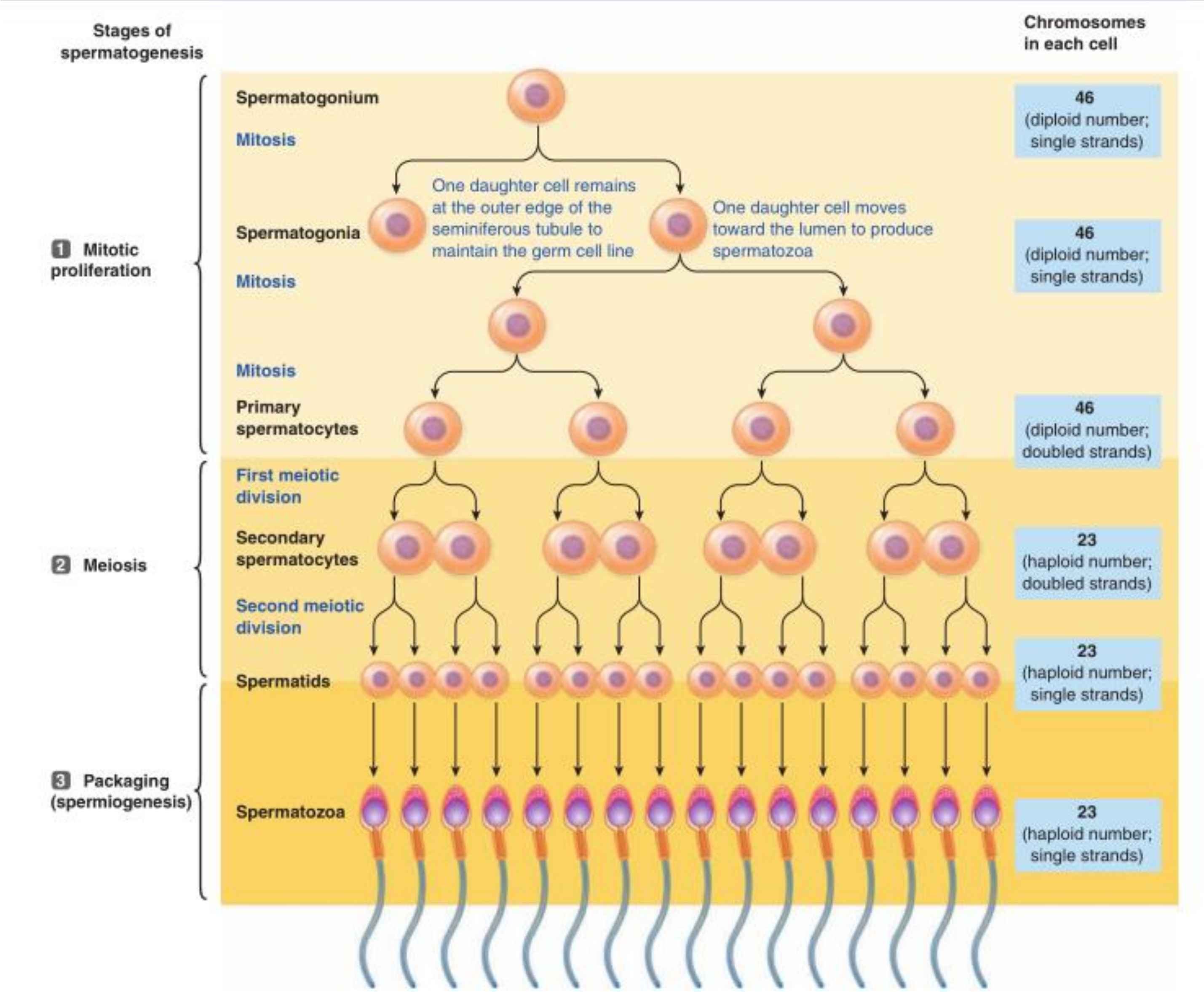
Puberty is the stage of life when the reproductive system matures and becomes functional.

Up until age 9, gonadotropin-releasing hormone (GnRH) from the hypothalamus and follicle stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary are secreted at low levels in both males and females.

At puberty, there is a shift to pulsatile GnRH release during various stages of sleep. GnRH causes upregulation of GnRH receptors in the anterior pituitary and a pulsatile release of LH and FSH (LH > FSH). Increased secretion of LH stimulates the production of the male sex hormones testosterone and dihydrotestosterone (DHT) and the female sex hormone estrogen that are responsible for the secondary changes in males and females at puberty.

Male Reproductive Physiology

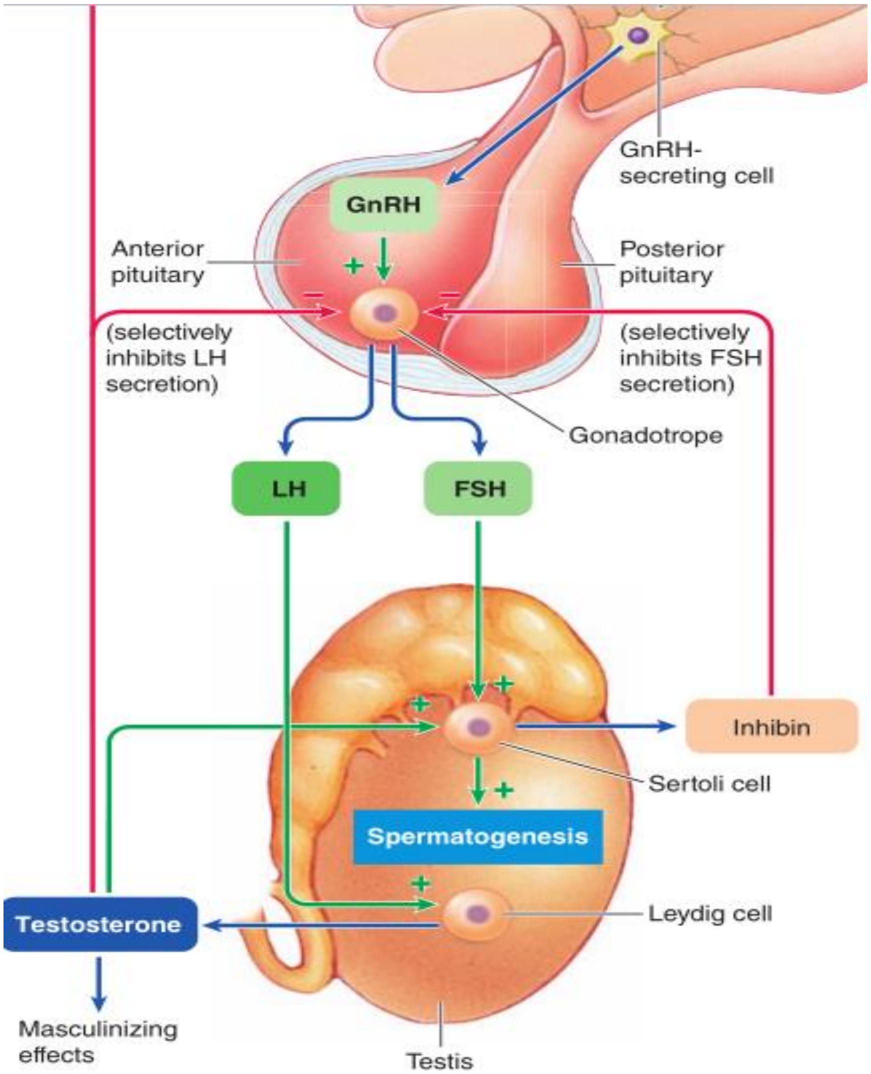
- The testes perform the dual function of producing sperm and secreting testosterone.
- About 80% of the testicular mass consists of highly coiled seminiferous tubules, within which spermatogenesis takes place.
- The endocrine cells that produce **testosterone**—the Leydig, or interstitial, cells— lie in the connective tissue (interstitial tissue) between the seminiferous tubules.
- **Testosterone** is a steroid hormone derived from a cholesterol precursor molecule.
- Once produced, some of the testosterone is secreted into the blood, where it is transported to its target sites of action.
- About 250 m (800 ft) of sperm-producing seminiferous tubules are packed within the testes
- Two functionally important cell types are present in these tubules:
  germ cells, most of which are in various stages of sperm development, and **Sertoli cells**, which provide crucial support for spermatogenesis
- **Spermatogenesis** is a complex process by which relatively undifferentiated primordial (primitive or initial) germ cells, the spermatogonia (each of which contains a diploid complement of 46 chromosomes), proliferates and are converted into extremely specialized, motile spermatozoa (sperm), each bearing a randomly distributed haploid set of 23 chromosomes.



LH and FSH from the anterior pituitary control testosterone secretion and spermatogenesis:

- The testes are controlled by the two gonadotropic hormones secreted by the anterior pituitary, luteinizing hormone (LH) and FSH, both of which are produced by the same cell type, the gonadotrope. Both hormones in both sexes act on the gonads by activating cAMP.
- LH and FSH, which are named for their functions in females, act on separate components of the testes.
- LH acts on Leydig cells to regulate testosterone secretion.
- FSH acts on Sertoli cells to enhance spermatogenesis.

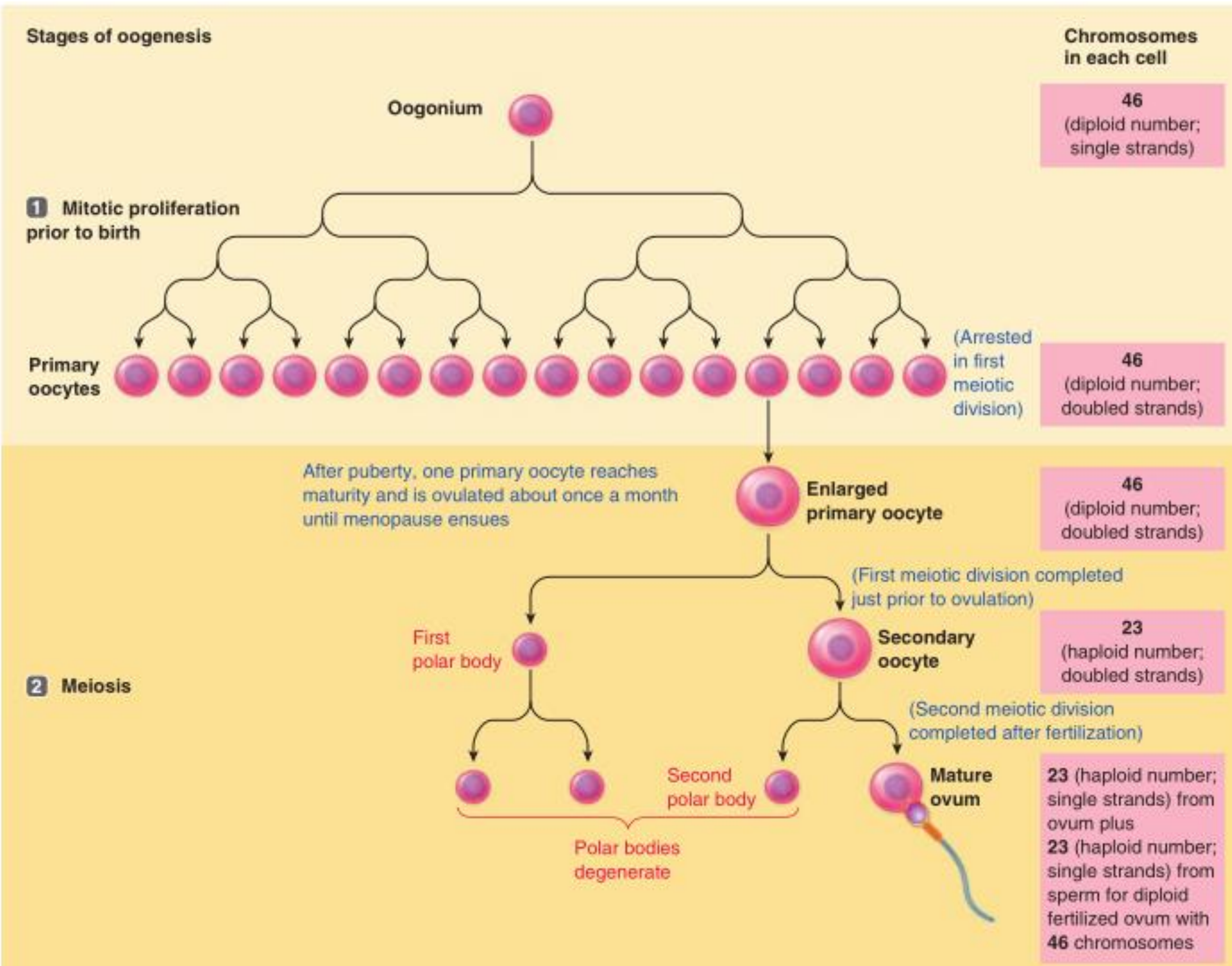
➢ Secretion of both LH and FSH from the anterior pituitary is stimulated in turn by a single hypothalamic hormone, gonadotropin-releasing hormone (GnRH).



Female Reproductive Physiology

- Female reproductive physiology is more complex than male reproductive physiology.
- Unlike the continuous sperm production and essentially constant testosterone secretion characteristic of the male, release of ova is intermittent, and secretion of female sex hormones displays wide cyclic swings.
- The tissues influenced by these sex hormones also undergo cyclic changes, the most obvious of which is the **monthly menstrual cycle** (menstruus means “monthly”).

- During each cycle, the female reproductive tract is prepared for the fertilization and implantation of an ovum released from the ovary at ovulation.
- If fertilization does not occur, the cycle repeats.
- **Oogenesis;** Oogenesis is the production of mature oocytes from oogonia. Oogonia within follicles in the ovary enter the prophase of meiosis and become primary oocytes approximately between 8 weeks gestation and 6 months after birth. They then remain quiescent until they complete the first meiotic division following recruitment into the menstrual cycle and ovulation many years later.



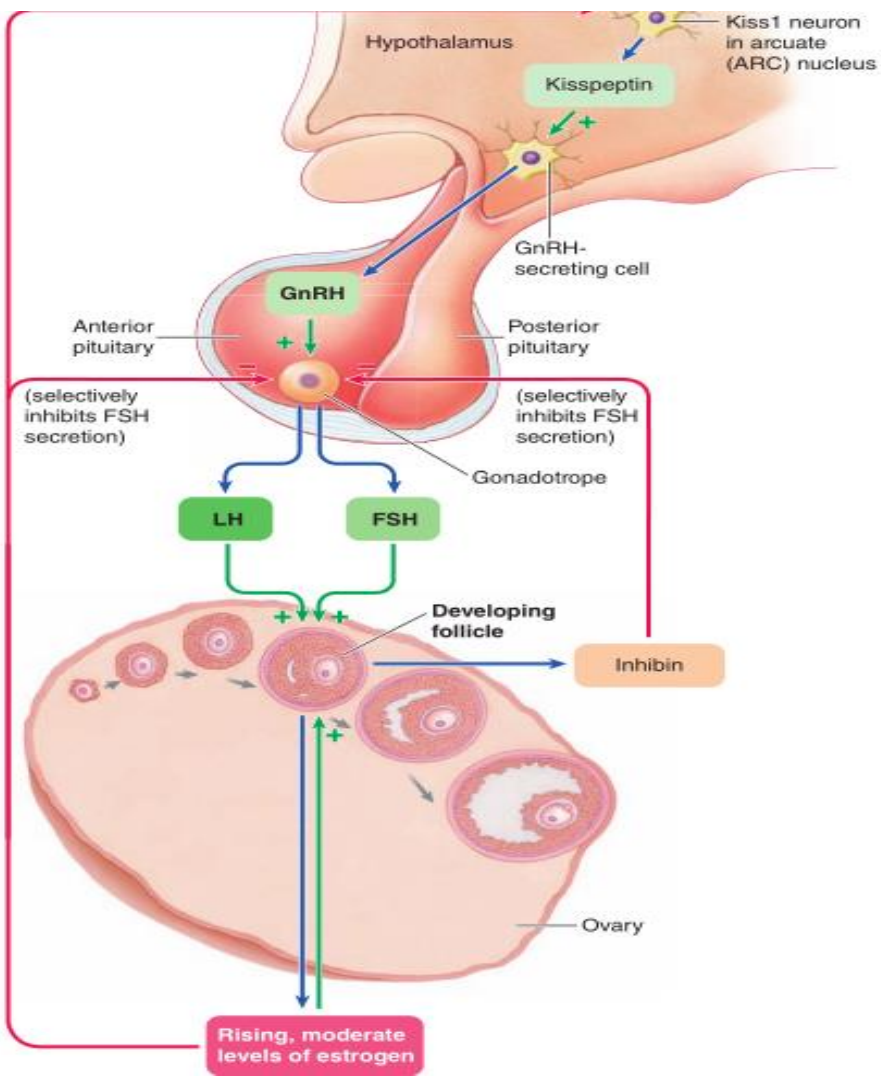
Female Sex Hormones: Estrogens and Progesterone

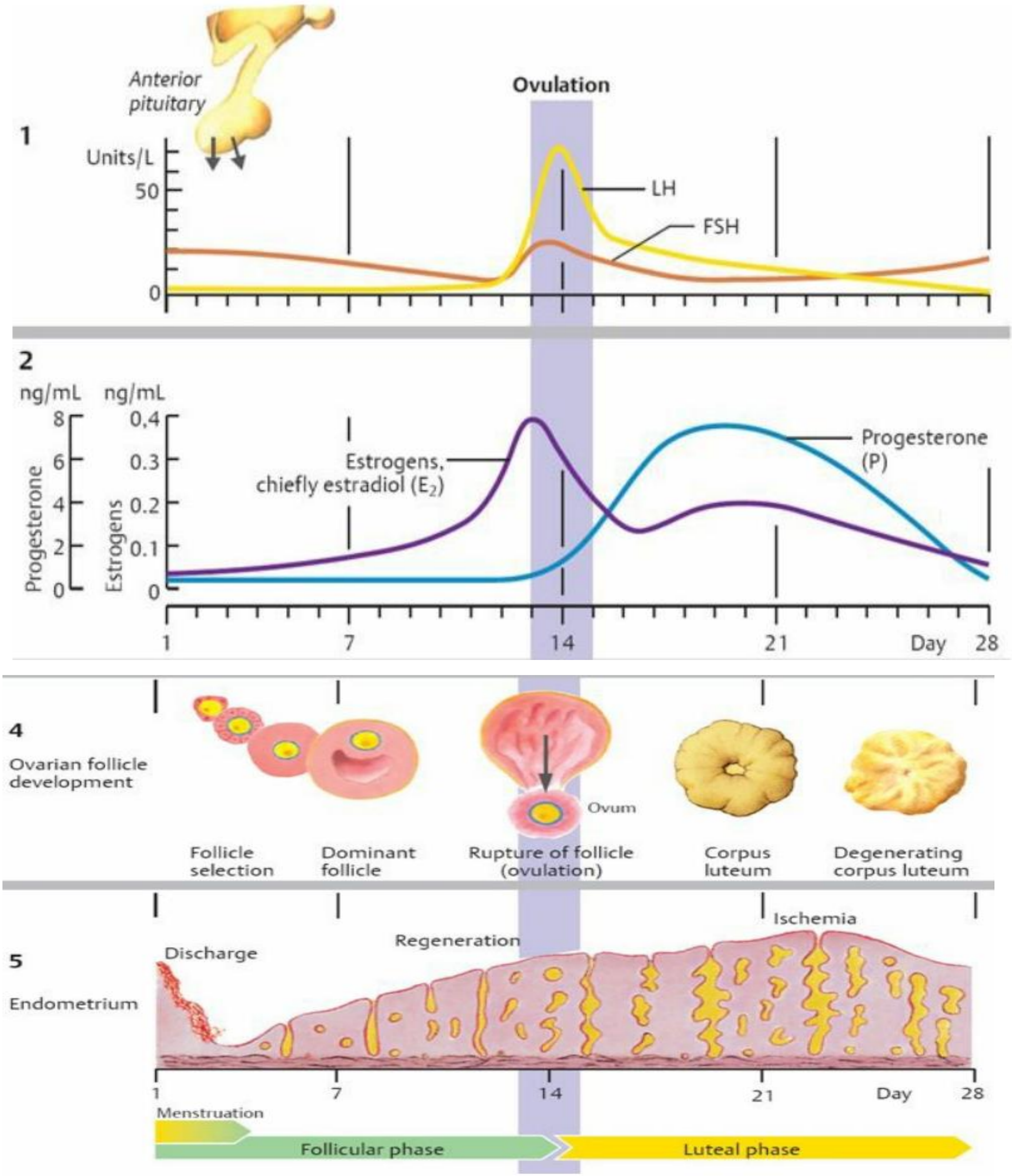
- The ovaries secrete estrogens (estrone [E 1], estradiol [E 2], and estriol [E 3]), and progesterone.

- Hypothalamic–anterior pituitary control: GnRH release from the hypothalamus is pulsatile.
- In females, GnRH pulses vary in accordance with the stage of the menstrual cycle, and the ovarian production of estrogen and progesterone.
- GnRH stimulates the anterior pituitary to produce FSH and LH in a corresponding pulsatile manner.
- FSH and LH act on the ovaries to cause the following:

-FSH stimulates estradiol synthesis and the development of multiple follicles.

-LH stimulates the synthesis of pregnenolone, and the LH surge causes ovulation.





Anterior pituitary
Ovulation
1
Units/L
50
0
LH
FSH
2
ng/mL
ng/mL
8
6
4
2
0
0,4
0.3
0.2
0.1
0
Progesterone
Estrogens
Estrogens, chiefly estradiol (E_2)
Progesterone (P)
1
7
14
21
Day
28
4
Ovarian follicle development
Ovum
Follicle selection
Dominant follicle
Rupture of follicle (ovulation)
Corpus luteum
Degenerating corpus luteum
5
Endometrium
Discharge
Regeneration
Ischemia
1
7
14
21
Day
28
Menstruation
Follicular phase
Luteal phase

Nervous System

The nervous system is the part of an animal that coordinates its actions by transmitting signals to and from different parts of its body.

To maintain homeostasis, cells must work in a coordinated fashion toward common goals. The two major regulatory systems of the body that help ensure life-sustaining coordinated responses are the nervous and endocrine systems.

Neural communication

- Is accomplished by means of nerve cells, or neurons.
- Which are specialized for rapid electrical signaling and for secreting neurotransmitters, short-distance chemical messengers that act on nearby target organs.
- The nervous system exerts rapid control over most of the body's muscles and exocrine secretions.

Hormonal communication

- Is accomplished by hormones.
- Which are long-distance chemical messengers secreted by the endocrine glands into the blood.
- The blood carries the hormones to distant target sites, where they regulate processes that require duration rather than speed, such as metabolic activities, water and electrolyte balance, and growth.

Functions of the Nervous System

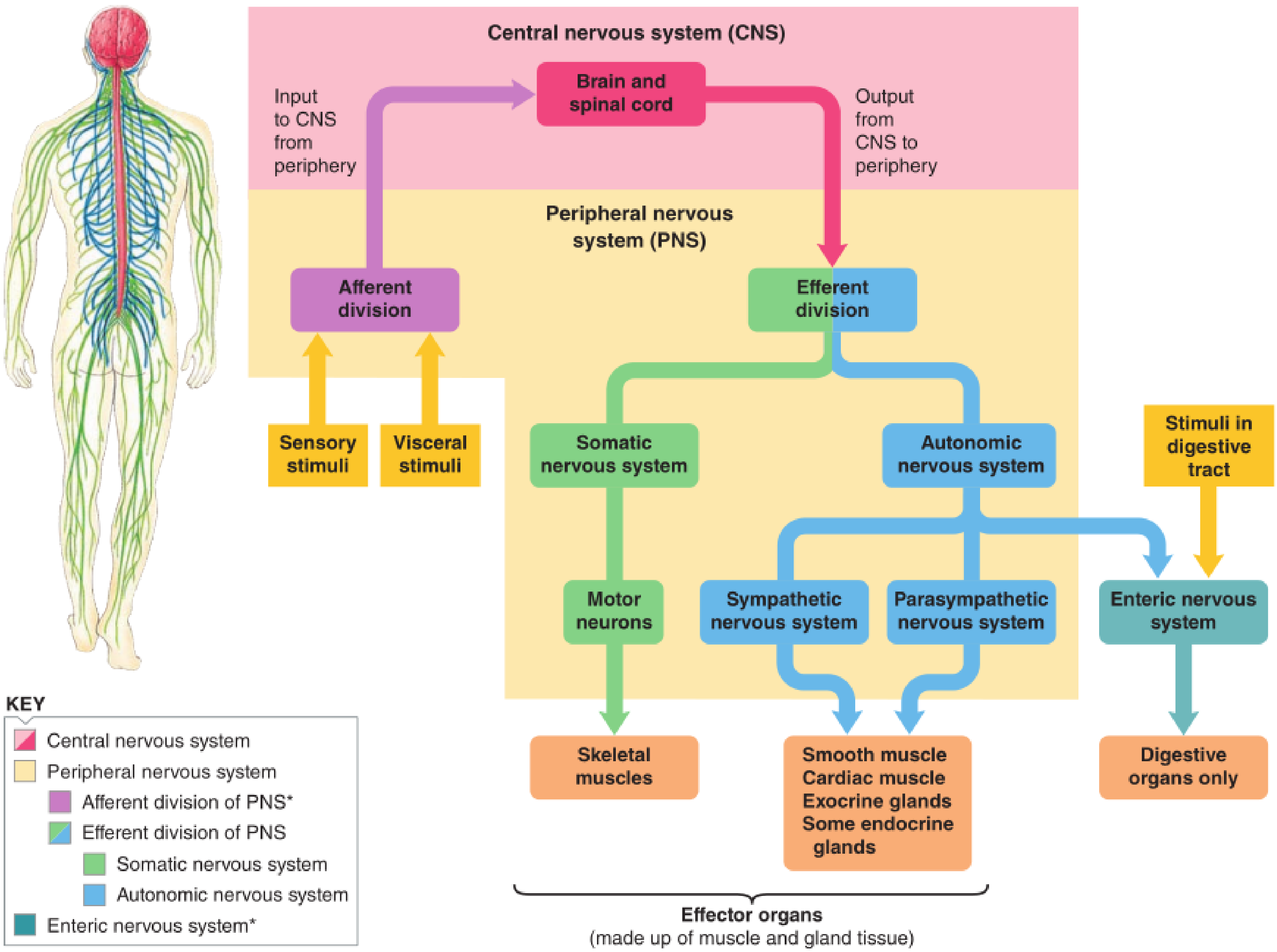
1. Integration of body processes
2. Control of voluntary effectors (skeletal muscles).
3. Control of involuntary effectors (smooth muscle, cardiac muscle, glands).

4. Response to stimuli
5. Responsible for conscious thought and perception, emotions, personality, the mind.

Divisions of the nervous system

The nervous system comprises three major systems;

1. **The autonomic nervous system**: Is the part of the nervous system which is concerned with the involuntary control of the visceral activity. It includes sympathetic, parasympathetic and enteric divisions.
2. **The somatic nervous system**: Is the part of the nervous system which is concerned with conscious perception of different sensations, and voluntary control of the muscular activity.
3. **The integrative nervous system**: Is the part of the nervous system which is concerned with the sophisticated functions of the brain. These functions include memory, thinking, learning, language, speech, emotions and general behavior.

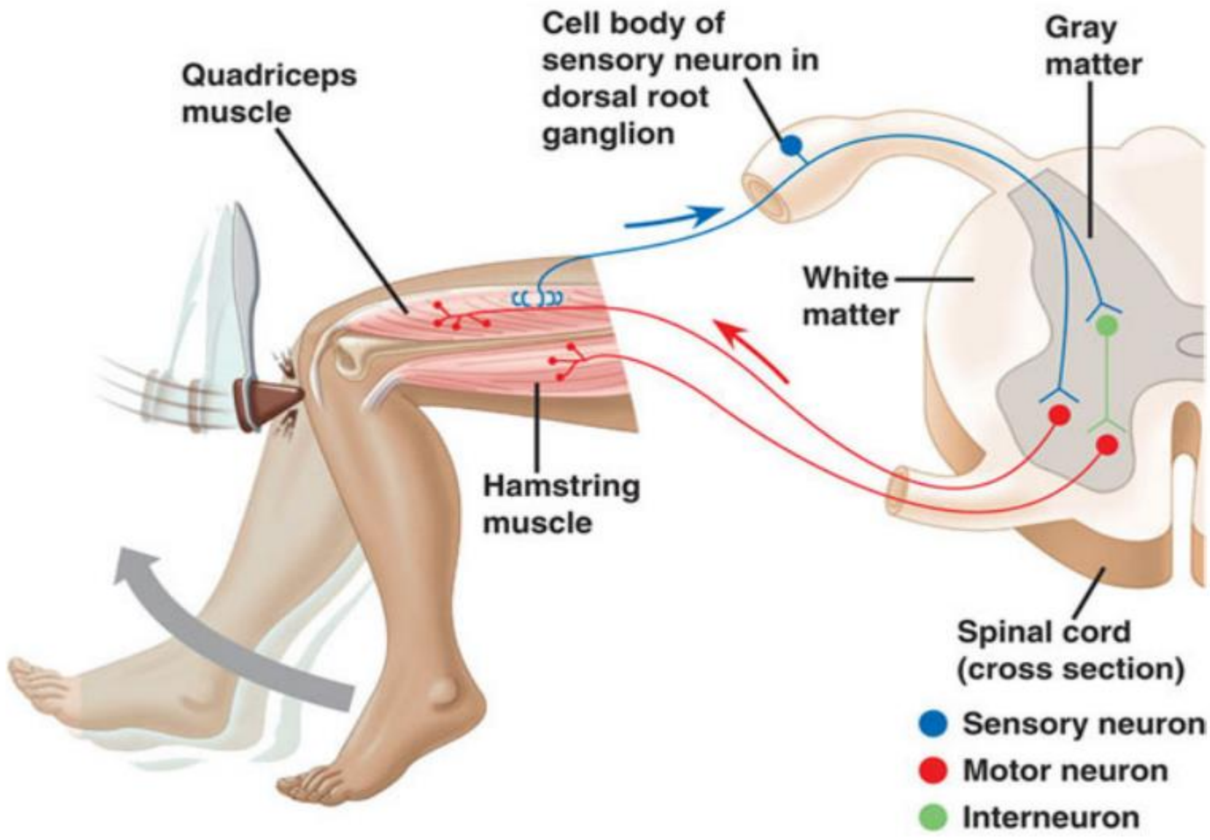


All these three systems and divisions are interconnected and their functions are integrated together and with other systems in the body.

The basic functional unit in the nervous system is the **reflex action**.

A reflex action is an involuntary action in response to a stimulus e.g. a. painful stimulus applied to the hand leads to reflex withdrawal of the arm (the withdrawal reflex).

The basic structural unit of the nervous system which is capable of conducting a reflex action is the reflex arc. A reflex arc; consists of 5 components:



1. **Receptor:** A sensor which is excited by the stimulus.
2. **Afferent nerve:** This conveys input signals to the CNS. The afferent nerve is also called the sensory nerve.
3. **Center:** A collection of neurons that receive the sensory information and issue the order for proper response.
4. **Efferent nerve:** A nerve that conveys output signals from the CNS to the effector organ. The efferent nerve is either a motor nerve to a muscle or a secretary nerve to a gland.
5. **Effector organ:** A muscular or glandular structure which receives the final order and executes the reflex response.

Neural synapses: its small gap or space between the axon of one neuron and the dendrite of another. which uses neurotransmitters to start the impulse in the second neuron or an effector (muscle or gland).

Neurotransmitters: Chemicals in the junction which allow impulses to be started in the second neuron. It also Propagated action potentials carry information through axons over long distances.

Examples of neurotransmitters are Acetylcholine, Norepinephrine, Epinephrine, Dopamine, Glutamate, Gamma-Aminobutyric Acid, Serotonin, Glycine, Histamine and Nitric Oxide.