XII - BIO.

LESSON NO. 8

RESPIRATION AND CIRCULATION

Gaseous exchange in plants :

- $C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O + 38\ ATP$
- Organs for respiratory surface

a. It should have a large surface area.

b. It should be thin, highly vascular and permeable to allow exchange of gases.

c. It should be moist.

- **Gaseous exchange in plants :**

Plants facilitate gaseous exchange by **diffusion.** A terrestrial flowering plant has many air spaces between the cells of stem, leaf and root. These air spaces are continuous. **Oxygen diffuses** into the air space through stomata (the pores on leaves and young stems), carbon dioxide and water vapour diffuse out. Woody flowering plants (trees and shrubs) have an *external impervious bark*. Here, gaseous exchange occurs through small pores in the stem surface, called **lenticels.**

https://www.youtube.com/watch?v=MvXboiJPi5c

https://www.youtube.com/watch?v=RYiYoY7mu

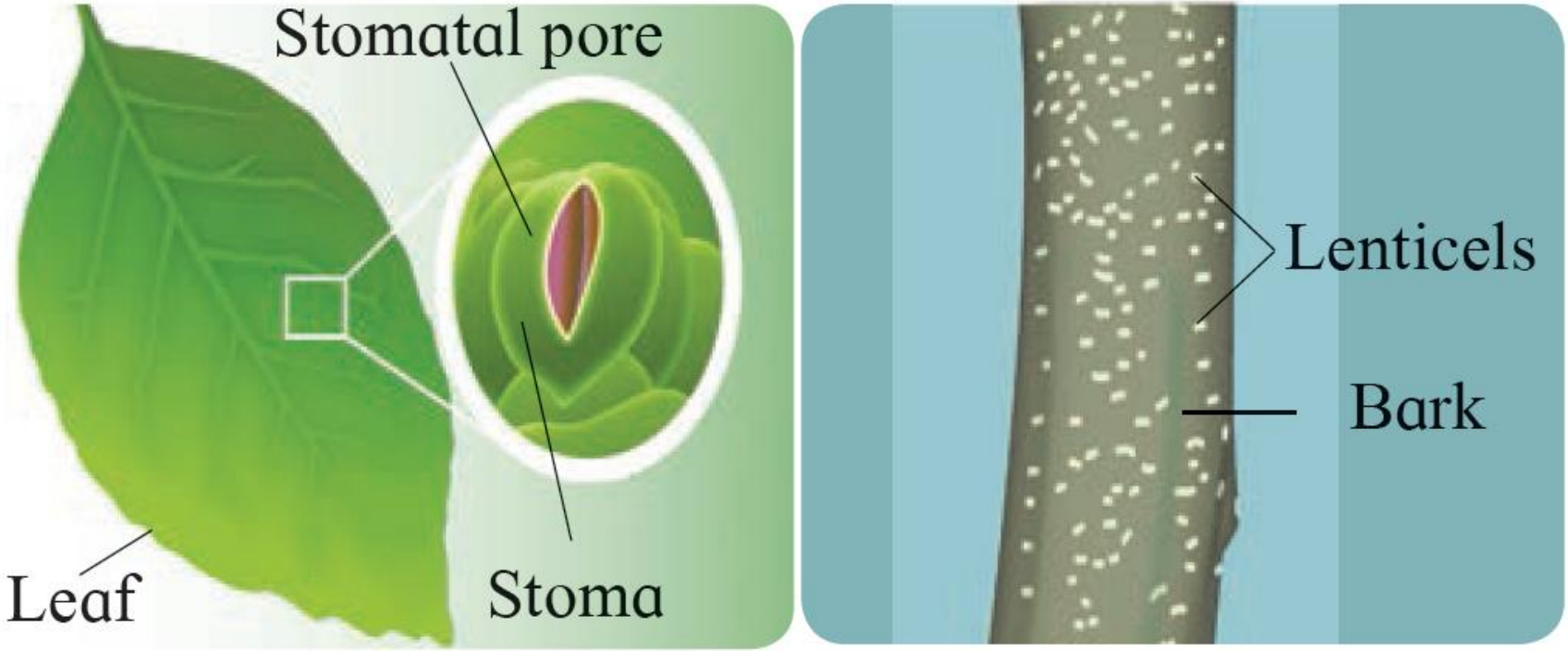


Fig. 8.1 : Organs of gaseous exchange in plants

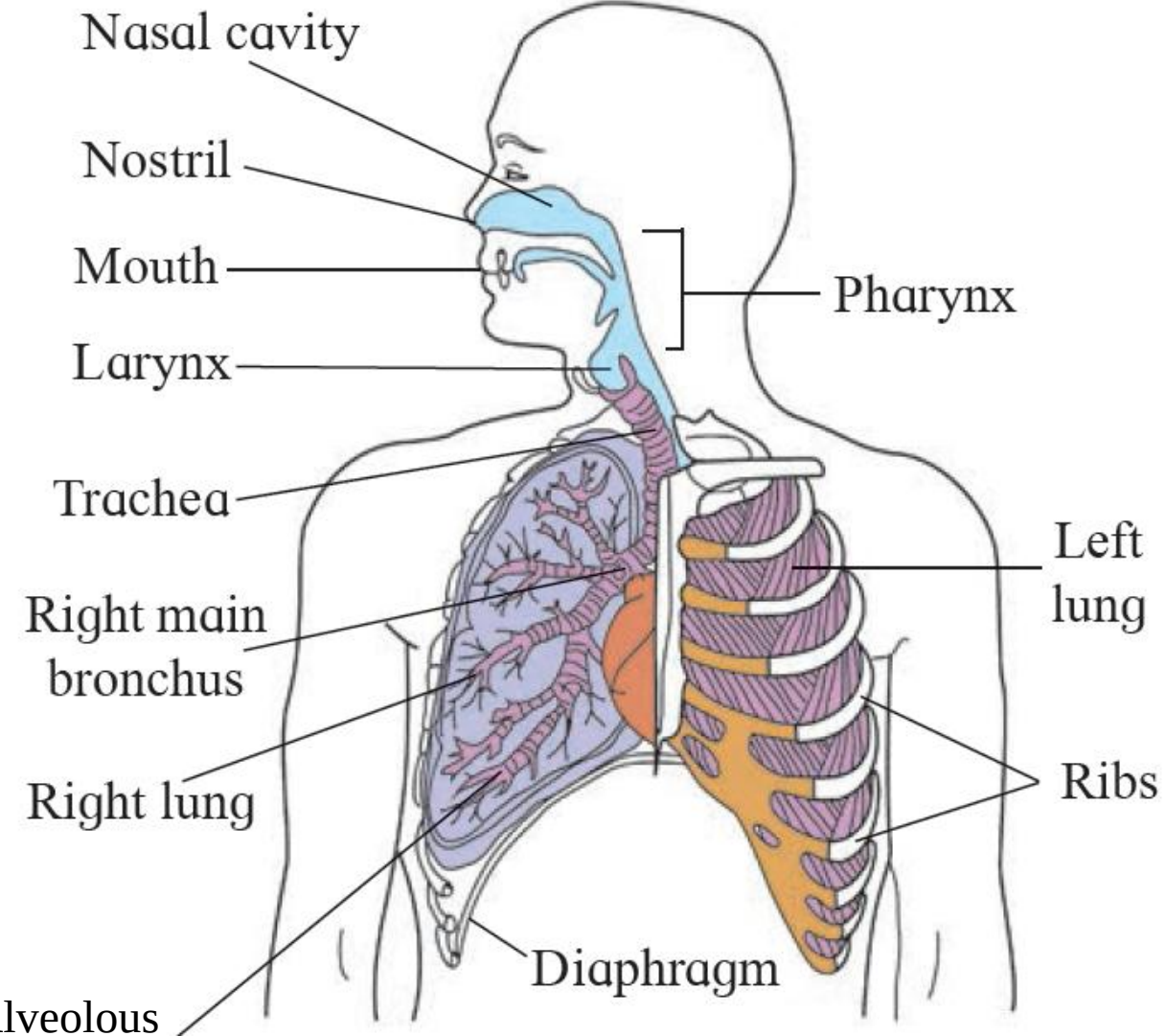
https://www.youtube.com/watch?v=qA9L7pWmxHc

Respiration in Animals

Organism	Habitat	Respiratory surface/ organ
Protists, Sponges and Coelenterates	Aquatic	Plasma membrane
Flatworms like Planaria, Annelids (earthworm, nereis, leech), amphibians (frog)	Aquatic or semiquatic	Plasma membrane, general body surface (moist skin)
Insects	Terrestrial	Tracheal tubes and spiracles
Arachnids like spiders and scorpions	Terrestrial	Book lungs
Limulus (Arthropod)	Aquatic	Book gills
Amphibian tadpoles of frog, salamanders and newts	Aquatic	External gills
Fish	Aquatic	Internal gills
Reptiles, Birds and Mammals	Terrestrial	Lungs
Turtles	Underwater	cloaca

Table 8.2 : Respiratory surface/ organ in organisms

Human Respiratory System



Respiratory Organs

- Nose
- Pharynx
- Larynx
- Trachea (wind pipe)
- Bronchi
- Lungs
- Alveoli
- Diaphragm
- https://www.youtube.com/watch?v=zd_e9gtDExM

- The respiratory system can be divided into an **upper respiratory system** having external nares, nasal cavities, internal nares, nasopharynx, nose, throat and associated structures. The **lower respiratory system** refers to the larynx, trachea, bronchi, bronchioles and lungs.

1. Nose : The nasal cavity is divisible into right and left nasal chambers by a **mesethmoid cartilage.** Each nasal chamber is further divided into three regions.

- **i. Vestibule :** Its skin has hair for filtering the air and trapping the dust and suspended particles in the inhaled air.
- **ii. Respiratory part (conditioner) :** The middle thin walled highly vascular part for warming and moistening the inhaled air.
- **iii. Olfactory or sensory chamber :**
- The uppermost part is lined by olfactory epithelium for detection of smell.

2. Pharynx : It is divisible into three parts.

- The **nasopharynx**, **oropharynx** (common passage for food and air), and **laryngopharynx**.
- The pharynx has a set of lymphoid organs called **tonsils.**

- **Larynx :**
- It is called voice box which contains **vocal cords** for producing sound. Its wall is made up of ***cartilage plates*** held by membranes and muscles. Internally, it is lined by a pair of folds of elastic vocal cords (true vocal cords).
- The larynx opens into the laygopharynx through a slit like opening called **glottis.** This opening of the trachea or wind pipe is guarded by a leaf like flap called **epiglottis.** It prevents the entry of food into trachea.

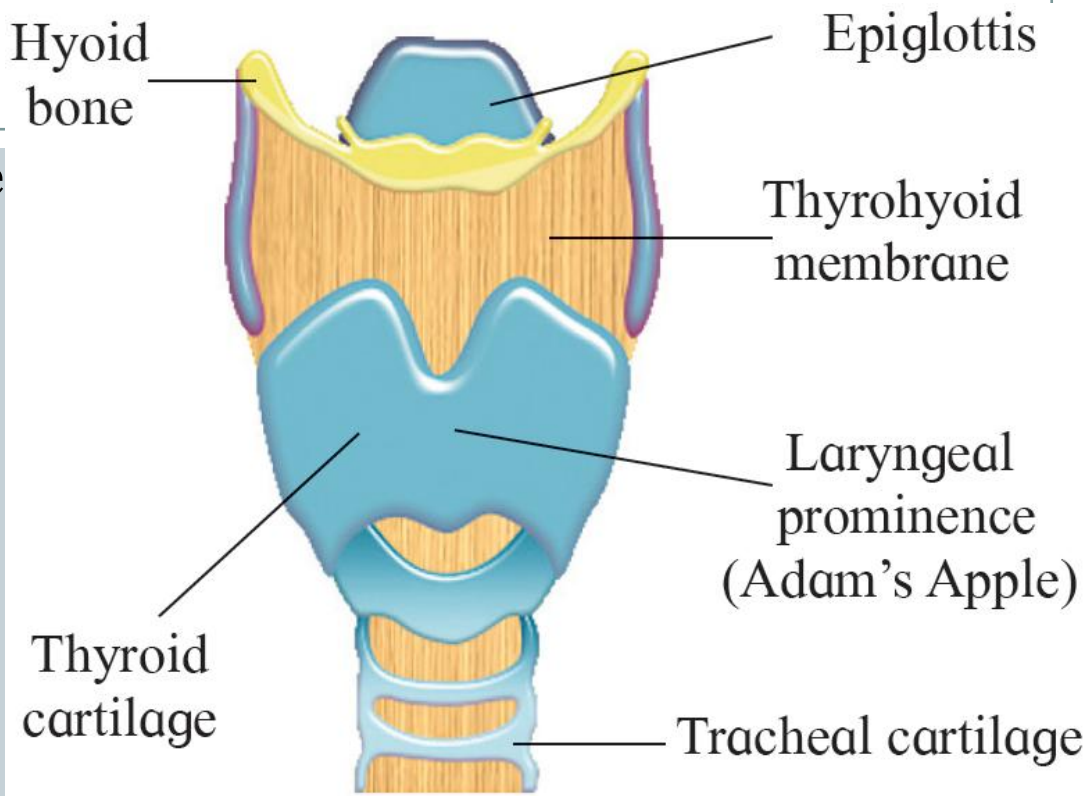


Fig. 8.4 : Larynx

- **Trachea (wind pipe) :** It is a long tube 10 to 12 cm in length. It is supported by 'C' shaped 16 to 20 rings of cartilage which prevent the collapse of trachea. It is lined internally with *ciliated, pseudostratified epithelium and mucous glands* that trap the unwanted particles preventing their entry into the lungs.
- **Bronchi :** The trachea divides into **right and left primary bronchi.** The bronchi are supported internally by 'C' shaped incomplete rings of cartilage. The primary bronchi divide to form **secondary** and **tertiary** bronchi which lead into **terminal bronchioles ending into alveoli**.
- **Lungs :** These are the main respiratory organs of humans. One pair of spongy and elastic lungs are present in the thoracic cavity. Each lung is enclosed and protected by a **double pleural membrane**, outer parietal and inner visceral membrane. Between the two pleura is a pleural cavity filled with a lubricating fluid called **pleural fluid**. It is secreted by the membranes. The **right lung** is larger and divided into **3 lobes**, while the **left lung** is smaller and divided into **2 lobes**. https://www.youtube.com/watch?v=PlNEabFZ5Qk

- Each lobe of the lung has the terminal bronchioles ending in a **bunch of air sacs**, each with **10 to 12 alveoli**.
- **Alveoli :** These are thin walled lobulated structures, like a bunch of grapes. Each alveolus is surrounded by a **network of capillaries** of **pulmonary artries and veins.**

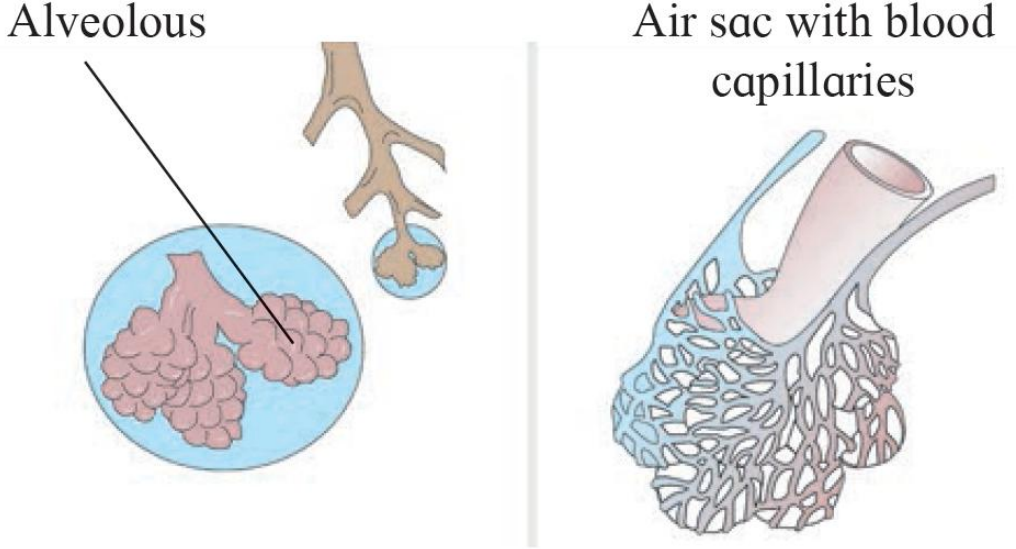


Fig. 8.3 : Human Respiratory system

These have **highly elastic wall** made up of a single layer of squamous epithelium **resting on a basement membrane** of connective tissue. There are about **700 million alveoli in the lungs** and they provide the surface area for exchange of gases.

Diaphragm : It is a muscular septum that separates the thoracic and abdominal cavity. It is dome shaped and on contraction it becomes flattened.

Mechanism of respiration

- A. Breathing
- B. External respiration
- C. Internal respiration
- D. Cellular respiration

https://www.youtube.com/watch?v=k9BWCnnXOG8

A. Breathing : – a. Inspiration
b. Expiration

It is a **physical process** by which **gaseous exchange** takes place between the *atmosphere and the lungs*. Both **inspiration** and **expiration** involved parts of the **thoracic cage, the ribs, sternum** and **the intercostal muscles** + **muscles of the diaphragm**

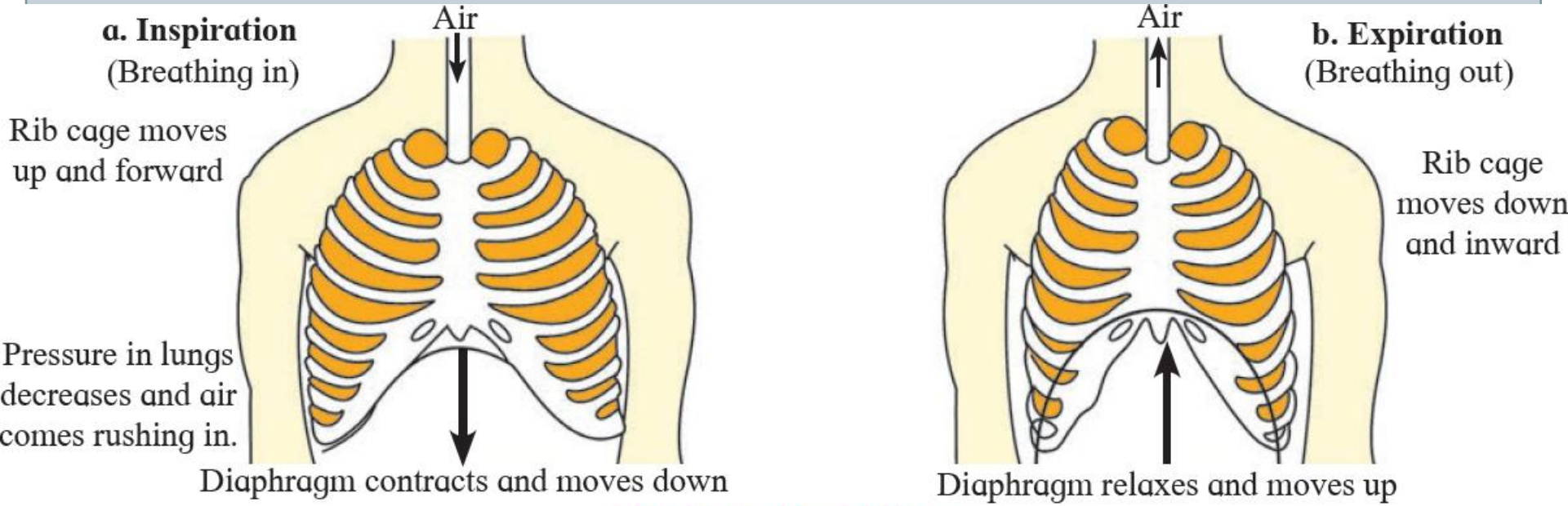


Fig. 8.5 : Breathing

a. Inspiration

- **Pressure gradient** formed between the lungs and the atmosphere, It is **an active process** in which the **diaphragm becomes flat** and goes downward,
- The external intercostal muscles contract so the ribs and sternum **move upward and outward.**
- This *leads to an increase in the* ***thoracic volume*** and a *decrease* in **pressure of thorax and the lungs.** To equalize the low pressure inside the lungs, air from the atmosphere rushes into lungs.

b. Expiration

- The **thorax contracts** causing air to be exhaled.
- The **diaphragm relaxes** and is **pushed upwards**. It becomes **dome shaped**.
- The intercostal muscles also **relax** pulling the rib cage **inward** and **downward**.
- This causes a decrease in ***thoracic volume*** and leads to *increase* in **pressure in the thorax and the lungs** as compared to the atmospheric pressure. So air from the lungs rushes out.

B. External Respiration

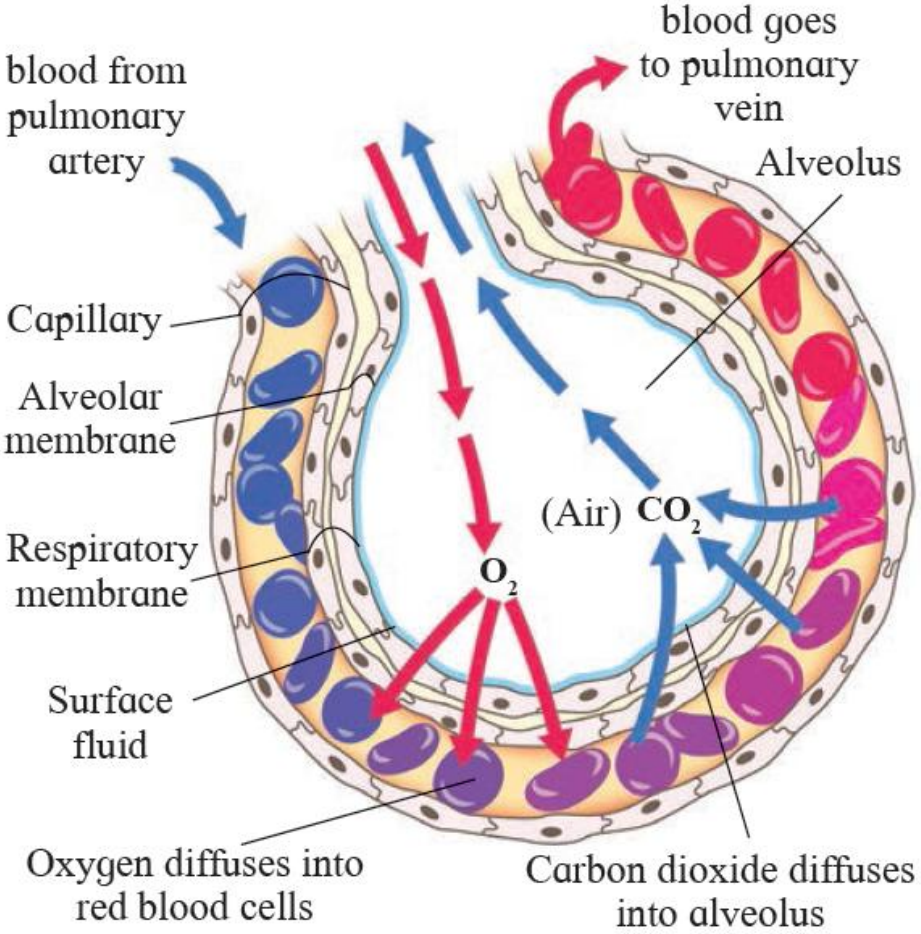


Fig. 8.6 : Exchange of gases between alveolus and capillary

Exchange of gases at the alveolar level :

https://www.youtube.com/watch?v=HI-R8uAh2fI

- **An alveolus** consists of a layer of *simple squamous epithelium* resting on a basement membrane. It is intimately associated with a **dense network of capillaries.**
- **The capillary wall** is also made up of *simple squamous epithelium* resting on a thin basement membrane.
- Together they make up the **respiratory membrane** through which gaseous exchange occurs i.e. *between the alveolar air and the blood*.
- **Diffusion of gases** will take place from an area of higher partial pressure to an area of lower partial pressure until the partial pressure in the two regions reaches equilibrium.
- The *partial pressure of carbon-dioxide* **of blood** entering the pulmonary capillaries is **45 mmHg** while *partial pressure of carbon- dioxide* **in alveolar air** is **40 mmHg**.
- Due to this difference, carbon dioxide diffuses from the capillaries into the alveolus.
- Similarly, *partial pressure of oxygen* **of blood** in pulmonary capillaries is **40 mmHg** while in alveolar blood it is **104 mmHg**.
- Due to this difference oxygen diffuses from alveoli to the capillaries.

Pulmonary volumes and capacities (Normal values)

Lung Volumes :

Tidal volume (T.V.) : It is the volume of air inspired or expired during normal breathing. It is 500 ml.

Inspiratory reserve volume (IRV) : The maximum volume of air, or the extra volume of air, that is inspired during forced breathing in addition to T.V. Its value is 2000 to 3000ml.

Expiratory reserve volume (ERV) : The maximum volume of air that is expired during forced breathing after normal expiration. Its value is 1000 to 1100ml.

Dead space (DS) : The volume of air that is present in the respiratory tract (from nose to the terminal bronchioles), but not involved in gaseous exchange. It is 150 ml.

Residual volume (RV) : The volume of air that remains in the lungs and the dead space even after maximum expiration. It is 1100 to 1200ml.

Lung capacities :

Total Lung capacity : The maximum amount of air that the lungs can hold after a maximum forcefull inspiration (5200 to 5800ml).

Vital capacity (VC) : The maximum amount of air that can be breathed out after a maximum inspiration. It is the some total of TV, IRV and ERV and is 4100 to 4600ml.

C. Internal Respiration

- The two main components of blood involved in transport of the respiratory gases- **CO_2 and O_2**, are the **RBCs** and the **plasma.**
- Total oxygen transported only **3%** is transported in a dissolved state by the **plasma**. The remaining **97%** is bound to the **haemoglobin (Hb)** present in the RBCs. It has a **high affinity for O_2** and combines with it to form **oxyhaemoglobin.**

$$Hb + 4O_2 \longrightarrow Hb(4O_2)$$

- Oxyhaemoglobin is transported from **lungs to the tissues** where it readily dissociates to release O_2.

$$Hb(4O_2) \longrightarrow Hb + 4O_2$$

- **i) Transport of Oxygen**
  - Bohr effect
  - Haldane effect

https://www.youtube.com/watch?v=PbwWOYciN5I

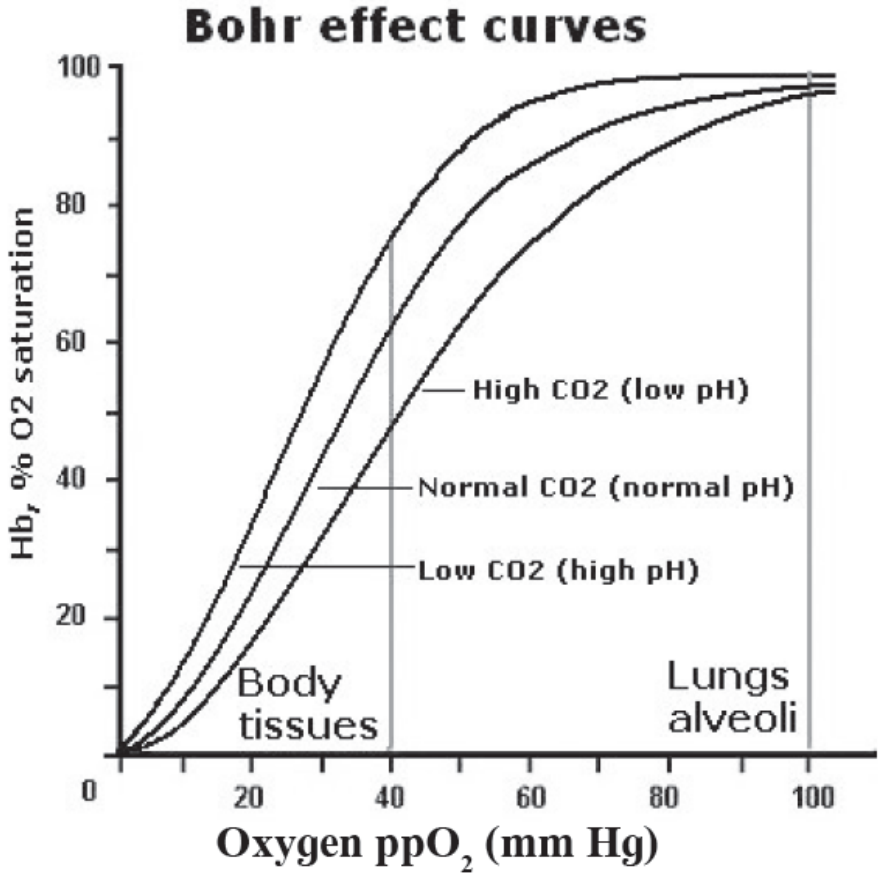
- **ii) Transport of Carbon dioxide**

a) By plasma in solution form (7 %)
b) By bicarbonate ions (70 %)
c) By red blood cells (23 %)

- 100% saturation is rare.
- Maximum saturation of **95 to 97% is at ppO_2 in alveoli (100 mmHg).**
- Degree of saturation decreases with the drop in ppO_2. This begins the dissociation of HbO_2.
- At 30 mmHg of ppO_2, only 50% saturation can be maintained.
- The relationship between **HbO_2 saturation** and **oxygen tension (ppO_2)** is called ***oxygen dissociation curve.*** This **oxygen - haemoglobin** dissociation curve is a **sigmoid curve** and it shifts towards the right due to the degree of saturation of Hb with O_2 depends upon the O_2 tension i.e. ppO_2. **Oxygen ppO_2 (mm Hg)** drop in ppO_2. This begins the dissociation of HbO_2.
- - increase in H^+ concentration, increase in $ppCO_2$ and rise in tempreature and rise in DPG (2, 3 diphosphoglycerate), formed in the RBCs during glycolysis. It lowers the affinity of haemoglobin for oxygen.
- **Bohr effect :** It is the shift of oxyhaemoglobin dissociation curve due to change in partial pressure of CO_2 in blood.
- **Haldane effect :** Oxyhaemoglobin functions as an acid. It decreases pH of blood. Due to increase in the number of H^+ ions, HCO^- changes into H_2O and CO_2.

C. Internal Respiration

O_2 dissociation curve



Graph 8.7 : Oxyhaemoglobin dissociation curve (pp = partial pressure)

Carbon monoxide poisoning :

Affinity of haemoglobin for carbon monoxide is about 250 times more, than for oxygen. In the presence of carbon monoxide, haemoglobin readily combines to form a stable compound carboxyhaemoglobin. The haemoglobin is blocked by carbon monoxide, preventing oxygen from binding with haemoglobin. Thus, less haemoglobin is available for oxygen transport depriving the cells of oxygen. This is carbon monoxide poisoning.

ii. Transport of CO_2 :

https://www.youtube.com/watch?v=VgpNSdWvrno

Carbon dioxide is **readily soluble** in water and is transported by RBCs and plasma.

- **a. By plasma in solution form (7%) :** Only 7% of CO_2 is transported in a dissolved form as carbonic acid (which can breakdown into CO_2 and H_2O).
- $CO_2 + H_2O \rightleftharpoons H_2CO_3$
- **b. By bicarbonate ions (70%) :** Nearly **70%** of carbondioxide released by the tissue cells diffuses into the plasma and then into the RBCs.
- • In the RBCs, CO_2 combines with water in the presence of a Zn containing enzyme,
- **carbonic anhydrase to form carbonic acid.**
- • Carbonic anhydrase enzyme is found in the RBCs and not in the plasma.
- • The rate of formation of carbonic acid inside the RBC is very high as compared to its formation in the plasma.
- • Carbonic acid being unstable almost immidiately dissociates into HCO_3^- and H^+ in the presence of the enzyme carbonic anhydrase (CA) leading to large accumulation of HCO_3^- inside the RBCs.
- $\mathbf{CO_2 + H_2O \xrightleftharpoons{CA} H_2CO_3 \xrightleftharpoons{CA} H^+ + HCO_3^-}$
- To maintain the ionic balance between the RBCs and the plasma, Cl^- diffuses into the RBCs. This movement of chloride ions is known as **chloride shift or Hamburger's phenomenon.**

- HCO_3^- that comes into the plasma joins to Na^+ / K^+ forming $NaHCO_3$ / $KHCO_3$ (to maintain p^H of blood).
- $HCO_3^- + Na^+ \longrightarrow NaHCO_3$

  Sodium bicarbonate
- • H^+ is taken up by protein (haemoglobin).
- $Hb + H^+ \longrightarrow HHb$

  (Reduced Hb)
- These H^+ ions might be expected to **lower blood pH**, but they are *buffered by haemoglobin* by the formation of deoxyhaemoglobin (reduced haemoglobin).
- • At the **level of the lungs** in response to the low partial pressure of carbon dioxide ($ppCO_2$) of the alveolar air, ***hydrogen ion and bicarbonate ions recombine to form carbonic acid*** and under the influence of carbonic anhydrase yields carbon dioxide and water.
- **$H^+ + HCO_3^- \xrightarrow{CA} H_2CO_3 \xrightarrow{CA} CO_2 + H_2O$**

ii) Transport of Carbon dioxide

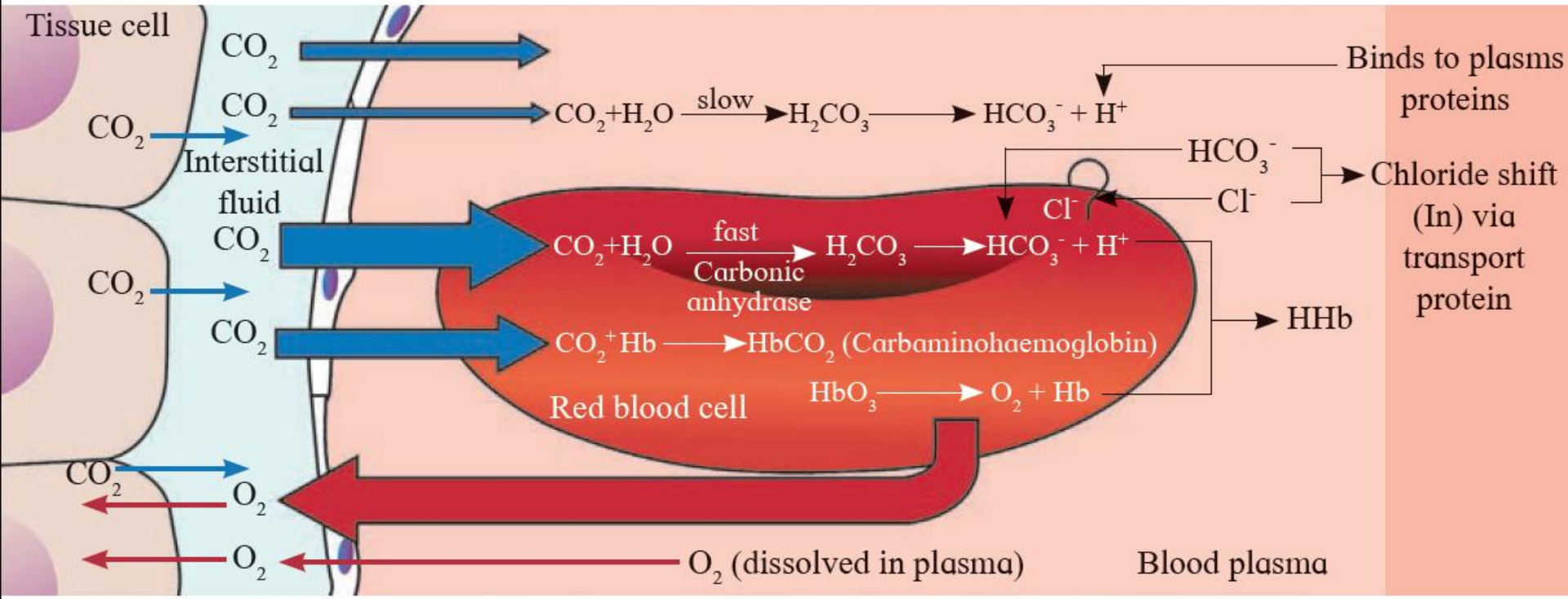


Fig. 8.8 : Oxygen pickup and carbon dioxide pickup at the tissue

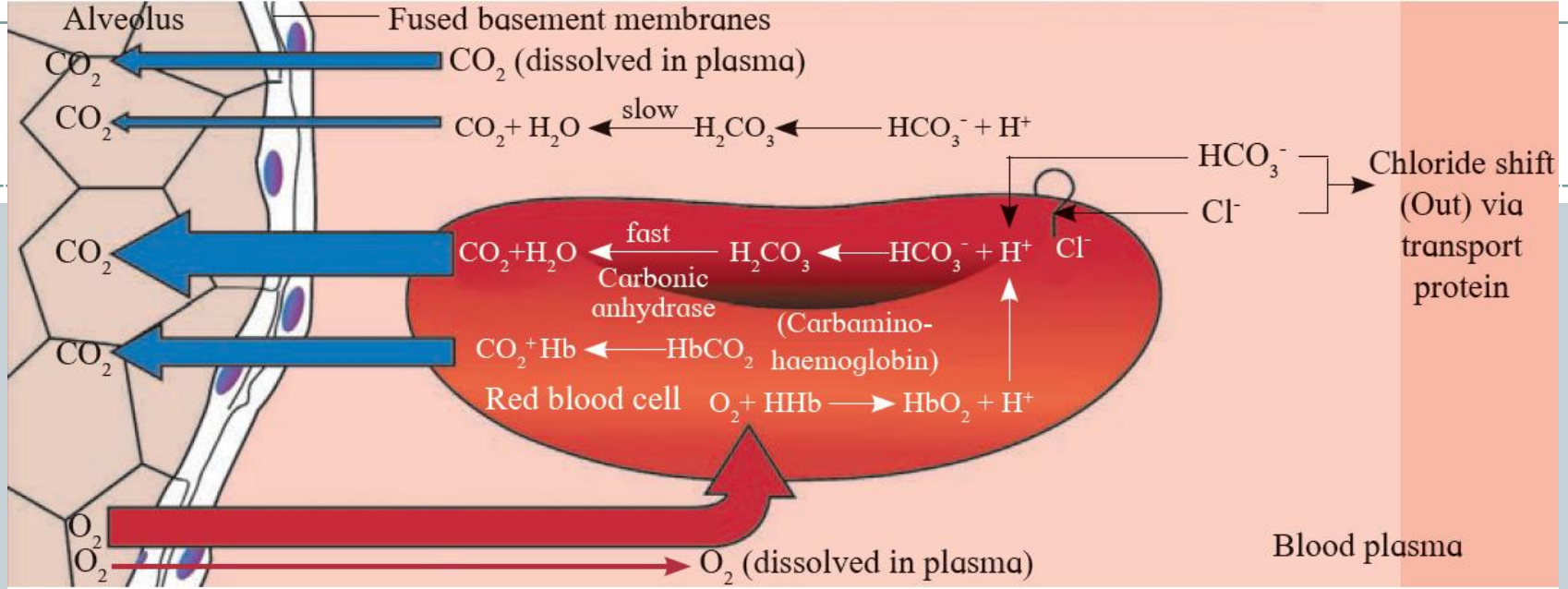


Fig. 8.9 : Oxygen pickup and carbon dioxide release in the lungs

c. By red blood cells (23%) : Carbon dioxide binds with the amino group of the haemoglobin and form a loosely bound compound **carbaminohaemoglobin.** This molecule readily decomposes in region where the partial pressure of carbon dioxide ($ppCO_2$) *is low (alveolar region)*, releasing the carbon dioxide.

$$Hb + CO_2 \rightleftharpoons HbCO_2$$

D. Cellular Respiration

- a) Oxidation

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 686\ Kcal\ \text{(Heat energy)}$$

- b) Phosphorylation

$$ADP + iP + 7.3\ Kcal \longrightarrow ATP$$

Regulation of Breathing –
https://www.youtube.com/watch?v=KITa-HNpJgU

https://www.youtube.com/watch?v=_KNAKKNbq20

Regulation of Breathing

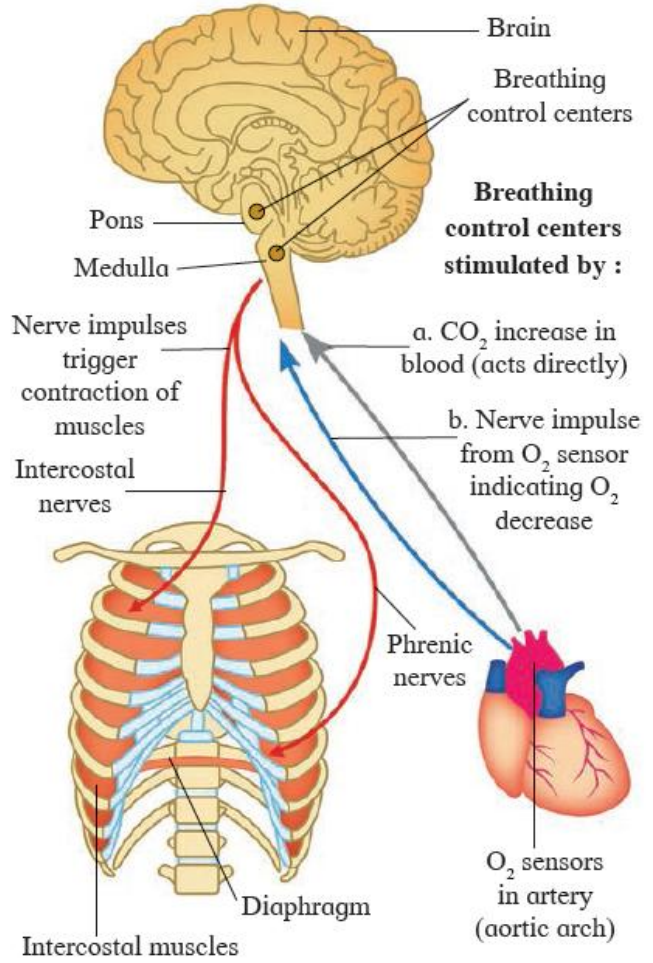


Fig. 8.10 : Regulation of Breathing

Respiration is under dual control : **nervous and chemical**. Human adults breathe about **12 times/minute** while a new born about **44 times/ minute.** Normal breathing is an *involuntary process*. Steady rate of respiration is controlled by neurons located in the **pons and medulla** and are known as the **respiratory centres.** It regulates the rate and depth of breathing. It is divided into three groups : dorsal group of neurons in the medulla *(inspiratory center)*, ventro lateral group of neurons in medulla *(inspiratory and expiratory center)* and *pneumotaxic center* located in pons **(primarily limits inspiration, slow wave sleep and rapid eye movement sleep)**. *Apneustic center* in the medulla is antagonistic to the neumotaxic center. It controls non rapid eye movement sleep and wakefullness.

- During inspiration when the lungs expand to a critical point, the **stretch receptors** are stimulated and impulses are sent along the **vagus nerves** to the expiratory centre. It then sends out inhibitory impulses to the inspiratory center.
- The inspiratory muscles relax and expiration follows. As air leaves the lungs *during expiration*, the lungs are deflated and the stretch receptors are no longer stimulated. Thus, the inspiratory centre is no longer inhibited and a new respiration begins. These events are called the ***Hering-Breuer reflex.*** *The* ***Hering-Breuer reflex*** controls the depth and rhythm of respiration. It also prevents the lungs *from inflating* to the *point of bursting*.
- The respiratory centre has connections with the cerebral cortex which means we can voluntarily change our pattern of breathing. Voluntary control is **protective** because it enables us to prevent water or irritating gases from entering the lungs. But the ability to stop breathing is also limited by the build up of carbon dioxide in the blood.
- **Modified Respiratory Movements :** Help **express emotion** or clear the air passage. movements some may be **reflexes**, but others can be initiated voluntarily *e.g.* ***coughing and yawning.***

Disorders of Respiratory system

Table 8.11 : Common disorders of respiratory system

Disorder	Symptoms	Cause	Treatment
Emphysema	Breakdown of alveoli, shortness of breath	Smoking, air pollution	Quit smoking, avoid polluted air, administer oxygen to relieve symptoms
Chronic bronchitis	Coughing, shortness of breath	Smoking, air pollution	Quit smoking, avoid polluted air, if possible move to warmer, drier climate
Acute bronchitis	Inflammation of bronchi, shortness of breath, yellow mucous coughed up.	Viruses and bacteria	If bacterial, take antibiotics, cough medicine, use vaporizer
Sinusitis	Inflammation of the sinuses, mucous discharge	Viruses and bacteria	If bacterial, take antibiotics and decongestants, use vaporizer
Laryngitis	Inflammation of larynx, vocal cords, sore throat, hoarseness of voice, mucous build up and cough	Viruses and bacteria	If bacterial, take antibiotics, cough medicines, voice rest, avoid irritants like smoke
Pneumonia	Inflammation of lungs ranging from mild to severe, cough and fever, shortness of breath, chills, sweating, chest pain, blood in mucous	Bacteria, viruses	Consult physician immediately, antibiotics, cough medicines, stay warm
Asthma	Constriction of bronchioles, mucus build up in bronchioles, periodic wheezing, difficulty in breathing.	Allergy to pollen, some foods, food additives, pet hair, etc.	Use of inhalants to open passage ways, avoid irritants
Occupational Respiratory Disorders- silicosis, asbestosis	Inflammation fibrosis, lung damage.	Long term exposure to dust particles silica and asbestos, particles during occupation	Protective mask and gear during work.

Artificial ventilation (artificial Respiration)

- It is a method of inducing breathing, it can prevent death due to drowning, choking, suffocation, electric shock, etc
- 2 steps https://www.youtube.com/watch?v=V8VIw0fk4X0

- Establishment & maintaining an open air passage from upper respiratory tract to the lungs.

- Force inspiration and expiration

- by mechanical means- Ventilator (a breathing machine)

Ventilator : https://www.youtube.com/watch?v=yDtKBXOEsoM

- A ventilator is a machine that **supports breathing** and is used **during surgery**, treatment for **serious lung diseases** or other conditions when normal breathing fails.
- Ventilators do the following,
- 1. Get oxygen into the lungs.
- 2. Remove carbon dioxide from the lungs.
- 3. Help the patient breathe.

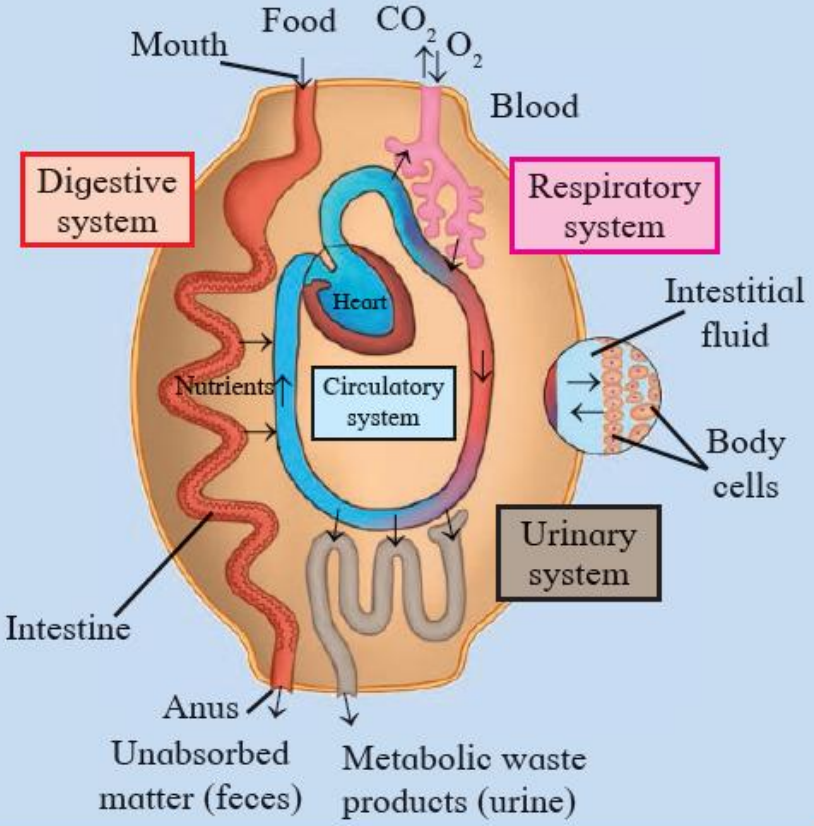
Transportation in living organisms :

- Transportation in organisms and animals occurs by **diffusion** and **by active transport** between the cells. This mechanism is suitable where the surface area of body is large and the distance between parts of the body in the organism is extremely small.
- **Cyclosis** is the streaming movement of the cytoplasm shown by almost all living organisms e.g. Paramoecium, Amoeba, root hair cells of many plants and WBCs in animals. It is for transportation within the cell or ***intracellular transport.***
- In *sponges* and *coelenterates* the surrounding *water is circulated* through the body cavities.
- In *flat worms* there is parenchymal circulation.
- In *round worms* there are no blood vessels and the body fluid is moved around the viscera by contraction of body wall and muscles. This is ***extracellular transport.***

Trasportation in living organisms

Observe and Discuss

Observe the diagram and discuss the process with your friends.



https://www.youtube.com/watch?v=ML2WX84gsGE

BLOOD VASCULAR SYSTEM : CIRCULATION IN ANIMALS

1. Open circulation – (haemocoels)

e.g. Arthropods (cockroach) and Molluscs.
low pressure,
no respiratory pigment

2. Closed circulation – (blood vessels)

All the vertebrates, higher molluscs and annelids.
high pressure,
respiratory pigments like haemoglobin.

a) Single circulation-

in fishes,
only once, '**venous heart**'.

b) Double circulation

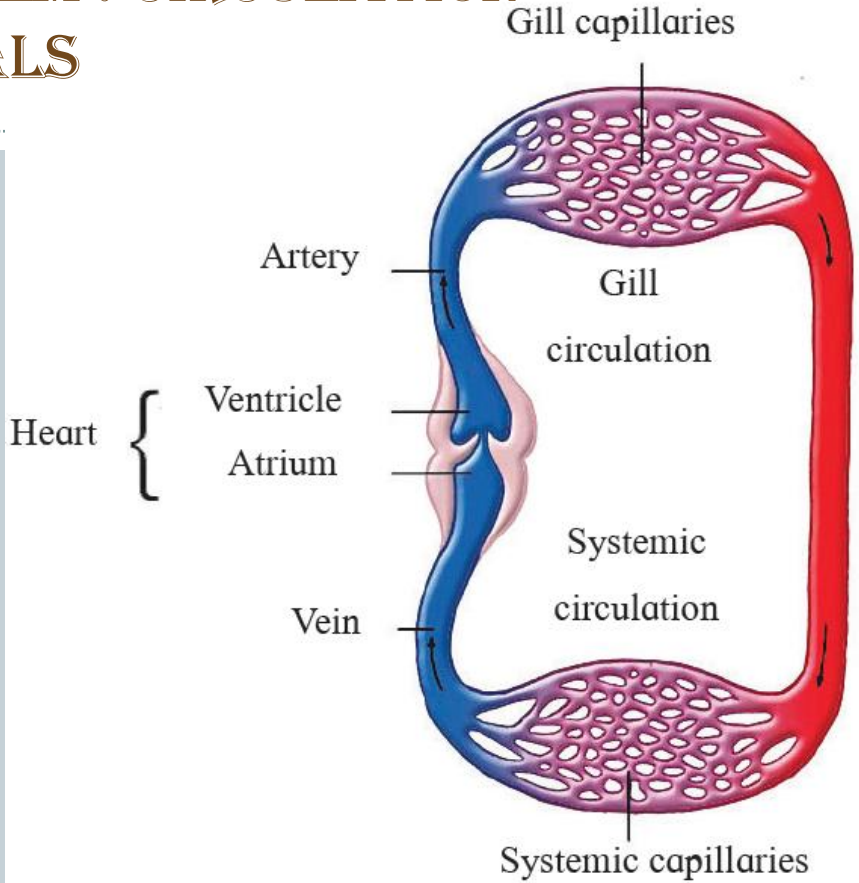


Fig. 8.12 : Single circulation

b) Double circulation

Twice, occurs in birds and mammals.

'**pulmonary circulation**' & '**systemic circulation**'

Human heart shows double circulation.

1. Find out the difference between coelom and haemocoel?

2. Name respiratory pigments present in the blood of different animals.

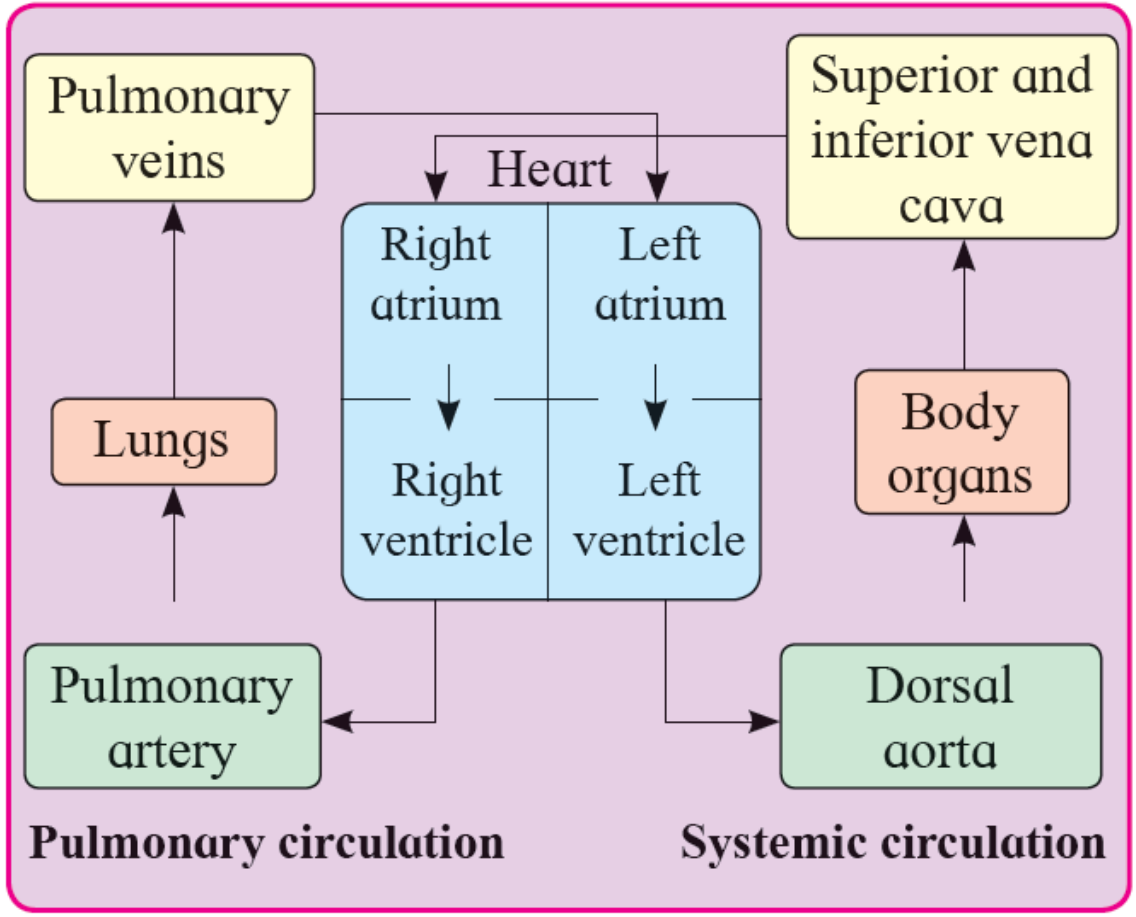


Fig. 8.13 : Double circulation (Diagrammatic)

https://www.youtube.com/watch?v=73ei6YDoVnM

Circulatory system in Human

Blood vascular system-

- consists of blood, heart and blood vessels.

- functions - transport, homeostasis and protection.

https://www.youtube.com/watch?v=SwHjwO7BnsI

Blood- (haematology)

- Adult - **4 to 6 liters** of blood.
- Red coloured fluid connective tissue,
- Slightly alkaline **(pH 7.4)**, salty and viscous fluid.

- Blood composition

I) Plasma - (55%)

II) Formed elements - i.e. blood cells (44%)

Table 8.14 : Composition of plasma

Contents	Percentage
1. Water	90 %
2. Proteins (albumen, globulin, properdin, prothrombin, fibrinogen)	7 to 8 %
3. Inorganic salts (Na, K, Mg, Ca, Fe, Mn and Cl^-, HCO^-_3 and PO^{3-}_4)	1 %
4. Others :	1 to 2 %
a. Food (glucose, amino acids, fatty acids, triglycerides)	
b. Wastes (urea, uric acid and creatinine)	
c. Regulators (hormones, enzymes, vitamins)	
d. Anticoagulants (heparin)	
e. Cholesterol and antibodies	
f. Dissolved gases (O_2, CO_2, N_2)	

I) Plasma - (55%) Straw-coloured, slightly alkaline, viscous fluid.
https://www.youtube.com/watch?v=MK921ZlPo8I

II) Formed elements - i.e. blood cells - (44%)
Human blood contains three types of formed elements as,

1. **Red blood corpuscles (RBCs),**
2. **White blood corpuscles (WBCs)** and
3. **Platelets**

Internet my friend

1. Find out the percentage and functions of different blood proteins.
2. What is the clinical importance of haematokrit value?
3. Differentiate between plasma and serum.

II) Formed elements

* Red blood corpuscles / Erythrocytes

* White blood corpuscles / Leucocytes

* Thrombocytes / Platelets

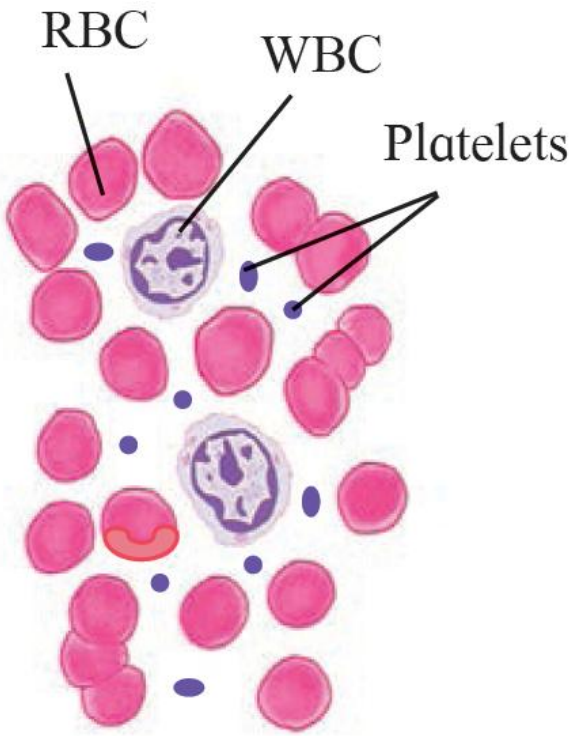
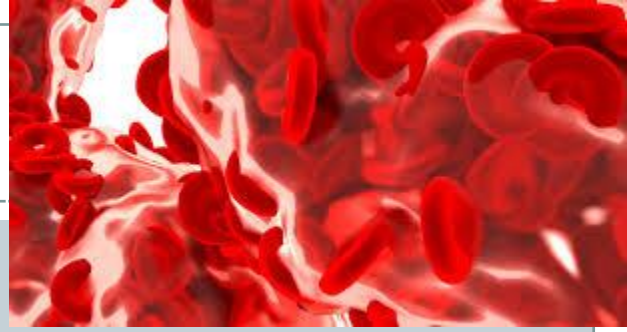


Fig. 8.16 : Blood smear

Red blood corpuscles / Erythrocytes



They are **circular, biconcave** and **enucleated** (in camel and llama they are **nucleated**).
https://www.youtube.com/watch?v=erMPkJt8Ndg

- **In males,** their average number is about **5.1-5.8 million/mm³ (per µL)**
- **in females** about **4.3-5.2 million/mm³.**
- This is called **total RBC count.**

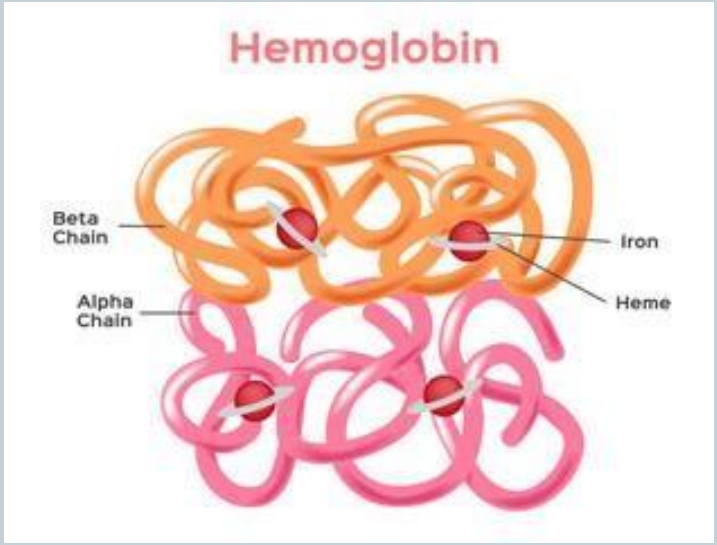
* The average life span of RBCs is **120 days.**
* The process of formation of RBCs is called **erythropoiesis.**
* RBCs are produced from **haemocytoblasts / reticulocytes.**
* The erythropoeitic organ of the foetus is the **liver** and **spleen** and in the adult, it is mainly the red bone marrow.
* **Vitamin B12, folic acid and heme protein** are required for production of RBCs . * The *old and worn out RBCs* are destroyed in the **liver** and **spleen** (graveyard of RBCs).

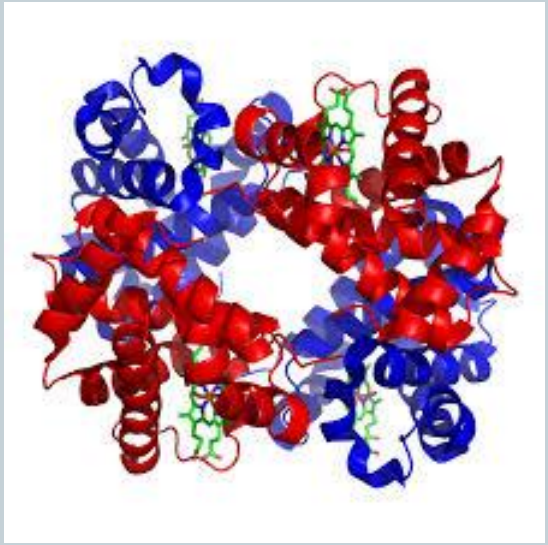
- Condition with ***increase*** *in the number* of RBCs is called **polycythemia** and with ***decrease*** *in number of RBCs* is called as **erythrocytopenia.**
- The hormone **erythropoietin** produced by the kidneny cells stimulates the bone marrow for production of RBCs.
- Mature erythrocyte is **devoid of nucleus**, **mitochondria** or *other membrane bound cell organelles*.
- Its cytoplasm (stroma) is **rich in haemoglobin** and O_2 carrying proteinaceous pigment that gives red colour to the RBCs and blood. It also contains an **enzyme, carbonic anhydrase.**
- Erythrocytes are responsible for the transport of respiratory gases O_2 and CO_2, **maintaining p^H and viscosity** of blood.
- They also contribute in the process of ***blood clotting***.
- The **hematocrit** is *ratio of the volume of RBCs to total blood volume of blood*. It is different for men and women.

https://www.youtube.com/watch?v=DhsV4itHZZ8

Haemoglobin

https://www.youtube.com/watch?v=HWEOmpvS6Zo





Anemia- https://www.youtube.com/watch?v=RWuKHeUA85g

Haemoglobin

- Each erythrocyte approximately contains 270 million molecules of haemoglobin.
- Normal content of haemoglobin in blood of **men** is about **14 – 17 gm%** and **in women** it is about **13 – 15 gm%.** Condition with less number of RBCs or **less amount of haemoglobin** or both is called as **anaemia.**
- Each molecule of haemoglobin is a protein-iron complex. It consists of four polypeptide (globin) chains **2 alpha** and **2 beta** chains. An **iron – porphyrin (haem)** group is *attached to each chain* and all four chains are bound together. Each haem group can **carry one O_2 molecule** and thus ***one haemoglobin molecule can carry four O_2 forming oxyhaemoglobin***.
- CO_2 interacts with amino acid residues of globin chains & forms carbaminohaemoglobin.
- After *haemolysis*, haemoglobin is broken down. Its globin part is broken to recycle the amino acids. Iron of heme group is stored as **ferritin** in the liver and **porphyrin group** of heme is converted into green pigment **biliverdin and then into red-orange coloured bilirubin.**
- These pigments (mainly **bilirubin**) are **added to bile** and finally removed out of body **along with faeces.**

White blood corpuscles / Leucocytes - 2 types

a) Granulocytes

b) Agranulocytes

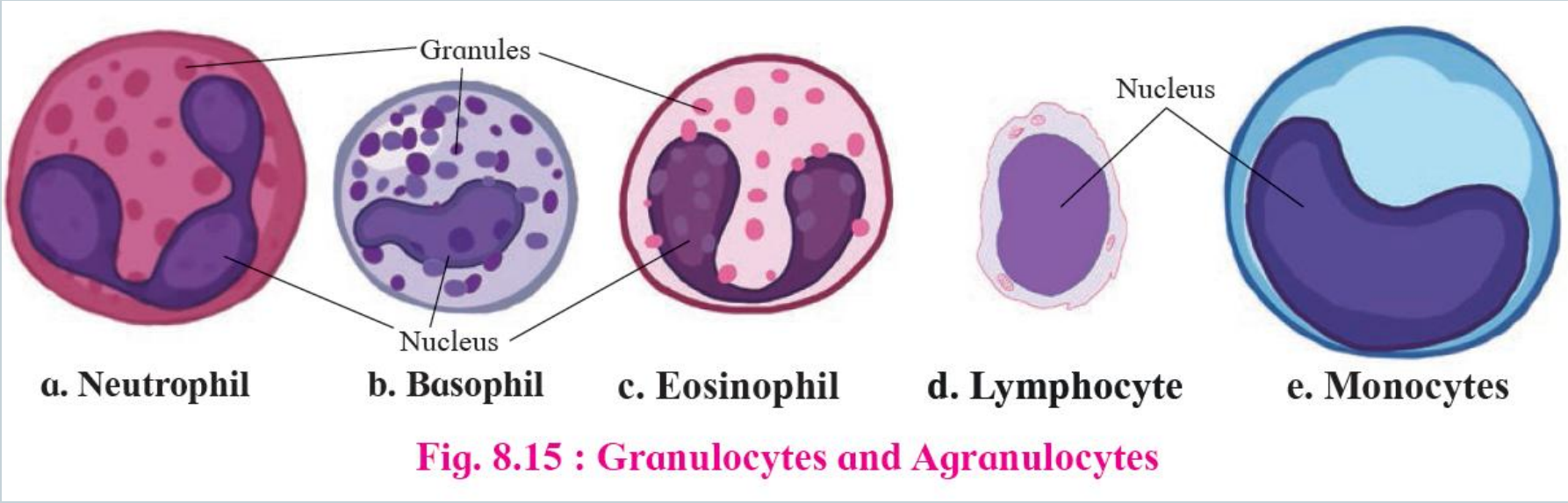


Fig. 8.15 : Granulocytes and Agranulocytes

https://www.youtube.com/watch?v=0TvTyj5FAaQ

Leucocytes (WBCs)

-Colourless, nucleated and amoeboid cells (Due to their amoeboid movement they can *move out of the capillary walls* by a process called **diapedesis.**)

an average, **5000-11000 WBCs per mm³** of blood.

* **Decrease** in number of WBCs *(<4000)* is called ***leucopenia*** (common in *HIV, AIDS and TB patients* or those *exposed to radiations, shock*, etc)

* Temporary **increase** in number of WBCs is called as ***leucocytosis.*** It is due to **infection**. It also occurs during pregnancy and **in newborn babies.**

* **Uncontrolled increase** in number of **WBCs** is a type of ***blood cancer*** called **leukemia.** WBCs are mainly concerned with **defense mechanism i.e. protection**.

Types of WBCs :

a) Granulocytes

- Neutrophil
- Basophil
- Eosinophil

b) Agranulocytes

- Lymphocyte
- Monocyte

These are Irregular nucleated cells and show **polymorphism** (exist in variable forms).

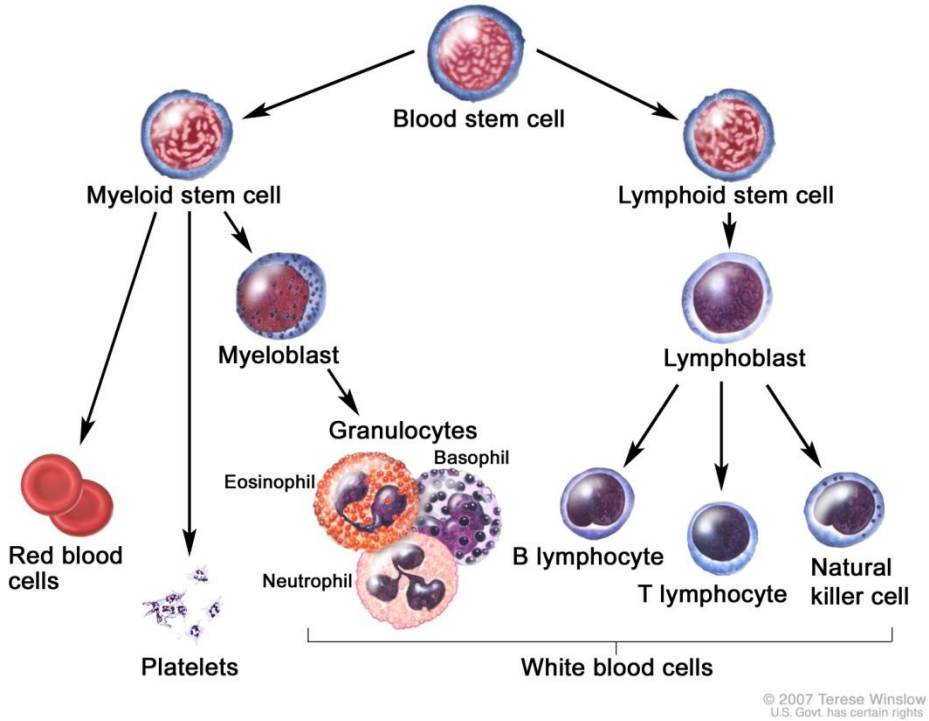
GRANULOCYTES VERSUS AGRANULOCYTES

	Granulocytes	Agranulocytes
Granulocytes are leukocytes that contain a granular cytoplasm	65% of total leukocytes	35% of total leukocytes
Agranulocytes are leukocytes that contain an agranular cytoplasm	Nucleus contains two to five lobes	Nucleus contains a single lobe
Also known as polymorphonuclear leukocytes	Contain enzymes, digesting phagocytized particles & inflammatory mediators	Contain enzymes in their lysosomes
Also known as mononuclear leukocytes	Mainly involved in innate immunity	Mainly involved in adaptive immunity
Classified into eosinophils, neutrophils & basophils		
Classified into monocytes, macrophages & lymphocytes		
Originated from the bone marrow		
Originated from lymphoid		

A. Granulocytes :

These are WBCs with a **granular cytoplasm,** also called **Polymorpho nuclear leucocyte (PMN) cells.** They have ***lobulated nuclei*** in different shapes. Granulocytes are formed from myeloid stem cells and once formed, do not divide. Granulocytes constitute about **72% of total WBCs**.

Granules are actually *secretory vesicles* which contain various secretions, enzymes, etc. Depending upon **staining** property of the granules, these granulocytes are classified into three types as **neutrophils, basophils** and **acidophills**.



a. Neutrophils :- stained with **neutral** stains (dyes), - **70%** of total WBCs, - spherical and nucleus is several **lobed (2- 7)**, - shows amoeboid movements and *phagocytosis*, responsible in pus formation along with damaged tissues and dead microbes.

- b. Basophils / Cyanophils : granules of large size, - stain with **basic stains** like **methylene blue**, non-phagocytic, small, spherical cells,- about **0.5-1%** of total WBCs, -Nucleus is **twisted**, -present in **infected** and **allergic** conditions only. **- secrete heparin, histamine and serotonin.**
- c. Eosinophils / Acidophills : - contain **lysosomal granules** which stained to red colour with **acidic stains like eosin**, - about **1 – 3 %** of total WBCs, - **Nucleus** is **bilobed**, - destroy antigen- antibody complex by *phagocytosis*. - number increases in **allergic** condition, - show **antihistaminic property**. - responsible for **detoxification** as they **produce antitoxins.**

B. Agranulocytes

- They are about **28%** of total WBCs. Cytoplasm of these leucocytes is **without granules.** They are **formed from lymphoid stem cells** and can divide by **mitosis**. Nuclei of agranulocytes are large in size but are **not lobulated** like the granulocytes.
- There are two types of agranulocytes - *Lymphocytes and Monocytes.*

- **a. Lymphocytes :** These are the **smallest** of all WBCs and have a large spherical nucleus. They constitute about **25-30%** of total WBCs. Depending upon function, two types of lymphocytes are present as **B-lymphocytes and T-lymphocytes**.
- *B-lymphocytes* mature in bone marrow and are responsible **for antibody production/humoral immunity**. It is a highly specific antigen, antibody immunity .
- *T-lymphocytes* mature in thymus and are responsible **for cell-mediated immunity**. *Helper T-cells, killer T-cell, memory T-cells and suppressor T-cells* are four main subtypes of T-lymphocytes.
- **b. Monocytes :** Monocytes are the **largest** of all the WBCs. Its **nucleus is large and bean or kidney shaped**. They form **3-5%** of WBCs. Monocytes are **actively motile** and give rise to **macrophages**. They are **mainly phagocytic** and destroy the bacteria and dead or damaged tissue by phagocytosis. https://www.youtube.com/watch?v=GbptpDSHQEM

Thrombocytes / Platelets

Cellular fragments – megakaryocytes, - produced in bone marrow, - very small+oval shaped cell fragments without nucleus, - Normal count of thrombocytes in human blood is about 2.5 – 4.5 lakh / mm3 of blood.

- If number of thrombocytes *decreases* than normal, condition is called as **thrombocytopenia.** This condition causes internal bleeding (haemorrhage).
- Platelets secrete **platelet factors** which are essential in blood clotting.
- Also seal the ruptured blood vessels by formation of **platelet plug/ thrombus.**
- They secrete **serotonin** a local **vasoconstrictor.**

Blood Clotting/ Coagulation of blood :

Clotting is initiated by contact of blood with any foreign surface (intrinsic process) or with damaged tissue (extrinsic process). These involves interaction of various substances called **clotting factors** by a step wise or **cascade mechanism.**

- There are in all twelve clotting factors numbered as I to XIII (factor VI is not in active use).

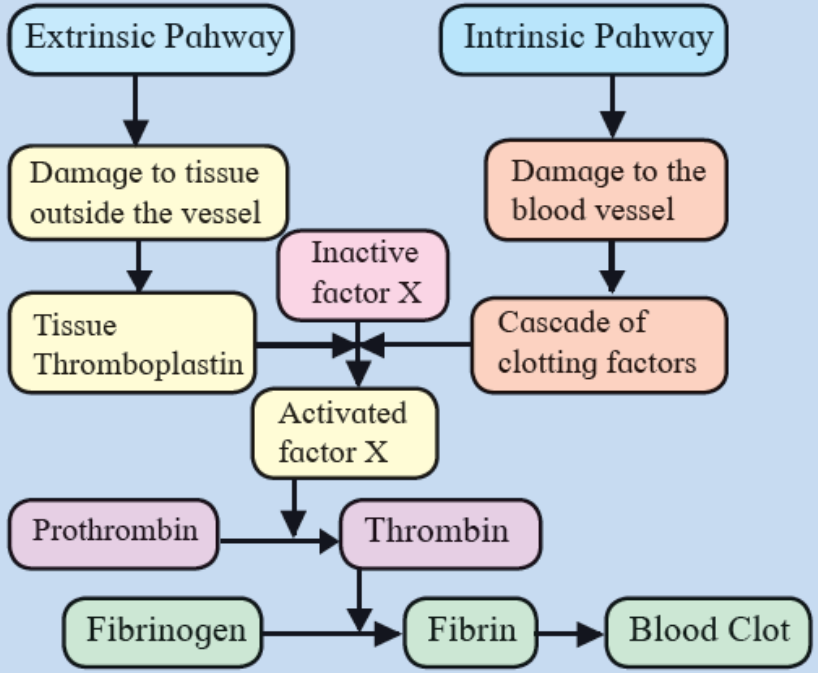
https://www.youtube.com/watch?v=R8JMfbYW2p4

Blood clotting / Coagulation of blood

pages continuously

Observe and Discuss

Observe the flow chart and discuss the process with your friends.



Interaction of all twelve clotting factors in a cascade manner leads to formation of the **enzyme thrombin**.

* *Thromboplastin*, helps in the formation of enzyme **prothrombinase.** This enzyme inactivates *heparin* and it also converts *inactive prothrombin* into its **active thrombin.**

Thrombin converts *soluble blood protein*-**fibrinogen** into **insoluble fibrin**.

Fibrin forms a mesh in which platelets and other blood cells are trapped to form the clot.

* Blood clotting occurs as in flowchart.

https://www.youtube.com/watch?v=QSCAPzrePSs

https://www.youtube.com/watch?v=j9Hdl9w-KoM

Curiosity

1. What is blood clotting? How and when does it occur?
2. What is immunity? Name its types.
3. Why does the platelet count decrease in dengue patient?
4. Why does our immune system fail against pathogens like *Trypanosoma* and *Plasmodium*?
5. What is the relation between immunity and organ transplantation?
6. How do monocytes perform amoeboid movement and phagocytosis?
7. How do monocytes modify into macrophages?

Heart :

- main pumping organ, reddish brown in colour, hollow, muscular organ, roughly the size of one's fist
- 300gm in males and 250gm in females
- Conical in shape and lies in **mediastenum,** Conical end is slightly tilted to left side https://www.youtube.com/watch?v=GMBSU-2GK3E
- Heart is enclosed in a membranous sac called **pericardium.**
- Pericardium is formed of two main layers - outer **fibrous** and inner **serous pericardium.**
- Serous pericardium is further divisible into two layers as **parietal** and **visceral layer** which have space pericardial space, filled with **pericardial fluid** (about 50ml). **Pericardial fluid-**
- It acts as a *shock absorber* and *protects* the heart *from mechanical injuries*.
- It also *keeps the heart moist* and *acts as lubricant*.

Heart wall

* **Mesodermal** in origin,
* Heart wall is formed of three layers, outer **epicardium,** middle **myocardium** and inner **endocardium.**
• Epicardium- squamous epithelium
• Myocardium- middle thick layer formed of cardiac muscles.
• Endocardium- squamous epithelium
Epicardium and Endocardium - **protective in function.**
Myocardium- responsible for **contraction** and **relaxation of heart**.

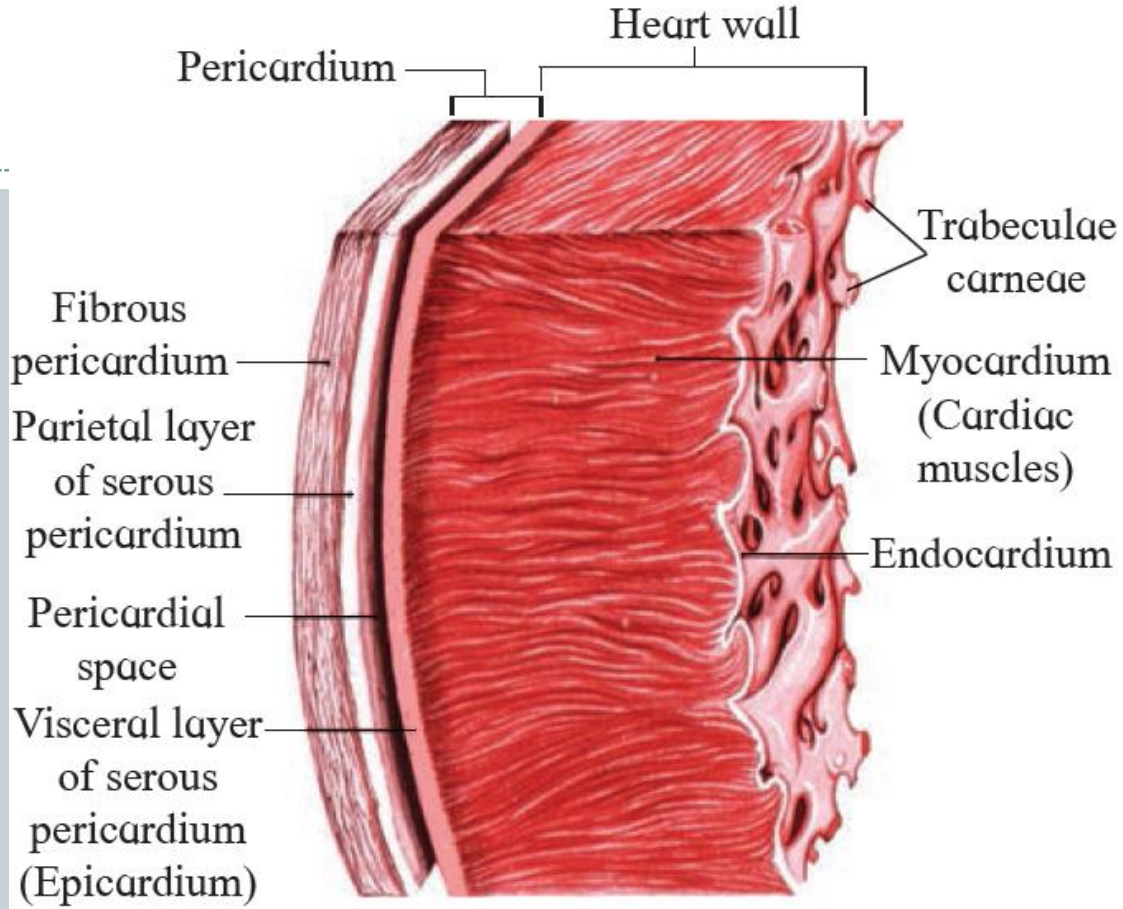


Fig. 8.17 : Heart wall and Pericardium

External structure of heart

https://www.youtube.com/watch?v=CWFyxnoqDEU

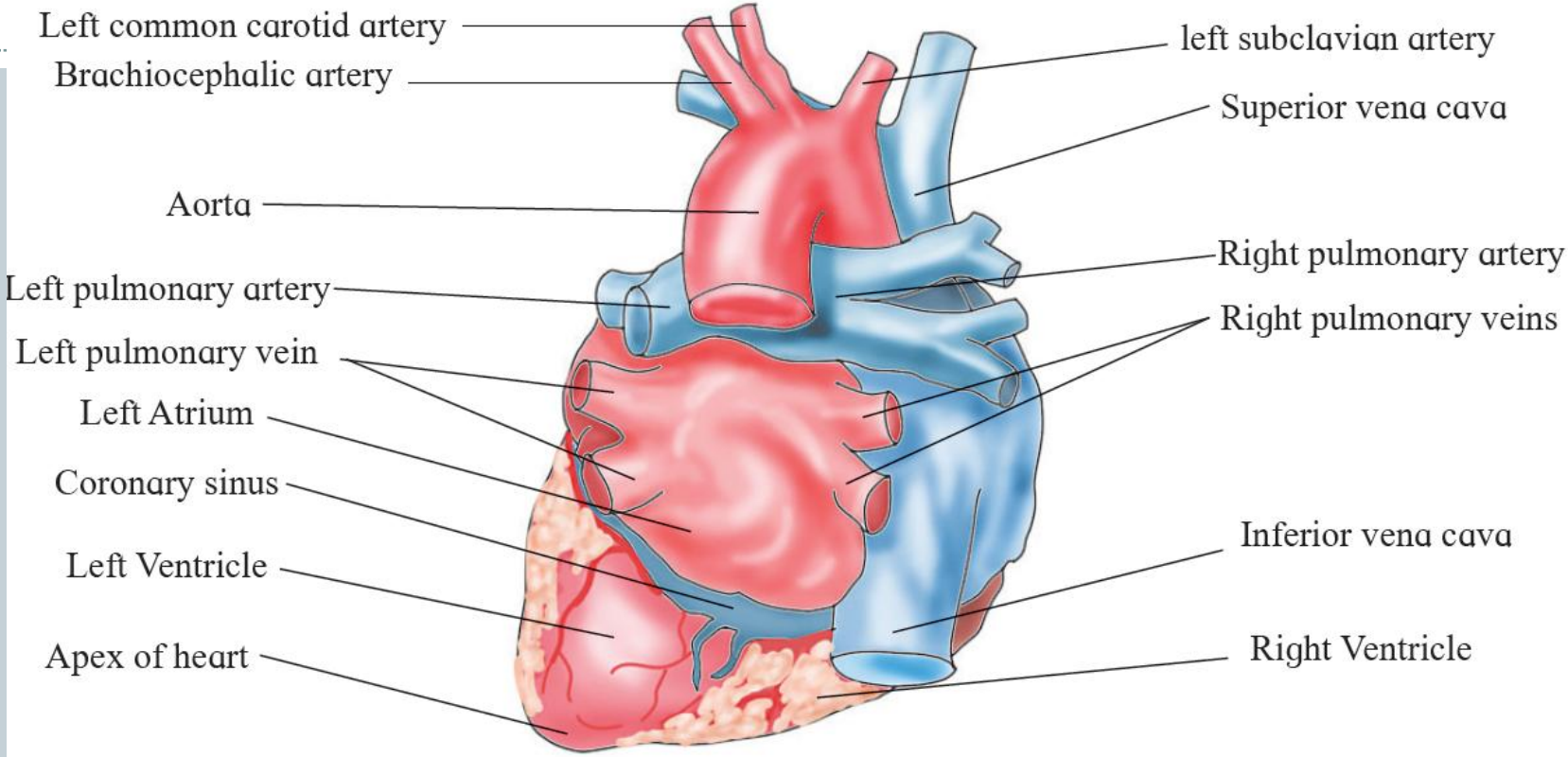


Fig. 8.18 : Posterior (dorsal) view : External structure of human heart

- The human heart - 4 chambers; - 2 superior - **atria (auricles),** 2 inferior - **ventricles.**
- Externally, atria separates from ventricles by a transverse groove called **coronary sulcus** or **atrioventricular groove.**
- The 2 ventricles are externally separated by two grooves, the ***anterior and posterior inter-ventricular sulci*.**
- **Coronary arteries** and **coronary veins** run through these sulci.
- **Pulmonary trunk** arising from right ventricle and aorta from left ventricle are *present on anterior surface* of heart. It bifurcates into **right and left pulmonary arteries.**
- **Aorta (systemic aorta)** is divisible into three regions as ascending aorta, systemic arch /aortic arch and descending aorta.
- The **Ligamentum arteriosum** *joins* pulmonary trunk and aortic arch. It is the *remnant of an embryonic duct* called **ductus arteriosus.**
- The ***aortic arch*** *gives out* three arteries viz. **brachiocephalic (innominate) artery, left common carotid** and **left sub- clavian.**
- The right atrium *recieves* **superior** and **inferior vena cava** along its dorsal surface.
- **Pulmonary veins** *open* into left atrium along the dorsal surface of heart.

External structure of heart

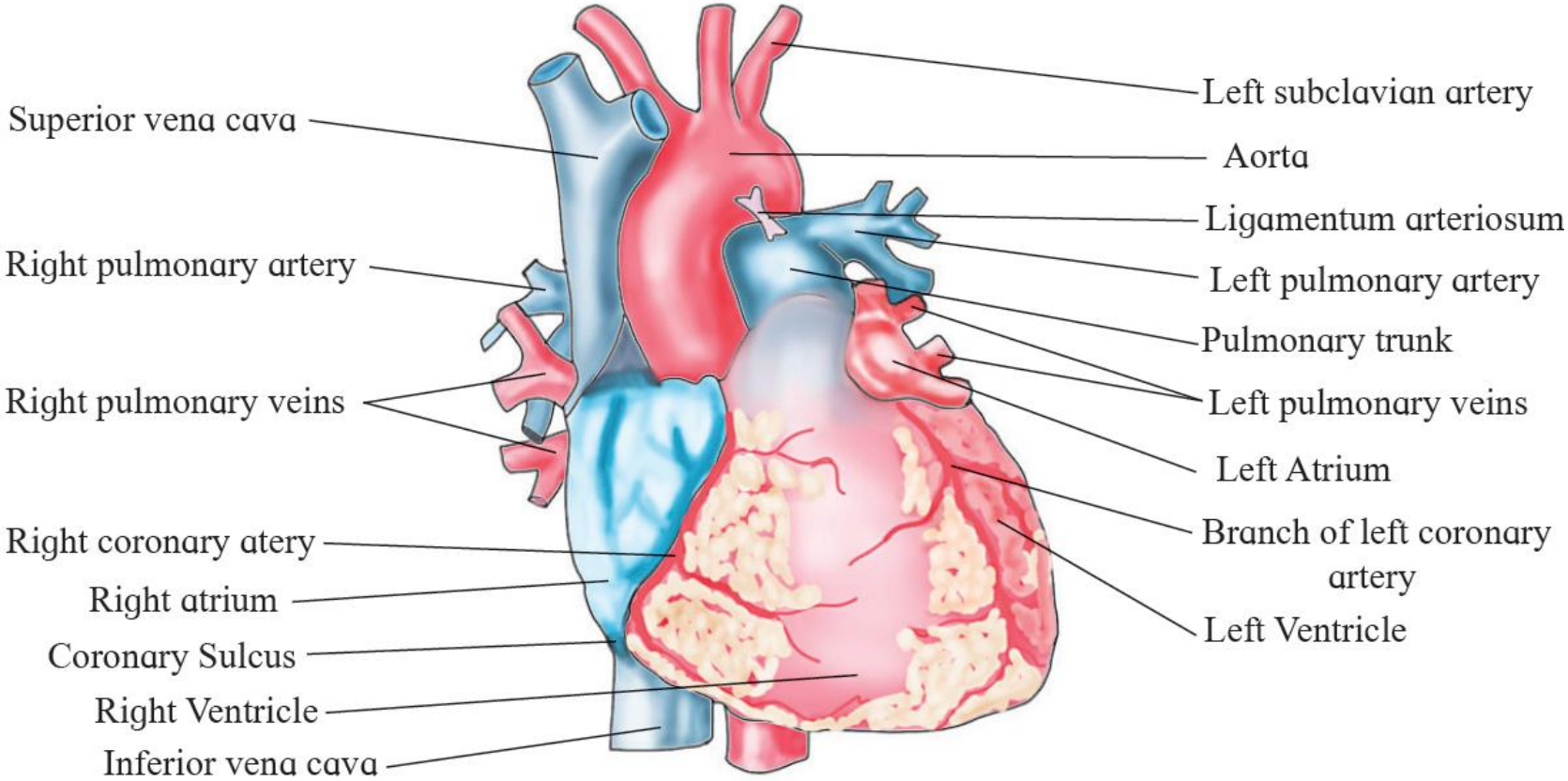


Fig. 8.19 : Anterior (ventral) view : External structure of human heart

Internal structure of Human heart

- **Atria : -** thin-walled receiving chambers, - separated from each other by inter-auricular septum, which has an oval depression **fossa ovalis** (remnant of the embryonic aperture- *foramen ovalis*)
- Superior vena cava (**precaval**), inferior vena cava (**postcaval**) and **coronary sinus** open into the *right atrium*.
- Opening of the *postcaval* is guarded by a **Eustachian valve** while the **Thebesian valve** guards the opening of *coronary sinus* into right atrium.
- Four **pulmonary veins** open into the *left atrium*. (openings are without valves)
- Both the atria open into the ventricles of their respective sides by **atrioventricular apertures**.
- These openings are guarded by cuspid valves. The **tricuspid valve** is present in the right AV aperture and **bicuspid valve (mitral valve)** is present in the left AV aperture. https://www.youtube.com/watch?v=qmpd82mpVO4
- All these **heart valves** help in maintaining a unidirectional flow of blood. They also avoid back flow of blood.

Internal structure of Human heart

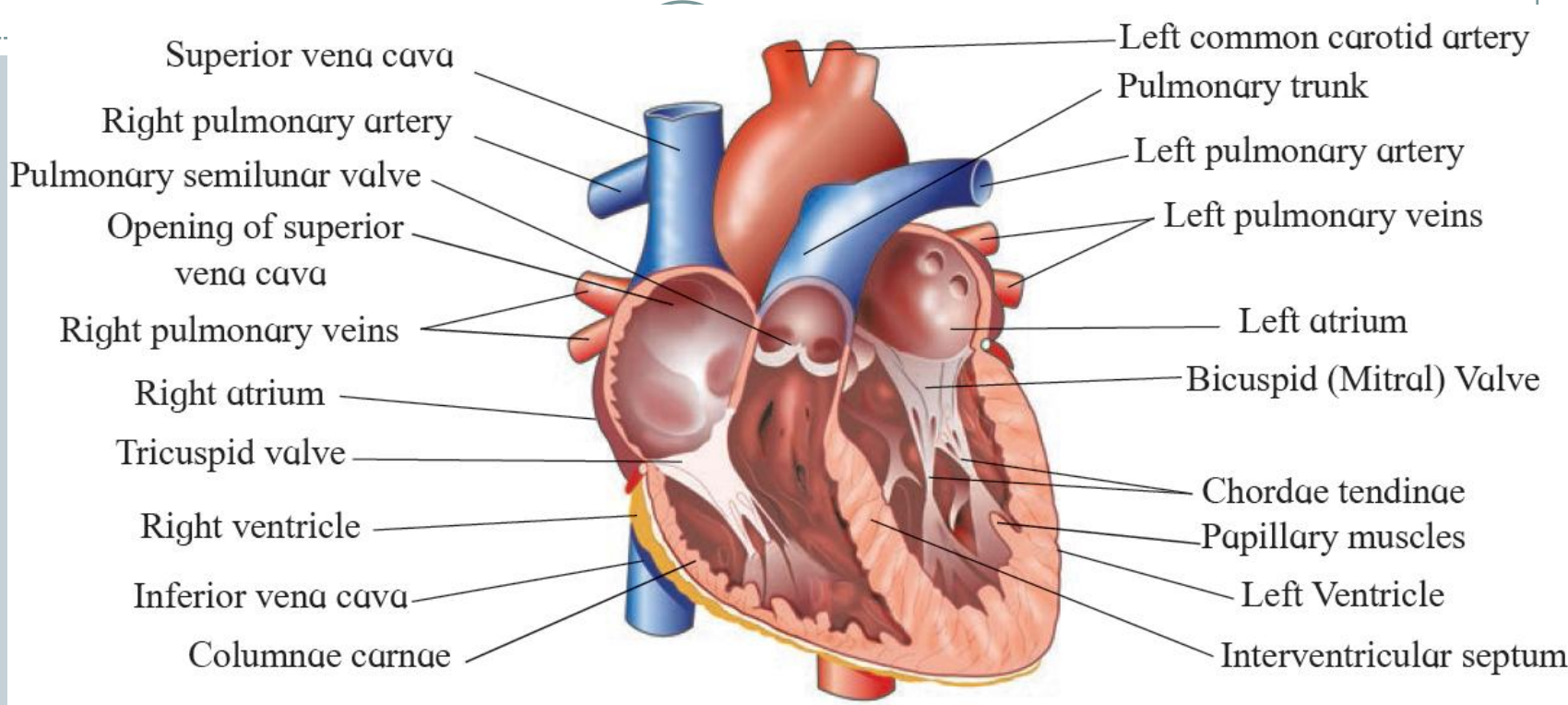


Fig. 8.20 : Internal structure of human heart

- **Ventricles :** inferior, thick-walled pumping chambers of the heart.
- The right and left ventricles are separated by an inter- ventricular septum.
- Wall of left ventricle is more muscular , 3-times thicker than right ventricle.
- Inner surface of the ventricles shows several *ridges* called **columnae carnae** or **trabeculae carnae** which divide the lumen of ventricle into small pockets or fissures.
- The lumen of ventricles also shows *inelastic fibers* called **chordae tendinae.**
- These attach the bicuspid and tricuspid valves to the ventricular wall (papillary muscles) and regulate their opening and closing.
- The right ventricle *opens into* the **pulmonary aorta** and left ventricle *opens into* the **aorta.**
- These openings are guarded by three **semilunar valves** each.
- These valves prevent the backward flow of blood into the ventricles.

https://www.youtube.com/watch?v=UMTDmP81mG4

Valves of The Heart

in Right atrium:-

Eustachian valve- at the opening of post caval.

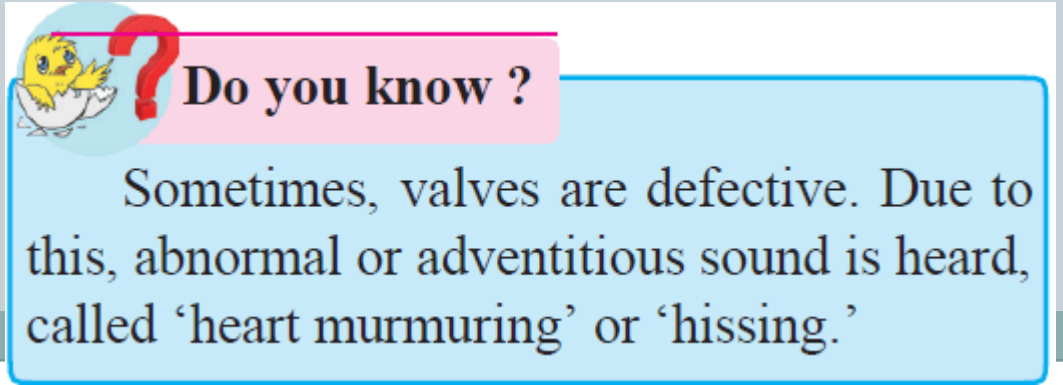
Thebasian valve- guards the opening of coronary sinus.

Atrio-ventricular apertures are guarded by:-

Tricuspid valve – on right AV aperture

Bicuspid (mitral) valve - on left AV aperture

Openings Aorta & Pulmonary trunk are guarded by **Semilunar valves.**



Pumping action of heart

- Contraction of heart muscles – Systole
- Relaxation of heart muscles – Diastole
- A single systole followed by diastole makes one **heart beat.**
- The heart beats 70 to 72 times per minute. This is called **heart rate.**
- During each heart beat ventricles pump about 70 ml of blood this is called **stroke volume.** https://www.youtube.com/watch?v=aJRduIb5YS4

Cardiac output (CO) :-

72 (heart beat rate) x 70 ml (stroke volume) = 5040 ml (appro. 5 liters) blood/min

HR SV = CO

Conducting tissues of heart

Myogenic heart- 1) SA node (Sinu-atrial node)

2) AV node (Atrio-ventricular node)

3) Bundle of Hiss / Tawara

Conducting system of Human heart

https://www.youtube.com/watch?v=IS9TD9fHFv0

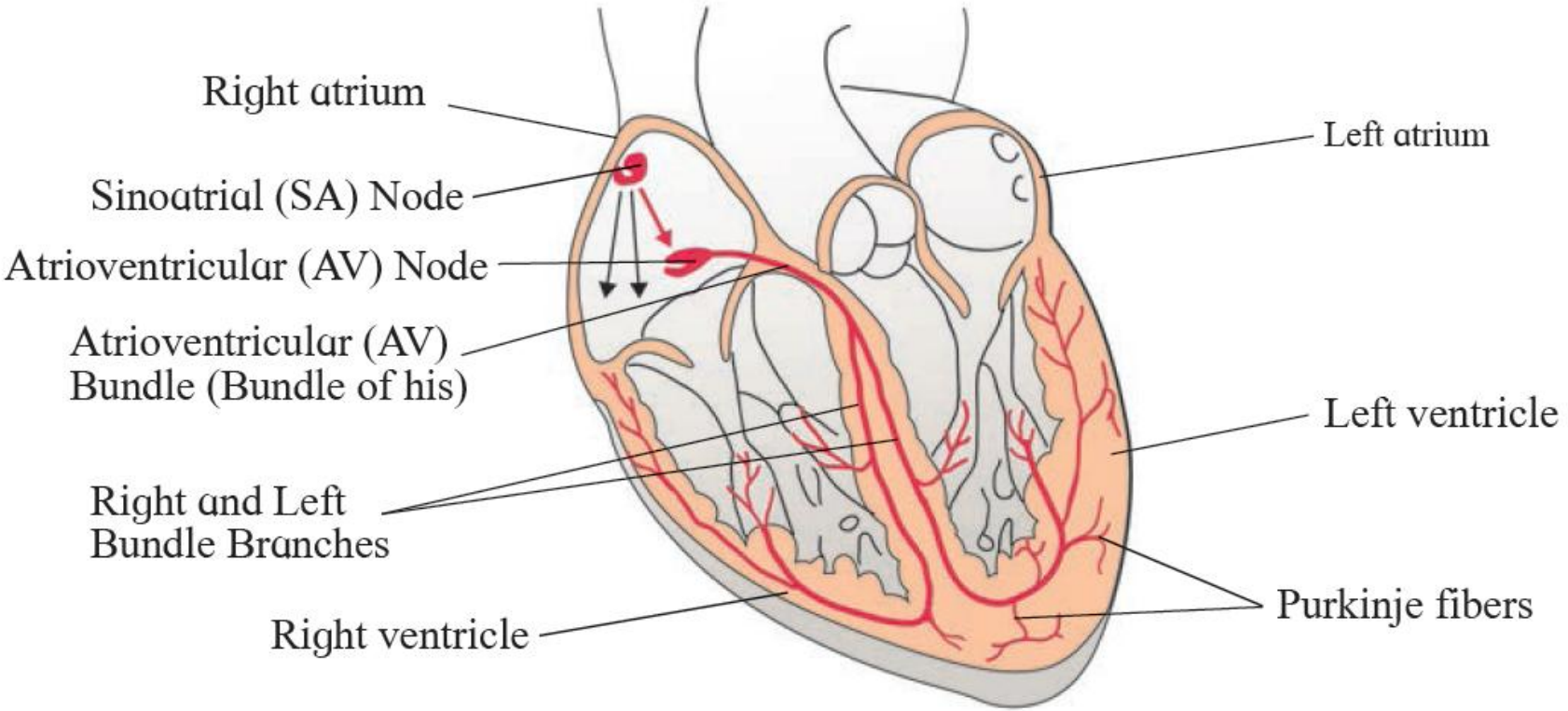


Fig. 8.21 : Conducting system of human heart

Conducting tissue of heart:

- The human heart is **myogenic** i.e. it can generate its own rhythm by specialized muscles. A specialized cardiac musculature called the **nodal tissue** It also shows **auto rhythmicity**. Conducting (nodal) tissue consists of **SA node, AV node, bundle of His** and **Purkinje fibers.**
- Conducting system of heart: **SA node (sinu-atrial node)** is present in the right atrium. It acts as **pacemaker** of heart because it has the power of generating a new wave of contraction and making the pace of contraction.
- **SA node** passes the contraction to the left ventricle and also to the AV node. **AV node** (atrio-ventricular node) is present in the right atrial wall near the base of interatrial septum. It acts as **pace setter** of heart.
- **Bundle of His/ Tawara** branches start from AV node and pass through interventricular septum. Bundle of His forms two branches, the *right and left bundles*, one for each ventricle.
- These branches form network in ventricular walls and these are called **Purkinje fibers.** Bundle of His and Purkinje fibers spread impulses in ventricles. As a result both the ventricles contract simultaneously.

Working mechanism of human heart

https://www.youtube.com/watch?v=46u2ON6d4mg

- Cardiac cycle-

a) Atrial systole (AS)

b) Ventricular systole (VS)

Cardiac output – (CO)

- It is the volume of blood pumped out per min.
- For a normal adult human,it is calculated as follows :

(CO) = SV × HR

= 70 × 72 = 5040 ml/min

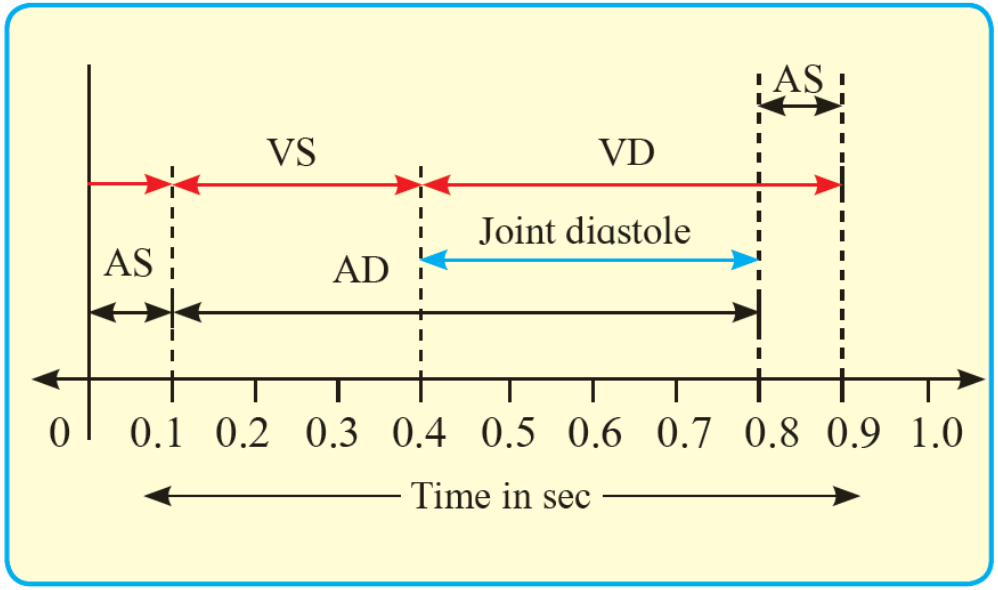


Fig. 8.22 : Diagramatic representation of cardiac cycle

- **a. Atrial systole (AS):** Right atrium receives **deoxygenated** blood and left atrium receives **oxygenated** blood. When both the atria are completely filled with blood, pressure is exerted on the wall. In response to this pressure, **SA node** gets excited and generates *cardiac impulse*. Due to this, cardiac muscles in the atrial wall contract causing **atrial systole.** During atrial systole, blood is pumped into ventricles. Blood is prevented from going back to the veins and coronary sinus by **Eustachian** and **Thebesian valve** respectively. After systole the atria go into diastole.
- In normal, **atrial systole** is for **0.1 sec**. and **atrial diastole** (AD) is for **0.7 sec.**
- **b. Ventricular systole (VS):** The impulse which started from SA node now reaches the **AV node** and it gets excited. AV node sends impulses to **bundle of His** and from bundle of His to **Purkinje fibers**. Purkinje fibers spread impulses all over the wall of ventricles. Due to this, ventricular wall contracts causing **ventricular systole**. During ventricular systole, right ventricle pumps **deoxygenated blood into pulmonary trunk** and left ventricle pumps **oxygenated blood into aorta.** During ventricular systole the cuspid valves close both the atrioventricular apertures preventing blood flow into atria (**lubb** sound is heard).
- In normal conditions, **ventricular systole** lasts for **0.3 sec.** and **ventricular diastole** (VD) lasts for **0.5 sec.**

Working mechanism of human heart

c. Joint diastole or complete diastole : During ventricular diastole, semilunar valves are closed, preventing backflow of blood from pulmonary trunk and systemic aorta into ventricles (**dub** sound is heard).

• For about **0.4 second**, both atria and ventricles are in diastole. When all the chambers of heart are in diastole, this condition is called **joint diastole** or complete diastole. Thus, duration of **one cardiac cycle** is **0.8 sec.**

• Right side of heart has *deoxygenated* and left contains *oxygenated* blood.

• Total volume of blood pumped during one ventricular systole is called **stroke volume (SV)** and it is it **approximately 70 ml.**

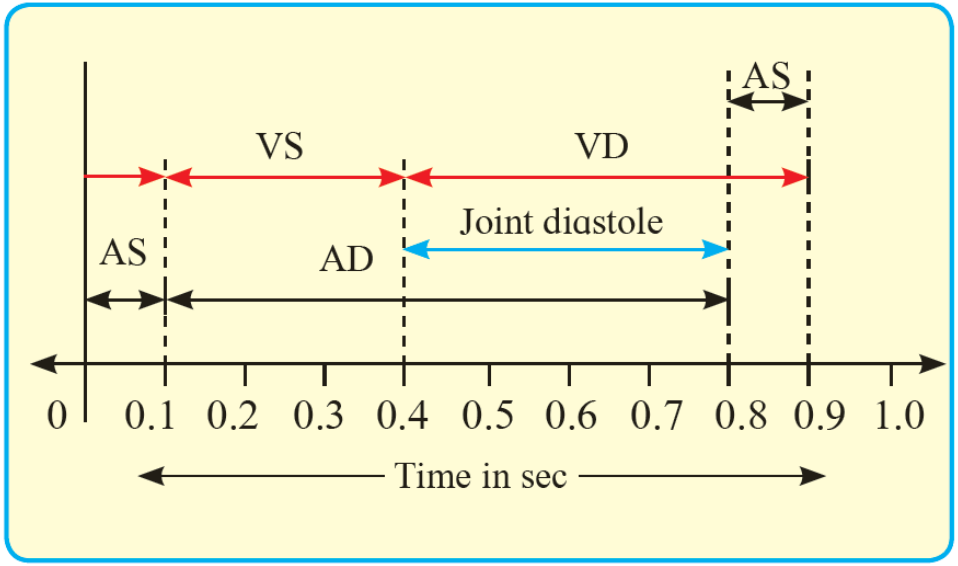


Fig. 8.22 : Diagramatic representation of cardiac cycle

Regulation of cardiac activity :

- Human heart is **myogenic,** it is also under *dual control*, the **nervous** as well as **hormonal**. The nervous control includes the part of **autonomic nervous system.** *Sympathetic system* (with hormone ***epinephrine*** as neurotransmitter) increase the rate of heartbeat during emergency. *Parasympathetic system* (with ***acetylcholine*** as neurotransmitter) reduces rate of heartbeat.
- **Nervous control** includes the part of the **autonomous nervous system-** its *cardiovascular center* lies in the **medulla oblongata**. It controls rate of heart beat in response to inputs from various receptors like *proprio-receptors* (which monitor the position of limbs and muscles), *chemoreceptors* (monitoring chemical changes in blood) and *baroreceptors* (monitoring the stretching of main arteries and veins).
- **Chemical control** of the heart rate includes the conditions like *hypoxia, acidosis, alkalosis* causing decreased cardiac activity, hormones like **epinephrine and norepinephrine** enhance the cardiac activity. Besides, concentration of cations like $\mathbf{K^+}$, $\mathbf{Ca^{++}}$ and $\mathbf{Na^+}$ have major effect on cardiac activity. Cardiac activity decreases with the elevated blood level of $\mathbf{K^+}$ **and** $\mathbf{Na^+}$

https://www.youtube.com/watch?v=Sc7znFkW9PM

https://www.youtube.com/watch?v=MFydNeGomec

Blood Vessels

* Arteries
* Veins
* Capillaries

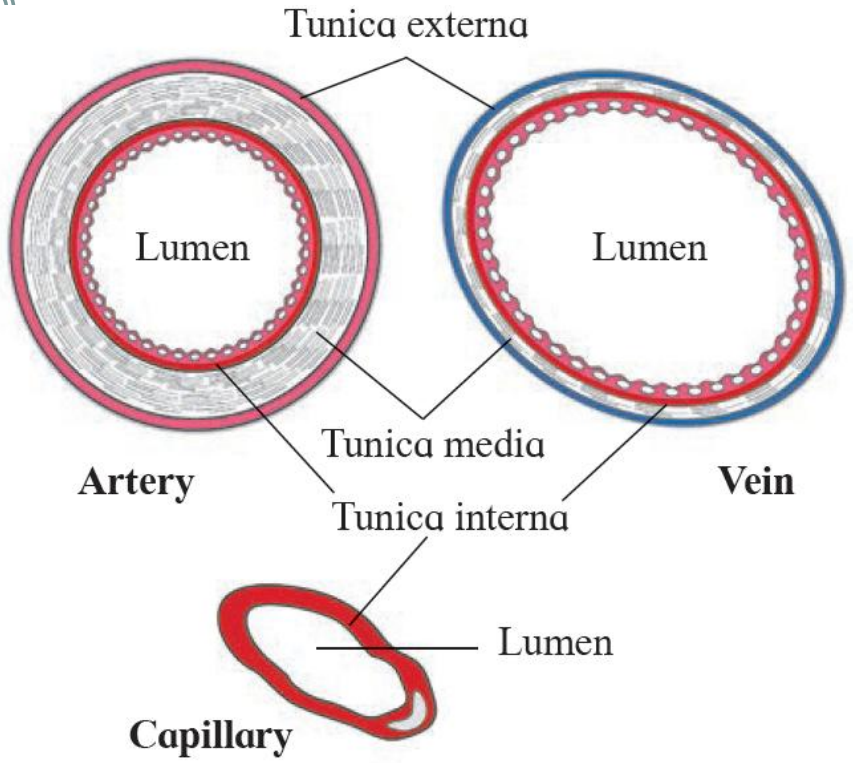


Fig. 8.23 : T. S. of Artery, Vein and Capillary

- Arteries :
- These blood vessels carry blood ***from heart*** *to various parts / organs* of the body, there they branch into arterioles and further into fine capillaries.
- They normally carry oxygenated blood to all parts of the body (except the pulmonary artery which carries *deoxygenated blood*).
- They are usually situated deep in the body except a few like the radial, brachial, femoral, etc. which are superficially located.

- Veins :
- Veins are thin walled, mostly superficial vessels which carry blood *from the organs* ***towards the heart.***
The capillaries around the various organs join to form the veins.
- Except for the pulmonary veins or other veins of the body carry deoxygenated blood towards the heart.

T. S. of artery & vein, their wall shows three layers.

1. Tunica externa or tunica adventitia
2. Tunica media
3. Tunica interna or intima

T. S. of Artery-

- The outermost tunica externa is a *thick, tough layer* of *collagen fibers.* The tunica media is made up of *smooth muscles* and *elastic fibres*.
- This thick muscular and elastic layer makes the arterial wall **pulsatile.** The innermost tunica interna is a single layer of flat compact *endothelial cells* surrounding the lumen.
- The angular margin around the lumen shows **tesselations.** Arterial lumen is devoid of valves and blood flows through it rapidly and with high pressure.

• T. S. of Vein

• Histologically, the veins also show the three layers like in the arteries.

• The tunica externa, tunica media and tunica interna. However, the tunica media is **comparitively thiner** and their lumen is wide and narrow.

• *Internal valves* at regular intervals can be seen.

• Blood flows with flow pressure and the valves prevent backflow of blood.

- Capillary :
- These are a network of minute blood vessels. They are thin walled having a single layer of flat squamous epithelium resting on a single basement membrane. They are mainly involved **in exchange of materials.**
- Blood flows through the capillaries under high pressure. Wall of capillaries bear **small endothelial pores** or **fenestrae** through which blood cells (WBCs) can escape by the process called as ***diapedesis.***

• Pulse :

- It is a series of pressure waves that travel through the arteries due to ventricular systole. It is the strongest in arteries closer to the heart and gradually becomes weak in arteries away from heart. It can be felt easily in the superficial arteries like **radial artery** in the *wrist* and **carotid artery** in the neck. The pulse can be felt at particular points on the body.
- Pulse rate is equal to heart rate. Pulse rate *higher than normal* (above 100 beats/min) is called **tachycardia** and *slower pulse rate* (below 60 beats/min) than normal is called **bradycardia.**

Pulse

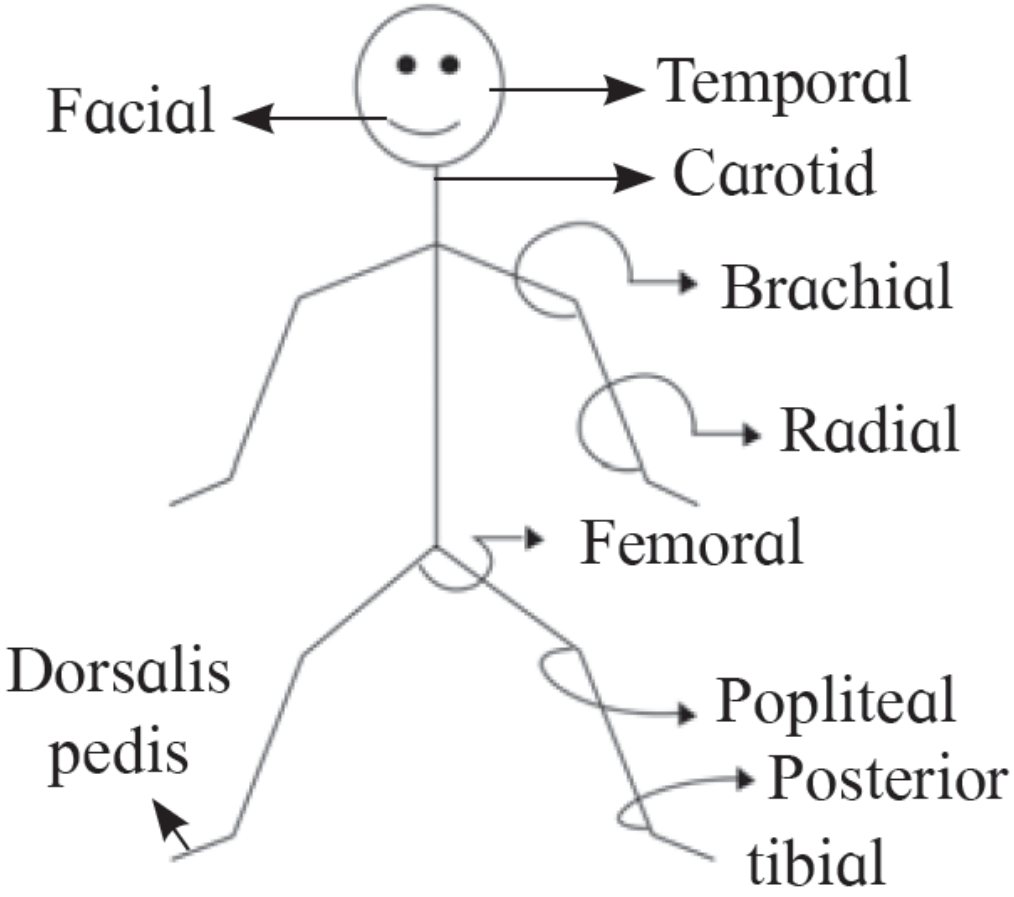


Fig. 8.24 : Pulse points

Blood pressure (B. P.)

- Arterial Blood Pressure- The pressure exerted by blood on the wall of the artery is called arterial blood pressure. It is measured by the sphygmomanometer.

BP = SP / DP

= 120 / 80 mmHg

- Pressure on arterial wall during ventricular contraction (systole) is systolic pressure (SP).
- Pressure on arterial wall during relaxation of ventricles is diastolic pressure (DP).
- Blood pressure is normally written as 120/80 mmHg.

SP - Systolic pressure

DP - Diastolic pressure

- SP – DP = Pulse pressure
- Difference between systolic and diastolic pressure is called **pulse pressure.** Normally, it is 40 mmHg.

- Deviations from normal blood pressure value indicate malfunctioning of heart- It may be due to high or low blood volume, arterial inelasticity or hardening of arteries **(arteriosclerosis)**, deposition of fats like cholesterol in the arteries **(atherosclerosis),** renal diseases and emotion induced hormonal changes, obesity, etc.
- Blood pressure lower than normal i.e. ***below 90/60 mmHg*** is called **hypotension** and blood pressure higher than normal i.e. ***above 140/90 mmHg*** is **hypertension.**
- Various **factors that affect the blood pressure** are cardiac output, peripheral resistance, blood volume, length and diameter of blood vessels, viscosity of blood, age, gender, venous return, sleep, emotions, exercise, anxiety, etc.

- Normal cardiac output is 5 lit/min. Increase in cardiac output increases systolic pressure. *Peripheral resistance depends upon the diameter of blood vessels*. Decrease in diameter of arterioles and capillaries under the effect of **vasoconstrictors** like **vasopressin or ADH** cause increase in *peripheral resistance* and thereby increase in blood pressure. (Blood loss in accidents decreases blood volume and thus the blood pressure)
- Blood pressure is directly proportional to **Viscosity of blood.**
- Blood pressure increases with **age** due to increase in inelasticity of blood vessels.
- *Amount of blood brought to the heart via the veins per unit time is called the* **venous return** and it is directly proportional to blood pressure. Blood pressure is also directly proportional to the total length of the blood vessel.
- Blood pressure can also be affected by vaso constriction or vaso dilation.
- Females have slightly lower BP than males her age before menopause. However, the risk of high B. P. increases in the females after menopause sets in.

Measurement of blood pressure

Fig. 8.25 : Sphygmomanometer

https://www.youtube.com/watch?v=pP_6917sJ

- Blood pressure is measured with the help of an instrument called **sphygmomanometer.**
- This instrument consists of **inflatable rubber bag cuff** covered by a cotton cloth. It is connected with the help of tubes to a **mercury manometer** on one side and a **rubber bulb** on the other side. During measurement, the person is asked to lie in a sleeping position. The instrument is placed at the level of heart and the cuff is tightly wrapped around upper arm. The cuff is inflated till the *brachial artery is blocked due to external pressure*. Then pressure in the cuff is slowly lowered till the **first pulsatile sound** is heard.
- At this moment, pressure indicated in manometer is **systolic pressure**. Sounds heard during measurement of blood pressure are called as ***Korotkoff sounds***. Pressure in the cuff is further lowered till any pulsatile sound cannot be heard due to smooth blood flow.
- At this moment, pressure indicated in manometer is **diastolic pressure**.
- An optimal blood presure (normal) level reads **120/80 mmHg.**

Problems

- **Hypertension**
- **Coronary Artery Disease (CAD)**
- **Angina Pectoris**

Technique – *Angiography, Heart transplant, ECG*

Hypertension : https://www.youtube.com/watch?v=diG519dFVNs

- Persistently raised blood pressure higher than the normal is called hypertension. 140/90 mmHg is called as *threshold of hypertension* and the 180/120 mmHg and higher readings are **dangerous to the health**. It may damage the heart, brain and kidneys.
- Under the condition of hypertension, ***heart uses more energy*** for pumping which causes *angina pectoris*- the chest pains due to lowered blood supply to cardiac muscles and may lead to *myocardial infarction*.

- There are *more chances of* **brain hemorrhage** due to hypertension as arteries in brain are less protected by surrounding tissues as compared to other organs. In kidney, *hypertension* may cause **kidney failure.**
- **Coronary Artery Disease (CAD) :-**
- It is also known as **atherosclerosis**. In this, *calcium, fat cholesterol and fibrous tissues* gets **deposited** in blood vessels suppling blood to the heart muscles making the lumen narrow.
- https://www.youtube.com/watch?v=flJsXOMhuKo
- **Angina Pectoris :**
- It is the **pain in the chest** resulting from a reduction in the blood supply to the cardiac muscles because of **atherosclerosis** or **arteriosclerosis**. It is charactarized by *severe pain and heaviness in the chest*. The pain may spread to the neck, lower jaw, left arm and left shoulder. The pain usually results from **exertion,** when there is more demand of oxygen by the heart, but the supply does not meet the requirement. https://www.youtube.com/watch?v=-I-NN2PSAU8

- **Angiography :**
- **X-ray imaging of the cardiac blood vessels** to locate the position of blockages is called **angiography.** Depending upon the degree of blockage, remedial procedures like **angioplasty or by-pass surgery** are performed.
- In **angioplasty,** a *stent* is inserted at the site of blockage to restore the blood supply while **in by-pass surgery,** the atherosclerotic region is by-passed with part of vein or artery taken from any other suitable part of the body, like hands or legs.
- **Heart Transplant :**
- Replacement of severely damaged heart by normal heart from brain-dead or recently dead donor is called heart transplant. Heart transplant is necessary in case of *patients with end-stage heart failure* and *severe coronary arterial disease*.
- **Silent Heart Attack :**
- Silent heart attack, also known as **silent myocardial infarction** is a type of heart attack that lacks the general symptoms of classic heart attack like **extreme chest pain, hypertension, shortness of breath, sweating and dizziness.** Symptoms of silent heart attack are so mild that a person often confuses it for regular discomfort and thereby ignores it. It has been studied that men are more affected by silent heart attack than women.
- https://www.youtube.com/watch?v=p3z9FLYijrQ

Know the Scientist :

Akash Manoj, a teenager from Chennai invented the non-invasive technique to predict the possibility of a silent heart attack. Interestingly, he invented this technique when he was in class-X.

For his innovation, he had been invited to the Rashtrapati Bhavan as a guest of the President of India under the Innovation Scholars In-Residence Programme.

His innovative kit analyses the level of FABP3 (Fatty Acid Binding Protein-3) with the help of UV light. It is the smallest protein in the blood.

Find out more information about.....

Electrocardiogram

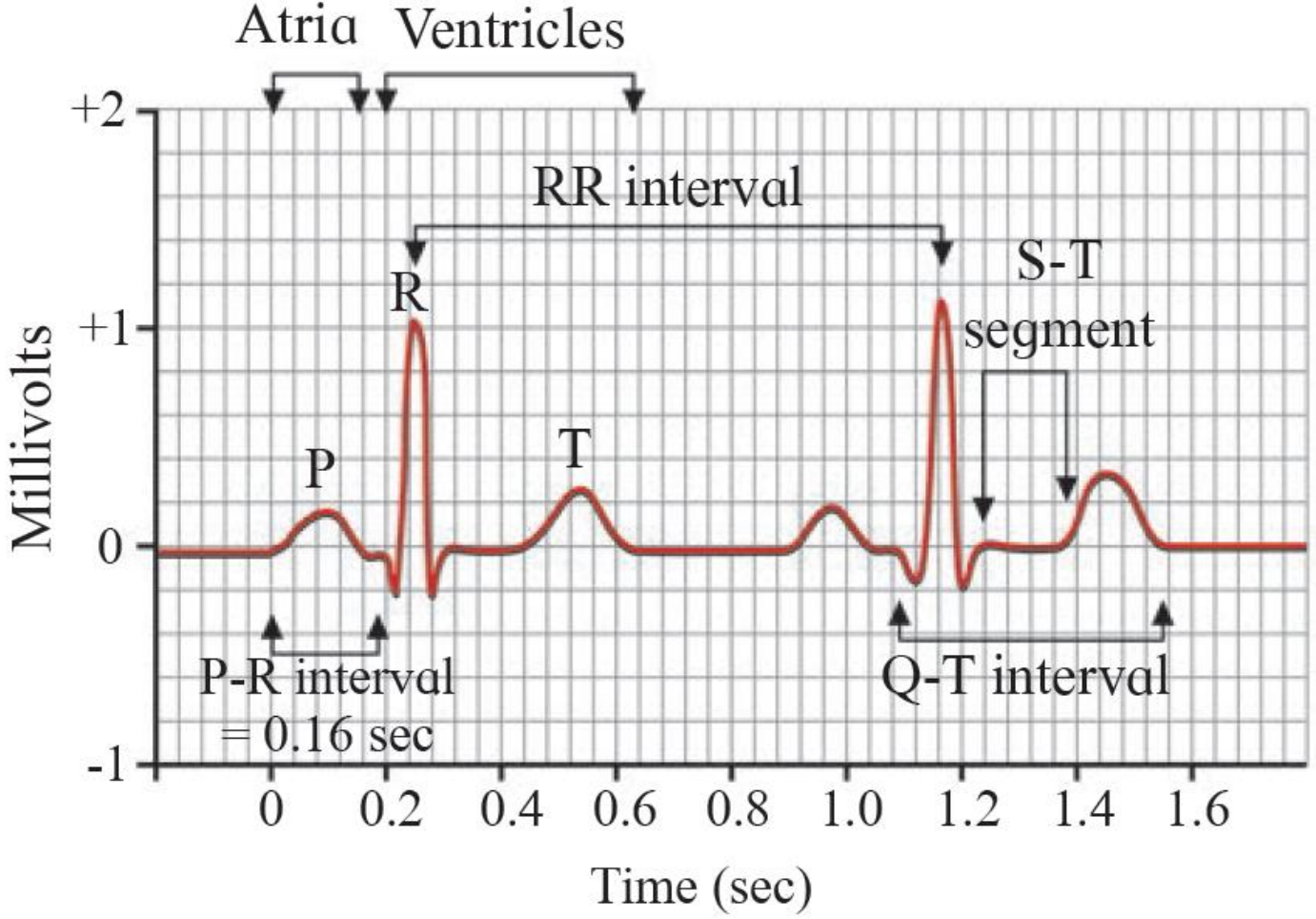


Fig. 8.26 : Normal ECG

Electrocardiogram:

- Graphical recording of *electrical variations* detected at the surface of body during their propagation through the wall of heart is **electrocardiogram (ECG).**
- The instrument used for this recording is the **ECG machine or electrocardiograph.** This instrument *detects* and *amplifies* the signals.
- Four electrodes are positioned on limbs; two on arms and two on legs. These are *limb electrodes*. Six electrodes are positioned *on chest*. These are chest electrodes.
- In a normal record, three different waves are recognized as *P-wave, QRS complex and T-wave.*
- * **P-wave** is a small upward deflection from baseline of graph. It represents the ***atrial depolarization***.
- * The **QRS complex** starts as a slight downward deflection from baseline, continues as sharp and large upright wave and ends as a downward wave. QRS complex represents the ***ventricular depolarization***.
- * **T-wave** is small, wide and upwardly elevated wave. It represents the ***ventricular repolarization***.

Electrocardiogram

ECG helps to diagnose the abnormality in conducting pathway, enlargement of heart chambers, damages to cardiac muscles, reduced blood supply to cardiac muscles and causes of chest pain. A physician can find out the defect in the heart by examining the *wave pattern* and the *time interval* betwen them.

P-wave :- atrial depolarization

QRS complex :-ventricular depolarization

T-wave :- ventricular repolarization

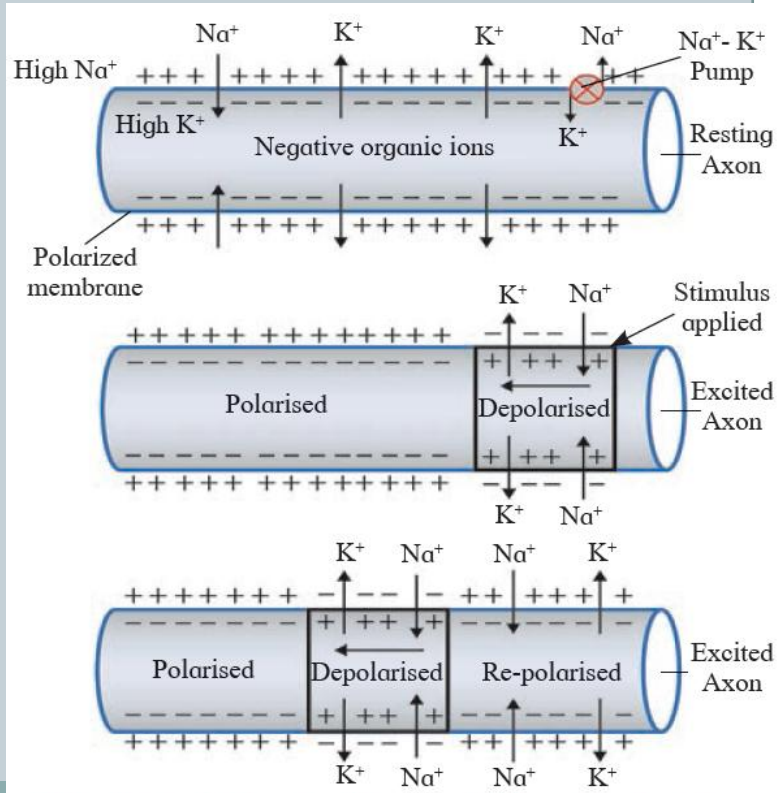


Fig. 9.6 : Polarisation and Depolarisation

Lymphatic System :

- Lymphatic system consists of **lymph, lymphatic vessels,** some organs and tissues. The word 'lymph' means 'clear water' and it is a fluid connective tissue with almost similar composition to the *blood except RBCs, platelets and some proteins.*
- Fluid from intercellular spaces of the body tissue enters into the lymphatic vessels, from here it is discharged into the blood vessels (veins) through the thoracic duct and the right lymphatic duct.

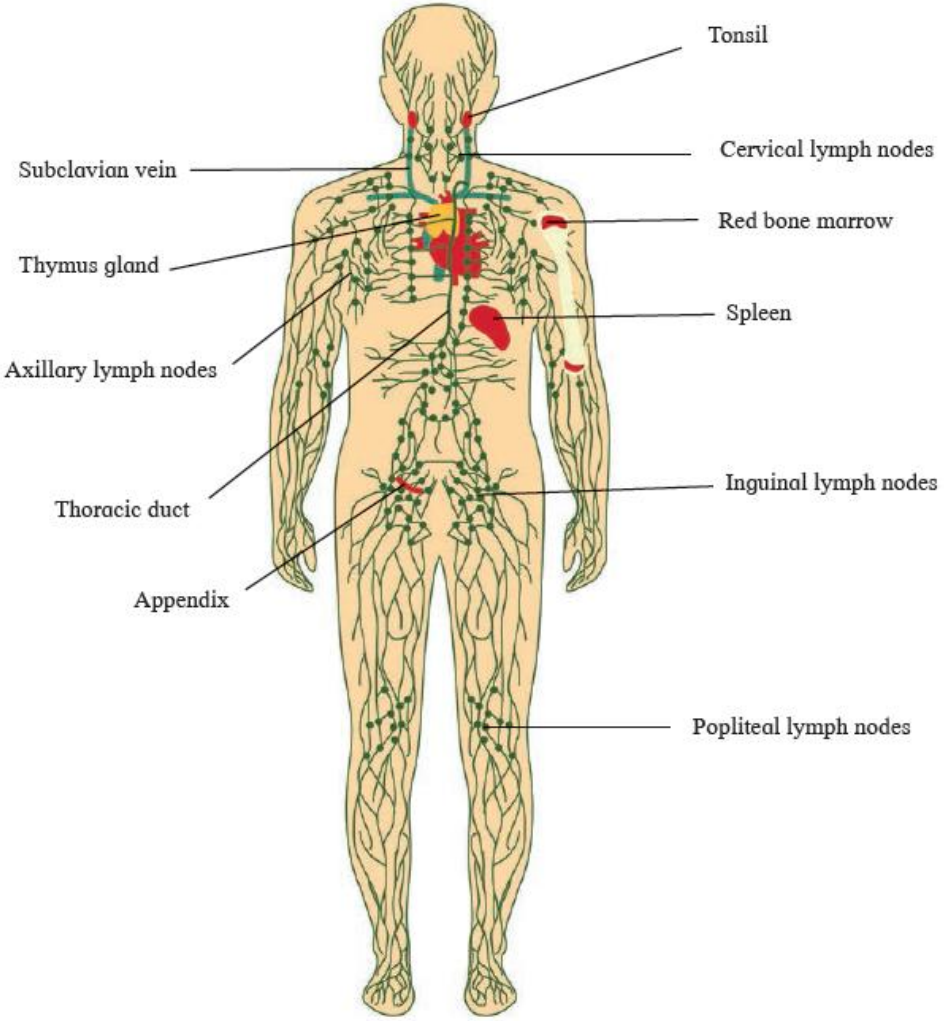
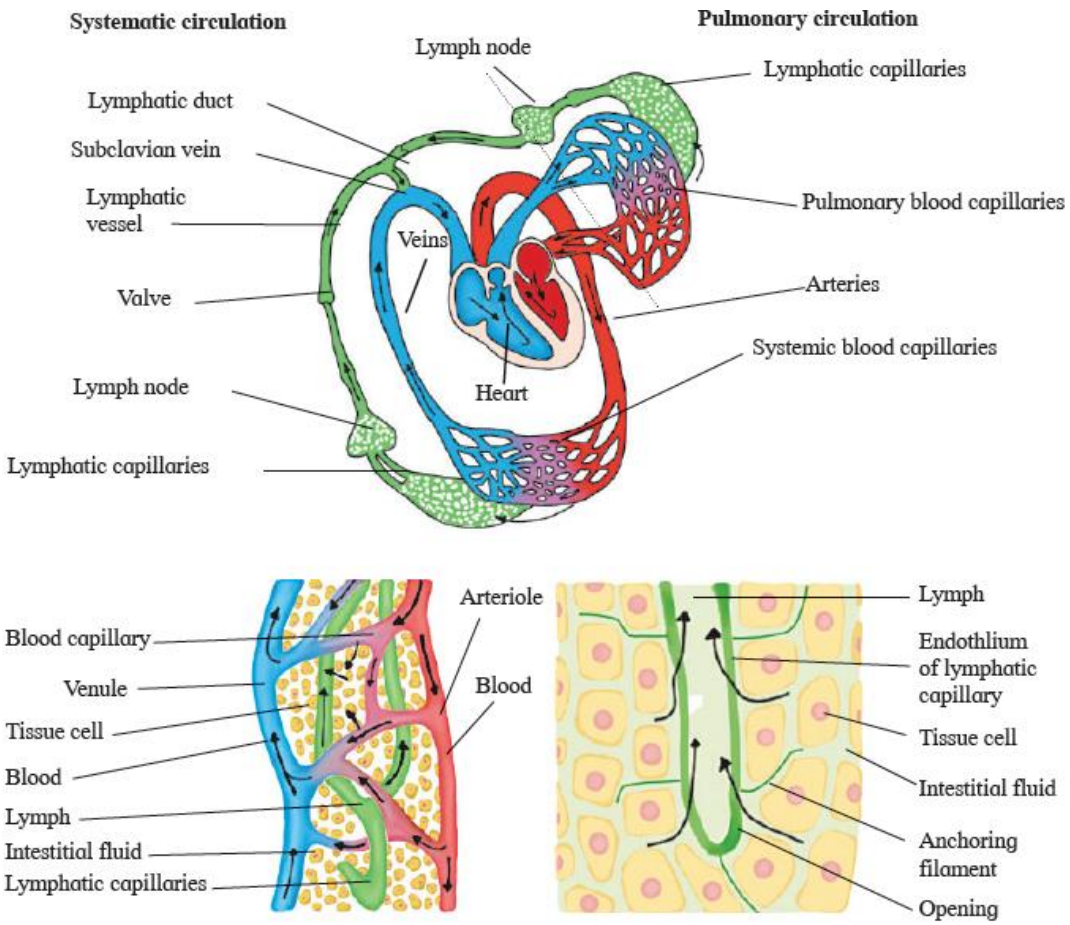


Fig. 8.27 : Lymphatic System

https://www.youtube.com/watch?v=cCPyWFKoIKs

Curiosity

1. What is depolarization and repolarization?
2. What is the correlation between depolarization and repolarization as ell as contraction and relaxation of the heart?
3. How are the signals detected and amplified by electrocardiograph?
4. Who discovered ECG?



a. Relationship of lymphatic capillaries to tissue cells and blood capillaries

b. Details of lymphatic capillary

Fig. 8.28 : Circulation and Lymphatic System

Thank you !