BODY FLUIDS AND CIRCULATION

VASCULAR CONNECTIVE TISSUE

There are two types of vascular connective tissue :

- ♦ (1) Blood (2) Lymph

Matrix is liquid & fibre free

BLOOD

Study of Blood — **Haematology**

Process of blood formation Haemopoiesis (in bone marrow).

- ♦ Colour — Red
- ♦ PH — 7.4 (Slightly alkaline)
- ♦ By weight — 7 to 8% of body weight
- ♦ By volume — 5 - 6 litres in male and 4 - 5 litres in female.
- ♦ Blood is a false CT because:-
  - a. Cells of blood have no power of division.
  - b. Fibres are completely absent in blood.
  - c. Matrix of blood is produced & synthesized by liver and lymphoid organs,

Composition of Blood

1. Liquid Part — Matrix — Plasma — 55%

   Solid Part — Blood corpuscles — 45% (RBC, WBC & Platelets)

PLASMA

1. Matrix of blood is called Plasma.
2. It is pale yellow in colour due to urobillinogen. (Billirubin)

Composition of plasma

Water : 90% – 92%

Solid part : 8 – 10%

In which inorganic and organic compounds are present.

Organic Part of Plasma — 7 - 9%

1. Proteins

– 6 - 7% Maximum

(A) Albumin $\rightarrow$ 4% (Max.)

– Produced & synthesized by liver.

– Smallest Plasma Protein.

– Responsible to maintain BCOP (28 - 32 mm Hg.)

(B) Globulin :- 2- 2.5%.

– Ratio of albumin & globulin is 2 : 1.

– Produce and secreted by liver and lymphoid organs.

– Transport or catty substance in body.

– Destory bacteria virus & toxic substances.

– In blood 3 type of globulins are present.

[i] **α–Globulin -** Produced by liver .

Eg. Ceruloplasrnin- Cu carrying protein.

[ii] **β–Giobulin** — Produced by liver

Eg. Transferin- Fe carrying protein.

[iii] **γ–Giobulin** — Produced by lymphoid organs

– Present in the fortn of antibodies which destroy bacteria, virus & toxic substance. Also called Immunoglobulins. These are of 5 types.

[A] **lg G** (γ lmmuno)

[B] **lg A** (α Immunoglobin)

[C] **lg M** (μ Immuno)

[D] **lg D** (δ Immuno)

[E] **Ig E** (ε Immuno)

(C) Prothrombin – 0.3% Produced by liver

(D) Fibrinogen – 0.3% Produced by liver

– Largest plasma protein.

– Help in blood clotting.

BLOOD CORPUSCLES

RCB

Erythrocytes (Red blood Corpuscles)

1. Mammalian RBC's are biconcave, circular & non nucleated.

2. At the time of origin nucleus is present in the RBC but it degenerates during maturation process.

3. Biconcave shape of RBC increases surface area.

4. Due to absence of nucleus & presence of biconcave shape more Haemoglobin can be filled in RBC.

Exception :- Camel & Lama are mammals with biconvex, oval shaped.

5. In RBC endoplasmic reticulum is absent so endoskeleton is composed of structural protein, fats and cholesterol present in the form of network called stromatin which is a spongy cytoskeleton.

6. Plasma membrane of RBC is called Donnan's membrane. It is highly permeable to some ions like Cl^- & HCO_3^- ions and impermeable to Na^+ & K^+ ions. It is called Donnan's phenomenon.

7. Due to presence of stromatin spongy cytoskeleton & flexible plasma membrane RBC (7.5μ) can pass through less diameter blood capillaries (5μ).

8. In RBC higher cell organelles like mitochondria & golgi complex is absent.

9. Due to absence of mitochondria anaerobic respiration takes place in RBC.

10. In RBC enzyme of glycolysis process are present, while enzyme of Krebs cycle are absent.

11. Antigen of blood group is present on the surface of RBC.

12. If Rh Antigen is present then it is also found on the surface of RBC.

13. Single RBC is pale yellow in colour while group of RBC appear red in colour.

14. In RBC red coloured respiratory pigment haemoglobin is present.

15. In each RBC 26.5 crores molecules of Hb are present.

16. Molecular weight of each molecule of haemoglobin – 67,200 Dalton.

17. In composition of RBC 60% Hp & 40% solid part is present. Only Hb. Constitutes 36% of total weight of RBC and 90% on dry weight.

Haemoglobin

It is composed of two components

1. Haem- 5%
2. Globin- 95% Protein part

Haem (Iron and Porphyrin)

1. Iron present in the form of Fe^{+2}

2. Each molecule of Hb carries 4 molecules of O_2.

Globin: Each molecule of globin protein is composed of 4 polypeptide chains. Polypeptide chains are of 4types.

1. α polypeptide chain having 141 amino acids.
2. β polypeptide chain having 146 amino acids.
3. γ polypeptide chain having 146 amino acids.
4. δ polypeptide chain having 146 amino acids.

On the basis of these polypeptide chains 3 type of Hb are formed in human -

- ♦ Hb A_1 (Adult Hb) — $2\,\alpha + 2\,\beta$
- ♦ Hb A_2 (Adult -2) — $2\,\alpha + 2\,\delta$
- ♦ Hb F (Foetal Hb) — $2\,\alpha + 2\,\gamma$

(Oxygen binding capacity-of foetal Hb is more than adult Hb.)

Size of RBC

Human – 7.5 μ

♦ Change in the size of RBC is called as Anisocytosis.

1. Due to Vit. B_{12} deficiency RBC become larger in size called as Macrocytes. These are immature RBC which are destroyed in spleen. In these RBCs amount of haemoglobin is normal.
2. Due to Fe deficiency RBC become smaller in size called as Microcytes. They are also destroyed in spleen. In these RBCs amount of haemoglobin is less.

Shape of RBC -

1. Biconcave
2. Change in the shape of RBC is called as Poikilocytosis.
3. Uremia- RBC become irregular in shape (Burr cells).
4. Sickle cell anaemia-RBC become sickle shaped.
5. If RBC is kept in hypertonic solution it will shrink (crenation).
6. In Hypotonic solution it will brust.

Life span of RBC is 120 days

Avg. life span of RBC in all mammals 120 - 127 days.

RBC count

Number of RBC in per cubic mm of blood is called RBC count.

$$\left.\begin{array}{ll} \text{Human (Male)} & 5.5\ \text{million} \\ \text{Human (Female)} & 4.5\ \text{million} \\ \text{Newly born boby} & 6.8\ \text{million} \\ \text{Robbit} & 7\ \ \text{million} \\ \text{Frog} & 0.4\ \text{million} \end{array}\right] \pm 1\ \text{Million}$$

♦ Decrease in RBC count condition is called Anaemia.

1. **Macrocytic anaemia –** Due to Vit. B 12 deficiency macroytes are formed which are destroyed in spleen.
2. **Microcytic anaemia –** Due to Fe deficiency microcytes are formed.
3. **Normocytic anaemia –** Excess blood loss.

Formation of RBC

1. Process of formation of RBC is called Erythropoiesis.
2. Organs which produce RBC's called Erythropoietic organs.
3. Hormone which stimulate Erthyropoiesis is called erythropoetin synthesize by Kidney & little quantity by liver.
4. 1^{st} RBC produced by yolk sac.
5. During embryonic life RBC are produced by Liver, Spleen, Placenta, Thymus galnd.
6. In adult stage RBC is produced by RBM which filled in between trabeculae of spongy bones.
7. 1% RBC are destroy daily but in same number new RBC are entered in the blood.
8. Destruction of RBC occur in spleen. So spleen is called Graveyard of RBC.
9. Spleen stores excess blood corpuscles so it is called Blood Bank of body.

WBC

♦ WBC (White Blood Corpuscles) are also called as leucocytes because they are colourless. TLC- Total leucocyte count. Number of WBC /mm^3 $\rightarrow$ 6000 – 8000/mm^3 (± 2000 – 3000)
Leucocytosis :- Increase in TLC. This condition occur in bacterial & viral infection.
Leucocytopenia :- Decrease in TLC. Normally TLC increases in bacterial & viral infection but in typhoid & AIDS, TLC decreases.
Leukemia :- Abnormal increase in TLC (more than 1 Lakh) it is called as blood cancer.

♦ **On the basis of nucleus & nature of cytoplasm, Leucocyte are of two types.**

(1) Granulocytes

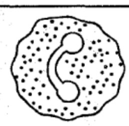
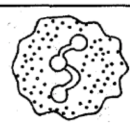
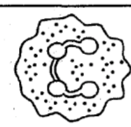
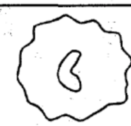
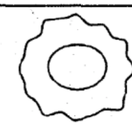
1. In their cytoplasm granules are present which can be stained by specific dye.
2. Nucleus is multilobed and lobes are interconnected by protoplasmic strand.
3. Due to presence of lobed nucleus they are called as polymorphonuclear WBC.
4. Produced in Bone marrow-

They are (i) Acidophils, (ii) Basophils & (iii) Neutrophils

(2) Agranulocytes

1. Cytoplasm is clear and agranular.
2. Nucleus do not divide in lobes so called as mononuclear WBC.
3. Produced in bone marrow.

They are of 2 types (i) Monocytes (ii) Lymphocytes

Characteristics	Acidophils	Basophils	Neutrophils	Monocytes	Lymphocytes
Size	10-14μ	8-10μ (smallest granulocytes)	10-12μ	12-20μ	6-16μ
Life span	14 hrs	10 hrs	12 hrs	less then 24 hrs in blood	5 to 7days in blood
stain with	acidic dye like eosin	Basic dye like methylene blue	any dye (acidic/ basic/neutral)		
Shape of nucleus	Bilobed	Two or three lobed, S-shape	3 to 5 lobed	Kidney / Bean shaped	Large due to which cytoplasm becomes peripheral
Function/s	They protect body against allergy and parastic infections.	Secrete and transport heparin, histamine and serotonin	Phagocytic in nature. Destory bacteria and viruses by phagocytosis.	Also called scavengers of blood because they engulf damaged or dead and minute bits of blood corpuscles.	– T–Killer – direct Kill microbes – T–Helper – Stimulate – B – Lymphocyts to produce antibody – T–Suppersor – Suppresses – T– Killer and protect immune system. – B-lymphocytes–Produce and transport antibodies.
Number	2-3% of TLC	0.5-1% (minimum in no.) of TLC	60-65% (maximum in no.) of TLC	6-8% of TLC	20-25% of TLC
Special point	Acidophils ↑ called Eosinophilia occurs during taeniasis, Ascariasis, Hay fever		– Due to their smaller size and phagocytic nature they are called micropoliceman of blood	Macropoliceman	
Diagram					

PLATELETS

1. Size 2 - 3 μ.
2. Life span - 2 - 4/5 days.
3. Count- 1.5 - 3.5 lakh/mm^3 .
4. Also known as Thrombocytes
5. They are non nucleated and derived from megakaryocyte cells of bone marrow.
6. In shape platelets are disc like, oval shaped or biconvex.
7. In their cytoplasm basophilic granules are present which can be stained by methylene blue.
8. Maximum part of cytoplasm is composed of contractile protein Thrombosthenin.
9. Decrease in number of blood platelets is called Thrombocytopenia.
10. Critical count of thromocytes is 40,000/mm^3. If number is less than critical count then red sopt or rashes appears on the skin called Purpura disease.

Function

1. Repair endothelium of blood vascular system by the formation of platelet plug because they have tendency to attach on gelatinous or mucilagenous surface,
2. Synthesize thromboplastin which help in blood clotting.
3. Synthesize serotonin (5-hydroxytriptamine).

BLOOD CLOTTING

♦ Blood flows from cut or wound but after some times it stops automatically, it is called clotting of blood.

♦ Bleeding time 1 - 3 min.
Clotting time 2 - 8 min.
Some times clots are also formed in intact blood vessels which are of two types.

Thrombus Clot

1. Static clots which grow bigger & bigger & ultimately block the blood vessels.

2. If this clot is formed in the coronary vessels then called as coronary thrombosis which can cause heart attack.
3. If found in brain, then called as cephalic thrombus causes paralysis.

Ambolus clot

1. Moving clots which flow with blood.
2. More harmful due to their moving nature.

Mechanism of blood clotting
(Enzyme Cascade theory)

♦ Proposed by Macfarlane & Co-workers.
♦ According to this theory there are 3 steps in blood clotting.

1. Releasing of Thromboplastin :-

– Injured tissue synthesize exothromboplastin and plat~lets synthesize endothromboplastin.
– Both these thromboplastin react with plasma proteins in the presence of Ca^{++} ions to form Prothrombinase enzymes. Cfhrombokinase)
– This enzyme inactivate heparin. (Antiheparin)

2. Conversion of Prothrombin into Thrombin

– Prothrombinase enzyme convert inactive prothrombin into active thrombin in the presence of Ca^{++} ion.

3. Conversion of fibrinogen into fibrin

– Fibrinogen is soluble protein of plasma. Thrombin protein polymerise monomers of fibrinogen to form insoluble fibrous protein fibrin.
– Fibrin fibres form network on cut or wound in whiCh blood corpuscles got trapped. This form clotting of blood.
– After clotting a pale yellow liquid oozes from clot called Serum. In which antibodies are found.

Blood – Corpuscles = Plasma
Plasma – fibrinogen = Seri,

Clotting Factors:-

1. 13 factors help in blood clotting.
2. These factors are mainly produced in liver.
3. Vitamin K is required in the synthesis of these clotting factors.
4. These factors are represented in Roman number.

I — Fibrinogen
II — Prothrombin
III — Thromboplastin
IV — Ca^{+2} (cofactor in each step of blood clotting)
V — Proaccelerin
VI — Accelerin (Rejected)
VII — Proconvertein
VIII — AHG (Anti Haeomophelic Globulin) (Absent in haemophilia-A)
IX — Christmas factor/plasma thromboplastin co-factor
X — Stuart factor
XI — PTA (Plasma thromboplastin anticedent)
XII — Hagman factor (become active by friction)
XIII — FSF factor (Fibrin stabilising factor) (Laki lowand factor).

Blood Groups

- Antigen of blood groups is present on the surface of RBC also called as agglutinogen.
- Antibody for blood group antigen is present in serum (plasma) called agglutinin.
- Blood grouping Antigen & Antibody are special type of glycoproteins.
- Blood groups are of 4 type A, B, AB, O.
- A, B, O discovered by Landsteiner. (Father of blood grouping)

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	anti-B	A, O
B	B	anti-A	B, O
AB	A, B	nil	AB, A, B, O
O	nil	anti-A, B	O

- Blood group 0 is universal donar & Blood group is AB is universal accentor.

RH FACTOR

- Discoverd by Landsteiner & weiner in Rhesus monkey.
- Rh antigen is due to dominent gene. So if one of the gamete possess gene of Rh factor, its off Spring will be Rh +Ve.
- If antigen is present then Rh^+ .
- If antigen is absent then Rh^-.

In India % ratio of Rh is -

Rh^+ — 97%

Rh — 3%

In World-

- Rh^+ — 80%
- Rh^- — 20%
- In Rh^+ antibody is absent for this antigen.
- Rh antibody is also absent in Rh^- blood.

But

1. If Rh^+ blood is transfused to Rh^- then 1st blood transfusion is complete successfully but during Ist blood transfusion Rh antibodies are formed in receiver's blood so in next blood transfusion, agglutination (Clumping) of blood takes place.

   O^- $\longrightarrow$ universal donar.

   AB^+ $\longrightarrow$ universal acceptor.

2. If mother is Rh^- & father is Rh^+ then offspring may be Rh^+. In this case 1st pregnancy is completely successful but during at the time of 1st delivery Rh antibody is formed in mother's blood due to damaged blood vessel so in next pregnancy death of foetus will occur in the earlier stage due to agglutination of blood called erythroblastosis foetalis.

   Rh antibodies are given to mother with 72 hrs to destory foetal RBC which prevent Rh-antibodies formation in mother.

GOLDEN KEY POINTS

1. **Packed cell volume** (PCV) :- % volume or Total number of blood corpuscles in blood.
2. **Haematocrit Volume** :- %volume or only number of RBC in blood.
3. PCV $\approx$ HV

because 99% of packed cell volume is contributed by RBC & in rest 1% WBC & Plaletets are present.

4. In RBC carbonic anhydrase enzyme is present which increases rate of formation & dissociation of carbonic acid by 5000 times. (Fastest catalyst (with zinc))

5. 1 gm Hb carries 1.34 ml O_2.

6. 100 ml blood contain 15 gm Hb.

7. 100 ml blood transport 20 ml O_2.

8. **Size of RBC**

Largest RBC- Amphiuma 75- 80 μ (Class : Amphibia)

Smallest RBC- Musk Deer 2.5 μ (Class: Mammalia)

9. Largest RBC among all mammals in elephant 9 - 11 μ.

New Born Baby	—	100	days
Rabbit	—	80	days
Frog	—	100	days

10. Increase in the RBC count condition is called polycythemia. This condition occurs at hill station.

11. Kidney is an erthyropoetic organ in frog.

12. In resting and slow flowing blood, the RBC form piles called Roulaux by adhering together due to surface tension.

13. Minute pits of disintegrated red blood corpuscles in known as Haemoconia.

14. In female neutrophils barr body is attached with lobe of nucleus which is formed by the modification of xchromosomes. It help in sex detection.

15. AB blood group is discoverd by De-costello and Sturli.

16. Oxygen association of Adult Hb is more than HbF.

BEGINNER'S BOX - 1

1. Which of the following is most abundant in blood.

(1) RBC (2) WBC (3) Platelets (4) All are equal

2. In DLC neutrophil found as:-

(1) 0-2% (2) 2-8% (3) 25% (4) 65%

3. Critical count of Platelet is :-

(1) 40,000 / mm^3 (2) 1 lac / mm^3 (3) 2 lac / mm^3 (4) 4 lac / mm^3

4. Mammalian mature RBC does not contain :

(1) Membrane bounded cell organelles (2) Carbonic anhydrase

(3) Haemoglobin (4) Enzyme of glycolyte pathway

5. Blood clot is mainly due to:-

(1) Fibrin + Corpuscles (2) Heparin + Corpuscles

(3) Plasma + Thrombocytes (4) Plasma + RBC

6. Macropolice man of blood:-

(1) Neutrophil (2) Basophil (3) Monocyte (4) Lymphocyte

CIRCULATION

An expanded pipe line system is present in human body. It is called closed circulatory system. A continuous chemical exchange of materials between animal body and environment among different tissues of the body, is done through this system. In this way digested nutrients from digestive system, oxygen from respiratory organs, hormones from endocrine glands are distributed to all the cells of body. Also the transport of CO_2 from body cells to respiratory organs, NH_3, urea etc. excretory substances to excretory organs is the function of circulatory system. The whole circulatory system is formed by the mesoderm of embryo.

Circulatory pathways: The circulatory patterns are of two types:- open or closed.

Open type	Closed type
(1) In this blood is pumped by heart passes through large vessels into large open spaces or body cavities called blood sinuses. (2) Tissues are in direct contact with circulating fluid. (3) Less advantageous pattern Eg. Arthropods, molluscs	(1) Blood is pumped by heart into closed network or blood vessels. (2) Tissues are not in direct contact with circulating fluid (3) More advantageous pattern eg. Annelids, Chordates, (Class caphalopoda of mollucs)

In human beings (on the basis of circulating fluid) two types of circulatory system are observed

(1) **Blood circulatory system:** It consist of : Blood, Blood vessels, Heart.

(2) **Lymphatic system :** It consist of lymph, lymph vessels , lymph nodes.

TYPE OF BLOOD CIRCULATION AND HEART IN VERTEBRATES

	Fishes	Amphibians	Reptiles	Crocodiles, Aves, Mammals
No. of heart Chamber	2	3	3	4
Atria	1	2	2	2
Ventricles	1	1	1	2
Type of circulation	Single	Incomplete Double	Incomplete Double	Double Circulation

Evolutionary sequence is present in vertebrates in heart.

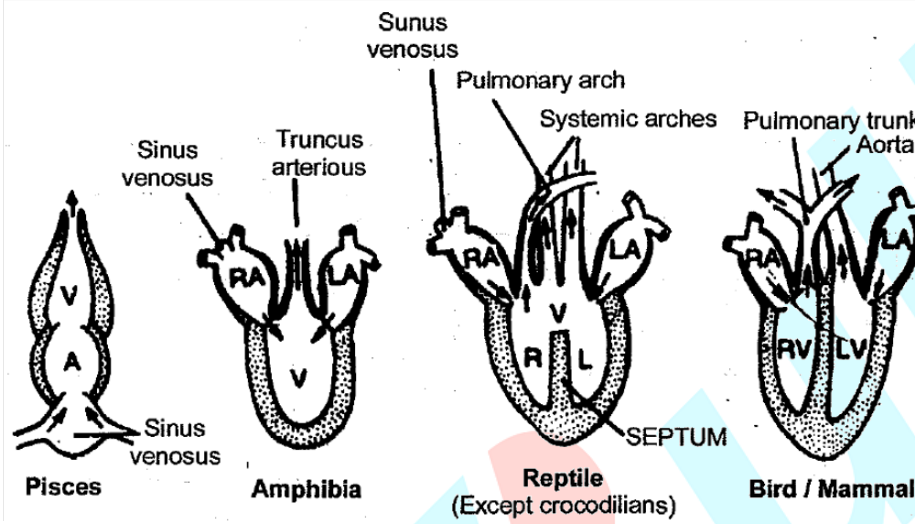
(1) Fishes have "Venous-Heart" In their heart, deoxygenated blood enters from one side and from the other side to the gills for oxygenation. This is called the "Single Heart Circuit."

(2) In amphibians and Reptiles the auricles are divided into right and left. Right auricle gets deoxygenated and left auricle gets oxygenated blood from the body. But only 1 ventricle is present or is incompletely divided so after coming here the pure and impure blood mix up. This is called Incomplete double circulation.

(3) In some reptiles (Crocodile, Gavialis and Alligator) and in all birds and mammals the heart is divided into 2 auricles and 2 ventricles so while circulating inside the heart the pure and impure blood remain separated. The right portion of the heart collects impure blood from the body and sends it to the lungs for purification, while the left portion takes pure blood from the lungs and distributes it to the whole body. This is called Double circulation.

- The right portion of the heart is called as the "Pulmonary-Heart" and the left portion is termed as the "Systemic-heart". This is termed as "Double Circulation of Heart" because the blood has to pass through the heart twice before being delivered to systemic organs.

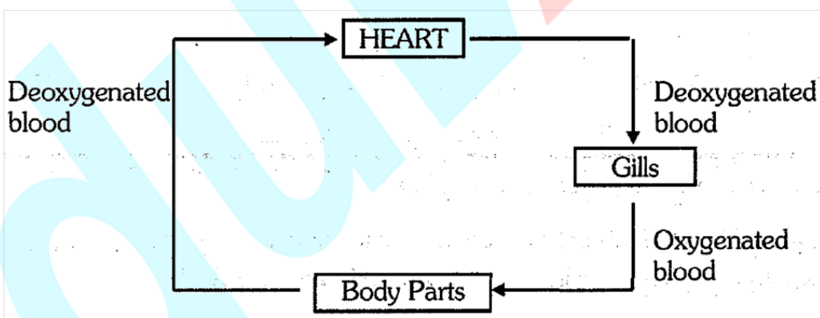
GOLEDN KEY POINTS



- **Sinus Venous and Conus Arteriosus-** They are accessory sacs connected to the heart. They are found in Fish and amphibia. They are absent in birds and mammals. In Reptiles sinus venosus present but conus arteriosus absent.

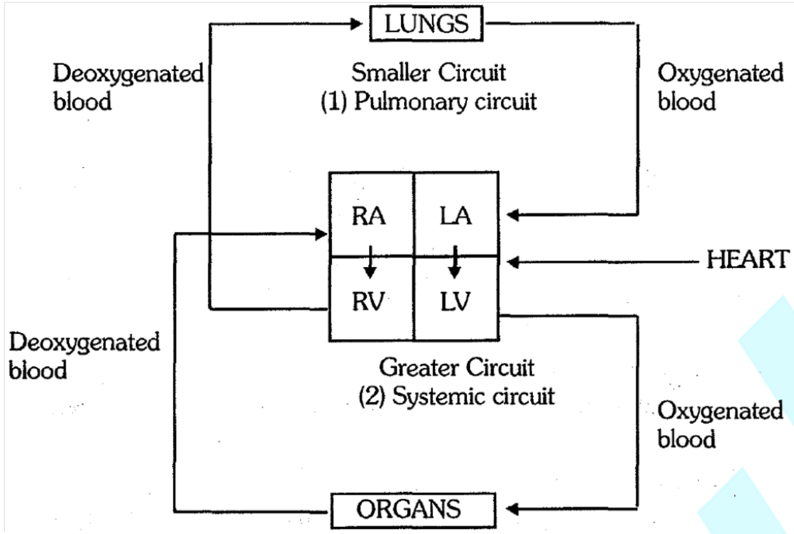
TYPES OF CIRCULATION OF BLOOD

1. **Single Circulation :-** Example : Fishes

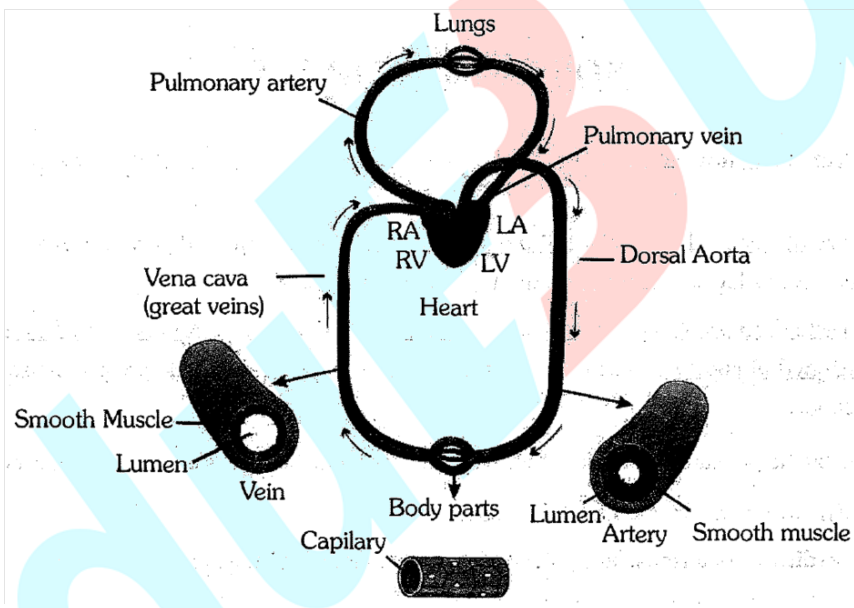


2. **Incomplete double circulation :-** Two circuits are not completely separate.
   - Amphibia, Reptiles

3. **Double Circulation :- Example** – Birds, Mammals



Path of Blood in Double Circuit (Man)



BEGINNER'S BOX - 2

1. Single heart circuit occurs in :-
(1) Fishes (2) Frog (3) Reptiles (4) Man

2. Which of these has a closed type of circulatory system:-
(1) Cockroach (2) Fish (3) Mollusca (4) Scorpion

3. Heart of frog differs from that of rabbit by presence of :-
(1) Sinus venosus (2) Four chambers (3) Mitral valve (4) Two aorta

4. Three chambered heart is found in :-
(1) Fish (2) Frog (3) Rabbit (4) Man

5. Heart of fishes:-
(1) Two chambered (2) Venous heart (3) Both (1) & (2) (4) None of the above

6. Circulation in Human is :-
(1) Single & Open (2) Double & Open (3) Double & Close (4) Single & Closed

7. Which organ receives only oxygenated blood ?
(1) Gill (2) Spleen (3) Lung (4) Liver

8. Open type of vascular system is predominant in
(1) Fishes (2) Arthropods (3) Amphibians (4) Earthworm

9. Which animal has most mixing of oxygenated and deoxygenated blood in the ventricles?
(1) Scoliodon (2) Rabbit (3) Frog (4) None of these

STRUCTURE OF HEART

♦ Heart the mesodermally derived organ, is situated in the thoracic cavity in between the lungs, slightly tilted to the left.

♦ Heart has size of clenched fist, weight 300 gm. Its triangular superior-broad portion is tilted slightly towards right (dorsal) side. Its lower narrow portion is tilted towards left side.

♦ Heart is protected by a double layered bag called pericardium. The narrow space in between these two membranes is called pericardial cavity in which pericardial fluid is present. Pericardial fluid provide moisture to heart and reduces frictions.

♦ It is secreted by the pericardium. Pericardial cavity is a true coelom (as it lies between two layers of mesoderm).

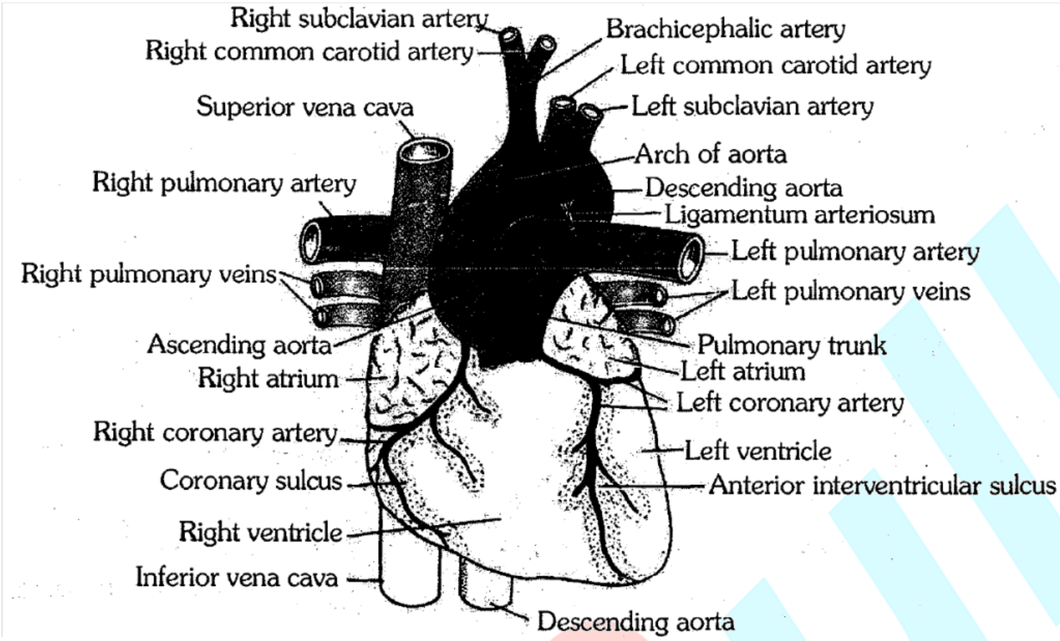
Wall of Heart : The wall of heart is made of three layers.

(i) **Epicardium -** outermost layer, Made of simple squamous epithelium.
(ii) **Myocardium -** middle layer, thickest, Made of cardiac muscles which are striated but involuntary.
(iii) **Endocardium –** innermost layer, Made of simple squamous epithelium.
Thickness of wall of Heart depends on Myocardium.

♦ The heart of man is four chambered. Two relatively small upper chambers called Atria and two larger lower 15 chambers called ventricles.

♦ The atrium and the ventricle of the same side are separated by a thick fibrous tissue called the atrio-ventricular septum.

♦ The right and left atria are separated by a thin muscular wall called Inter atrial septum. Which is shifed slighty towards left. So right atrium is slightly bigger than left atrium.



- Ventricular part is broad, muscular and of light colour. Ventricles have thicker walls than auricles.

- The septa which divide the two ventricles are termed as lnter-venticular septum. It is oblique or tilted toward Right. It does not reach till the tip or apex of the heart, So the right ventricle is smaller than the left ventricle.

- Left ventricle is more muscular and thick walled then right because it has to pump blood into those arteries which take blood throughout the body while right ventricle has to pump blood only to the lungs.

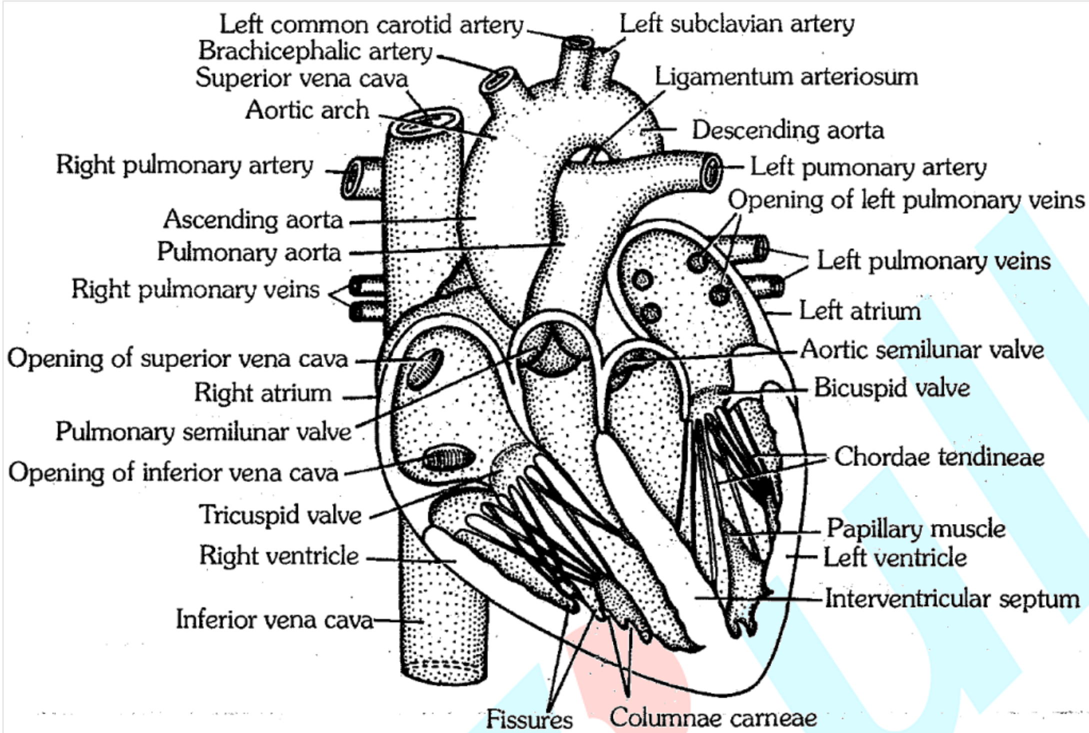
- Left ventricle is the largest chamber of heart.

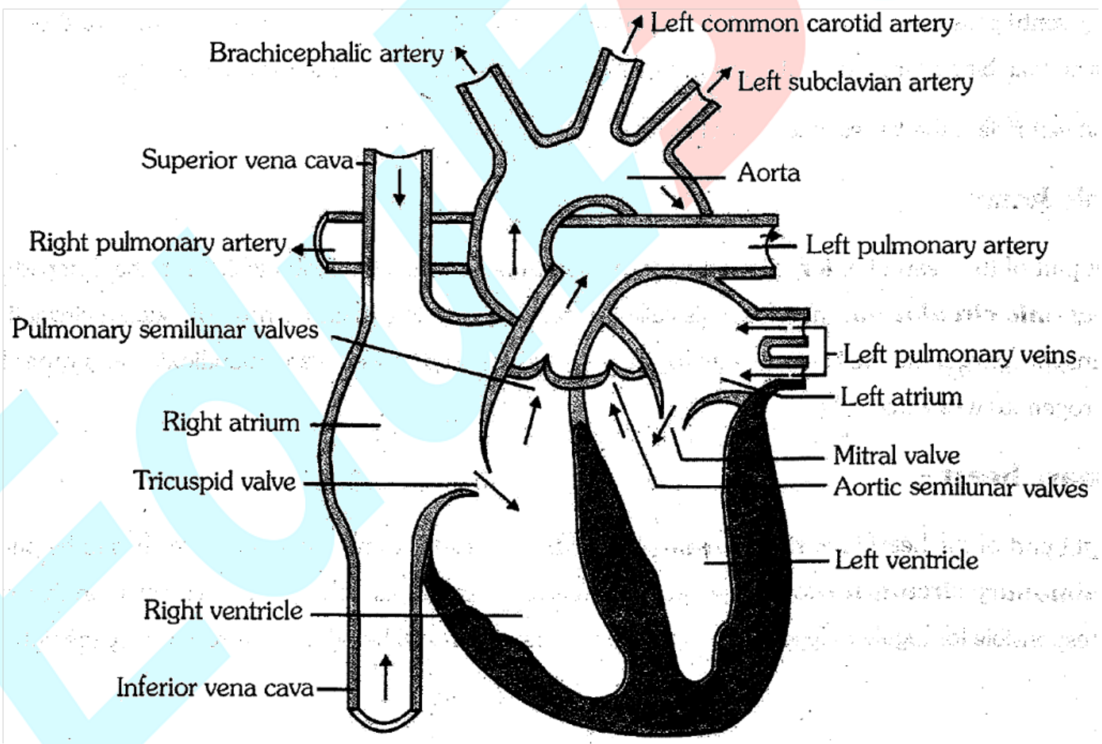
Systemic heart -

left part of the heart (i.e. left atrium and left ventricle) contain the blood which is to be pumped into the systemic circulation, therefore it is called systemic heart. The main purpose of such a circulation is to transport oxygen ,as well as nutrients to the body tissues and to remove carbondioxide and other harmful nitrogenous waste from them.

Pulmonary heart -

Right part of the heart (i.e. right atrium and right ventricle) contain the blood which is to be pumped in pulmonary circulation for oxygenation, therefore it is called pulmonary heart. The pulmonary circulation is responsible for regular oxygenation of the impure deoxygenated blood which is received by the right auricle,





Vessels

♦ **Right Atrium-** Receives one S.V.C., one I.V.C. and one opening of coronary sinus in man. SVC = superior vena cava; IVC = inferior vena cava. The SVC & IVC bring impure blood from the upper and lower body parts respectively. The Coronary sinus receives impure blood from the rt. & lt. Coronary veins and drains it in the right auricle

- **Right Ventricle-** Receives impure blood through right AV foramen from right atrium. Drains the impure blood into pulmonary artery through which it reaches lungs for oxygenation.
- **Left atrium -** Receives oxygenated blood from lungs via pulmonary vein. This pure blood is drained into left ventricle through left AV foramen. In human four pulmonary veins open into LA through separate openings.
- **Left Ventricle -** Drains pure blood into the Aorta from where it is supplied to systemic organs :

Wall

Atrium - The inner wall surface here presents a series of transverse muscular ridges called musculi peotinati. They run forwards and downwards towards AV foramen, giving appearance of the teeth of a comb (combed muscles).

Ventricles - The inner wall is rough due to presence of muscular ridges trabeculae carnae or columnae carnae. These continue as papillary muscles, whose one end is attached to the ventricular wall and the other end connected to the cusps of AV valves by chordae tendinae. These chorda tendinae are collagenous and inelastic chords, one end of which is inserted in the papillary muscles and other end is connected to the flaps of AV valves. These are meant for preventing the pushing of flaps into atrium during ventricular contraction.

Valves

Rt. Atrium : Superior vena cava, inferior vena cava and coronary sinus open in right atrium. The IVC which opens below this has its opening guarded by a valve called Eustachian valve (during embryonic life the valve guides the inferior vena caval blood to the left atrium through foramen ovale) The opening of coronary sinus in rt. Atrium is guarded by Thebesian valve.

Lt. Atrium : At its inlet is pulmonary vein (four veins in man and two in rabbit), these have no guarding valve.

AV foramen: The right AV foramen has a unidirectional valve called tricuspid valve (made of three flaps or cusps) which allows entry of Blood from Rt. Atrium to Rt ventricle and prevents its backflow. The unidirectional valve present on left AV foramen is made of two cusps only hence called bicuspid valve. (also called as the Mitral valve).

Rt. Ventricle: Its outlet is in the pulmonary artery. it is guarded by a pulmonary semilunar valve.

Lt. Ventricle : Its outlet is in the systemic aorta. This opening is guarded by an aortic semilunar valve. Both these semilunar valves are made of three cusps each and are unidirectional in nature.

The valves in the heart allows the flow of blood only in one direction from atria to the ventricles from the ventricles to the pulmonary aorta. These valves prevent any backward flow.

GOLDEN KEY POINTS

1. Total number of valves in human embryonic heart are six - Tricuspid, bicuspid, pulmonary, semilunar, aortic semilunar, Thebasian and Eustachian. Thebasian and eustachian valves merge into the musculature of their respective veins after birth.
2. In embryonic heart small opening, foramen ovale is present at interatrial septum which after birth is modified to fossa ovalis.
3. In embryonic heart a small duct, ductus arteriosus is present which connect pulmonary artery and aorta, which after birth is modified to ligamentum arteriosum.

Blood supply of heart (Coronary circulation)

The oxygenated blood is supplied to the heart musculature for its consumption with the help of two coronary arteries, left and right. These arteries arise from the common origin at arch of aorta the left and right coronary arteries then further subdivides into a number of branches carrying blood to different regions of heart. The deoxygenated blood from heart walls return back via coronary veins which drain into the coronary sinus. The coronary sinus opens in the right atrium.

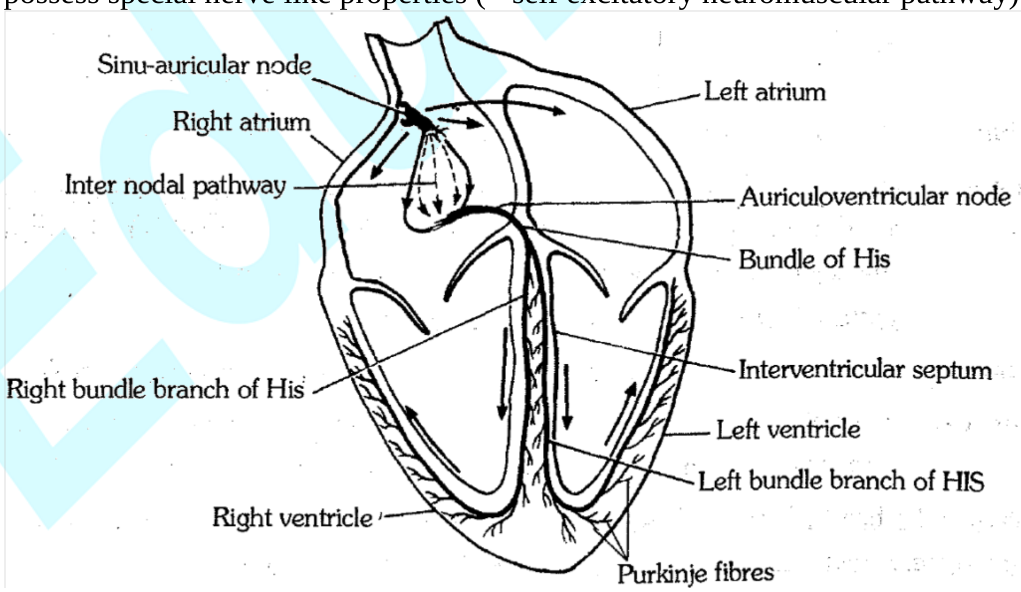
HEART BEAT

Differences between Neurogenic and Myogenic Hearts

	Neurogenic Heart	Myogenic Heart
1.	Impulse of heart beat comes from outside heart.	The impulse of heart beat develops within the heart.
2.	Impulse is generated by nervous system e.g. Arthropods and some annelids	Impulse is generated by a special muscular tissue. e.g. Molluscs and vertebrates

The conducting system of Myogenic Heart

It is made of myocardium that is specialised in for initiation and conduction of the cardiac impulse. Its fibres are finer than other myocardial fibres, these are completely cross striated and possess special nerve like properties (= self excitatory neuromuscular pathway).



The conducting system has the following parts :-

S.A. Node (Pacemaker)

↓

Inter nodal pathway
↓
A.V. Node
↓
Bundle of His
↓
Purkinje fibres (Rt & Lt)

♦ **Speed of conduction is fastest in Purkinje fibres and slowest in AV node**

(1) **Sinuatrial node (SA node).** It is known as the "pacemaker" of the heart. It is present in right upper comer of the rigth atrium. It generates impulses at the rate of about 72 per minute and initiates heart beat.

(2) **Internodal pathway** that connects the SA node to the AV node.

(3) **Atrioventricular node (AV Node).** It is situated in the lower left comer of the right atrium close to the atrioventricular septum. It is capable of generating impulse at rate of about 40/min.

(4) **Bundle of His (AV Bundle).** It is the connection between the atrial and ventricular musculature. It begins at the AV node and then divides into left and right branches as it descends down towards ventricles.
Branches of the AV bundle descends on the interventricular septum and is distributed to the ventricle after dividing into Purkinje fibres.

(5) **The Purkinje fibres.** These are distributed through the endocardium of the ventricles and propagate the impulse in the entire ventricle musculature. (18-25 per min.)·

♦ The SAN can generate the maximum number of action potentials, i.e 70-75 $\min^{-1}$ and is responsible for initiating and maintaining the rhythmic contractile activity of the heart. Therefore, it is called the pacemaker.
Our heart normally beats 70-75 times in a minute (average 72 beats $\min^{-1}$).

♦ Rhythmic contraction and relaxation of heart is called heart beat. Actually, contraction and relaxation occur separately in atria and ventricles. However, ventricular movements are quite prominent and forceful. Therefore, heart beat is synonym with ventricular or apex beat. It increases temporarily with activity and disease.
In animals heart beat is connected with size. In mammals, smaller animals have higher heart beat,

Adult human - 72 per min.
Rabbit - 210 per min.
New born - 120-140 per min

$$\text{Bluewhale (Balaenoptera musculus)}\left\langle \begin{array}{l} \text{Largest heart} \\ \text{Heart beat} - 25/\text{min (Least)} \end{array} \right.$$

Note : Heart rate is higher in women, children and infants and lower in aged persons.

BEGINNER'S BOX - 3

1. The pace maker in heart is:-
(1) SA Node (2) AV Node (3) Conus arterious (4) Heart muscles

2. How many contraction nodes are found in heart of Human :-
(1) One (2) Two (3) Many (4) None

3. Tricupsid valve is found in between
(1) Sinus venosus and right atriurn (2) Right atrium and right ventricle
(3) Left ventircle and left atrium (4) Ventricle and aorta

4. Heart of Man is :-
(1) Myogenic (2) Neurogenic (3) Cardiogenic (4) Digenic

5. Chordae tendinae are found in :
(1) Ventricles of brain (2) Ventricles of heart
(3) Atria of heart (4) Connection between bone

6. Which has the thickest walls :-
(1) Right auricle (2) Left auricle (3) Right ventricles (4) Left ventricle

7. Choose the correct pathway of the transmission of impulses in the heart beat :
(1) AV node → SA node → Bundle of His → Purkinje fibres
(2) SA node → AV node → Bundle of His → Purkinje fibres
(3) SA node → Bundle of His → AVnode → purkinje fibres
(4) AV node → Bundle of His → SA node → Purkinje fibres

8. Impulse of heart beat originates from -
(1) S. A. Node (2) A. V. Node (3) Vagus Nerve (4) Cardiac Nerve

Regulation of Heart Beat

Centre for heart beat Regulation is located in medulla oblongata. (Brain stem)

(a) Nervous Control-

- The "Cardiac-centre" (neural centre) which regulates heart-beat is found in Medulla-oblongata of the brain it can moderate the cardiac function through ANS. This cardiac-centre has two units -
  (i) Cardio- accelerator centre.
  (ii) Cardio-inhibitory centre.
- From the cardio-acceleratory centre, a pair of sympathetic nerves go into the S.A. node. Neural signals through the sympathetic nerves can increase the rate of heart beat the strength of ventricular contraction and there by cardiac output.
- While the cardio-inhibitory centre sends impulses to the S.A. node through cardiac branch of Vagus-nerve. From the parasympathetic nerve-fibres, hormone Acetyl-choline is secreted which decrease the heart rate, speed of conduction of action potential and the cardiac output.

(b) Hormonal control : Adrenal medulla hormone (Adrenaline, nor adrenaline) and Thyroxine hormone of thyroid gland increase heart rate and the cardiac output.

Key Point

Hormonal control	Adrenaline	–	↑ Rate
	Nor adrenaline	–	↑ Rate
	Thyroxine	–	↑ Rate
Autonomic Nervous System	Sympathetic	–	↑ Rate
	Parasympathetic	–	↑ Rate
	Vagal stimulation releases Acetyl choline	–	↑ Rate

Tachycardia. It is the condition where heart rate exceeds 90 per minute for an average adult.

Common causes of tachycardia :-

(i) Temperature.

(ii) Stimulation by sympathetic nerves

(iii) Weak condition of the heart

(iv) Shock/loss of blood

(v) Exercise

Bradycardia. It is the condition where the heart rate falls below 60 per minute in an average adult.

Common causes of bradycardia :-

(i) Temperature

(ii) Stimulation by parasympathetic Vagus nerve

(iii) Stronger condition of the heart

CARDIAC CYCLE

The cardiac events that occur from the begining of one heart beat to begining of the next are called cardiac cycle. The action potential travels rapidly through both atria and then through the AV bundle into the wall of ventricles. Because of special arrangement of the conducting system from the atria to the ventricles, there is a delay of more than l/10th a second between passage of the cardiac impulse from the atria into the ventricles. This allows the atria to contract ahead of the ventricles, there by pumping blood into the ventricles before the strong ventricular contraction begins.

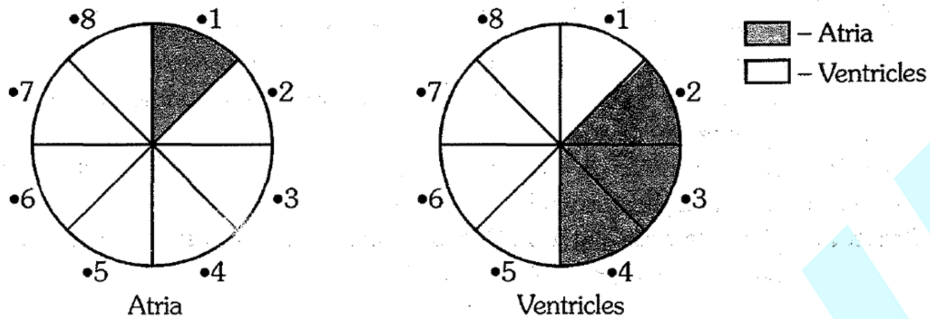
Thus the atria are the primer pumps for the ventricles, and ventricles then provide the major source of power for moving blood through the vascular system.

Cardiac-Cycle :-

The process of heart-beat begins from the time of embryonal development. Once the heart beat starts, it continues throught out the life (inherent capacity). In resting stage of man in 1 minute the heart beats around 72 times and during this 1minute, 5 litres of blood is pumped to different parts of the body through heart through left ventricle.

- The serial wise or sequential changes which take place in the heart are called cardiac-cycle .
- The contraction of the atria is termed as atrial-systole and their relaxation is called atrial-diastole .
- Same way the contraction and relaxation of ventricles is termed as ventricular systole and ventricular diastole,
- The time of cardiac-cycle is the reverse ratio of heart beat per minute. If heart beat per minute is 72, then the time of cardiac-cycle is 60/72 = 0.8 seconds.

Cardiac Events

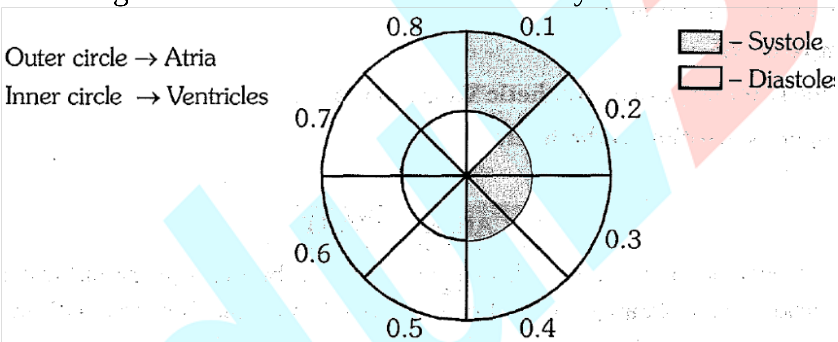


Joint Diastole 0.8 – 0.4 = 0.4 sec. (Period during which entire heart is in Diastole)
In a single cardiac cycle of man-

In a single cardiac cycle of man-

(1) Atrial systole	=	0.1 sec	0.8 sec
(2) Atrial diastole	=	0.7 sec	
(3) Ventricular systole	=	0.3 sec	0.8 sec
(4) Ventricular diastole	=	0.5 sec	

♦ Following events are related to the Cardiac-cycle-



Common diagram showing events of both atria & ventricles

(1) **"Ventricular-systole"** – It is an important process because during it the blood is pumped out of the heart into the arteries. It has main parts-

(a) **"Isometric-contraction"** – Walls of the ventricles start contracting, due to which pressure is more in the ventricles. Due to the increase of this pressure the "Cuspid valves" closed producing "LUBB" sound.

(b) **"Period of Ejection"** – During this cycle when pressure increases in the ventricles, then the semi-lunar values of the arches open and blood rapidly enters into the arches pushing the valves on one side.

♦ Oxygenated blood from the left-ventricle enters into the carotico-systemic arch or aorta and deoxygenated blood from the right-ventricle enter into the pulmonary-arch.

During ventricular systole, the auricles receive blood from the veins.

(2) **"Ventricular Diastole"-** Ventricles start relaxing now due to which pressure inside them falls further. As a result of this, closure of semilunar valves occurs due to which 'DUP' sound is heard at the onset of ventricular diastole.

Ventricular-diastole has sub-stages-

(a) **"Isometric Relaxation"** – When due to blood-ejection, the pressure inside the ventricles decreases as compared to the pressure inside the arches. The blood stops moving out and the ventricles prepare for relaxation.

(b) **"Rapid in-flow"** – After the systole in the ventricles the systolic pressure reduces very much. This pressure becomes very less than the atrial-pressure. Moreover due to relaxation in ventricles the pressure inside them falls further. So, now the cuspid-valves open up and blood flows rapidly from the atria to the ventricles. S_3 heart sound is produced.

(c) **"Diastasis"** – After rapid in flow the atria transfer the blood to the ventricles at the same rate at which they received blood from the veins. So the inflow of blood reduces considerably. At this moment pressure inside all four chambers is equal and entire heart is in diastole. Also at this moment of this time, the AV values are open but semilunar valves are closed.

(3) **"Atrial-Systole"** – Due to contraction in the atria the remaining blood comes into the ventricles so the atrial pressure now becomes zero. S_4 heart sound is produced.

(4) **"Atrial-Diastole"** – Atria start relaxing now. Due to the presence of almost zero pressure in the atria, during diastole the auricles start receiving further blood from the veins.

Volumes of blood related with cardiac cycle.

During diastole, filling of the ventricles normally increases the volume of each ventricle to about 120 mililitres. This volume is known as end diastolic volume. Then as the ventricles empty during systole, the volume decreases by about 70 mililitres, which is called the stroke volume.(i.e. the volume of blood pumped by each ventricle in the aorta in one stroke or beat). The remaining volume in each ventricle is now about 50 mililitres is called end systolic volume.

The fraction of the end diastolic volume which is ejected out is called the ejection fraction. (usually around 60% or 7/12). EF = SV / EDV

Cardiac output it is the amount of blood pumped by the each ventricle per minute. Its value in a normal adult is about 5 litre/minute.

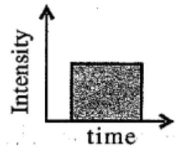
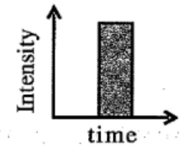
Cardiac output = stroke volume x heart rate.

♦ End diastolic volume ⇒ 120 ml.
♦ End systolic volume ⇒ 50 ml.

Stroke Volume = EDV – ESV = 70 ml (approx)

Heart - Sound

♦ During each cardiac cycle two prominent sounds are produced.
♦ These "Lubb" and "Dup" sounds of the heart can be heard with the help of an instrument called **" Stethoscope"(lnvented by lennec).**

I Heart Sound	II Heart Sound
1. LUBB 	• DUP 
2. Dull ; Prolonged (0.15 sec)	• Sharp, Shorter timed, High pitch (0.1 sec)
3. At the begining of Ventricular Systole	• At the begining of ventricular diastole
4. Caused by Closure of AV valves	• Caused by Closer of Semilunar valves

Defective heart sounds due to defects in heart valves called murmur.

BEGINNER'S BOX - 4

1. One of the following nerves inhibit the rate of heart beat :-
(1) Vagus (2) Sympathetic
(3) Occullomotor (4) None of the above

2. First heart sound is :-
(1) Lubb sound at the end of systole
(2) Lubb sound at the begining of ventricular systole
(3) 'Dup' sound at the end of systole
(4) Dup sound at the begining of ventricular systole

3. The heart beat of which animal is myogenic in nature
(1) Cockroach (2) Leech (3) Elephant (4) All of these

4. Which of the following sequence is truly a systemic circulation pathway :-
(1) Right ventricle → Pulmonary aorta → Tisues → Pulmonary veins → Left auricle
(2) Right auricle → Left ventricle → Aorta → Tissues → Veins → Right auricle
(3) Left auricle → Left ventricle → Pulmonary aorta → Tissues → Right auricle
(4) Left auricle → Left ventricle → Aorta → Arteries → Tissues → Veins → Right auricle

5. Cardiac output is determined by
(1) Heart rate (2) Stroke volume (3) Blood flow (4) Both 1 and 2

6. Cardiac ouput is blood
(1) Received by heart per minute (2) Pumped by ventricles per sec
(3) Pumped by left ventricle per minute (4) Pumped by left ventricle per hour

7. The 'Lubb' and "Dupp" heart sound are due to :
(1) Opening of heart valves (2) Action of papillary muscles
(3) Closing of heart valves (4) Activity of pace maker

8. Ist Heart Sound is due to :

(1) Closure of Semilunar valve
(2) Closure of Pulmonary & Aortic Valve
(3) Vibration just after Closure of Mitral & Tricuspid valve
(4) Vibration after Closure of Pulmpnary & Aortic Valve

Blood Pressure

Blood Pressure :

Blood pressure is the pressure exerted by the flowing blood on the elastic walls of arteries.
Blood-pressure is measured in two stages.

(1) Systolic Pressure (Pumping Pressure) :- It is the higher limit of blood pressure that shows the state of heart (systole) contraction. For man this limit is 120 mm Hg (normal)

(2) Diastolic pressure (Resting Pressure) :- It is the lower limit of B.P. that shows the state of heart relaxation (expansion = Diastole). For man this limit is 80 mm Hg (normal)

- ♦ The instrument by which we can measure B.P. is called sphygmomanometer.
- ♦ In man B.P. is measured in the brachial artery of arm or in radial artery.

[Normal B.P. ofa healthy person is 120/80 mm Hg.]
Age: B.P. increases as the age advances.

Pulse-

The pulse is felt in the radial artery present in the wrist of a man. It is also felt in the artery of neck region. The graph of pulse of an artery is marked by an instrument that is called sphygmograph.

Pulse pressure is the Pressure difference which generates a pulse. This is systolic minus diastolic B.P

Disorders related to the Circulatory System

1. Hypertension :

It is also called high blood pressure. Hypertension or high blood pressure is the occurrence of persistent systolic arterial pressure of more than 140 mm Hg and diastolic arterial pressure of more than 90 mm Hg. Hypertension is of two types primary and secondary.

High blood pressure must be managed. Excessive high blood pressure, say 220/120 mm Hg. Is dangerous as it may cause haemorrhages in different parts of body causing blindness (due to optic arteries), nephritis (renal artery), brain stroke or CVA (Cerebra vascular accident) (due to rupturing of cerebral artery).

2. Hypotension :

It is also called low blood pressure. Hypotension or low blood pressure is the occurrence of persistent systolic arterial pressure of less than 110 mm Hg and diastolic arterial pressure of less than 70 mm Hg. It is caused by persistent vasodilation of arterioles, reduced ventricular pumping, valvular defects, anaemia and deficient diet.

3. Varicose Veins :

On prolonged standing or due to defect in the valves of the veins of the legs. These veins may become dilated, torturous and thickened (Most commonly affected is the saphenous vein). Such veins become clearly visible and prominent. Treatment is surgical removal of such veins.

	Atherosclerosis	**Arteriosclerosis**
1.	Deposition of lipids (Cholestrol) on the walls (such depositions are called	Hardening of arteries due to thickening along with deposition of calcium salts

	atheromatous plaque)	with cholestrol
2.	Takes place in Lumen of large and medium size arteries of body	Can take place in medium to small arteries of limbs
3.	Plaques are formed due to proliferation of smooth muscles of the inner wall of arteries (due to platelet derived growth factors)	No plaque formation occurs, but the arteries are stiff and rigid due to calcification
4.	Narrowing of Artery	Hardening· of artery
5.	Artery lumen may get blocked resulting in no blood supply.	Artery becomes hard, looses its capacity of distention and may rupture

4. Heart Failure :

Heart failure means the state of heart when it is not pumping blood effectively enough to meet the needs of the body. It is sometimes called congestive heart failure because congestion of the lungs is one of the main symptoms of this disease. Heart failure is not the same as cardiac arrest (when the heart stops beating) or a heart attack (when the heart muscle is suddenly damaged by an inadequate blood supply).

5. Heart-block :

When A.V. Node gets damaged, so contractions do not reach up to ventricles this event is called heart block.

BLOOD – VESSELS

In closed type of blood vascular system blood vessels are of 3 types :-

(1) Arteries (2) veins (3) Capillaries

Anatomy of arteries and veins:- Normally there are three layers are found in the walls of blood vessels-

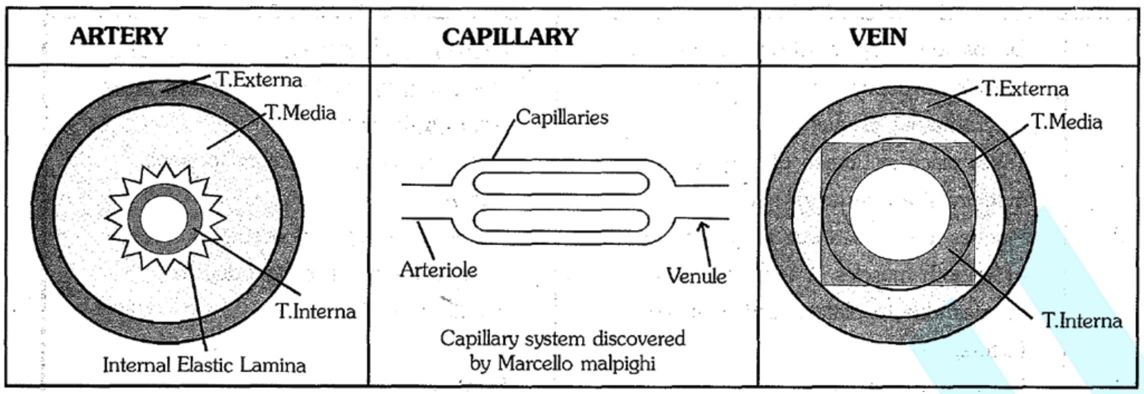
(i) Tunica extema :- It is the outer most layer. It is formed of loose connective tissue in which many collagen fibres, elastin fibres and longitudinal muscles are found.

(ii) Tunica media :- It is a thick layer of circular non striated muscles and a network of elastin fibres.

(iii) Tunica interna :- This layer is made up of squamous epithelium, It is also known as Endothelium

- Walls of arteries are thick and more muscular and these walls are elastic and non-collapsable.
- The walls of veins are thin, less muscular non elastic and collapsable.
- In the walls of blood capillaries only endothelium layer is found. Its cells are flat and squamous, Their walls are perforated. These blood capillaries join the arteries with the veins.

Main differences in arteries and veins :-



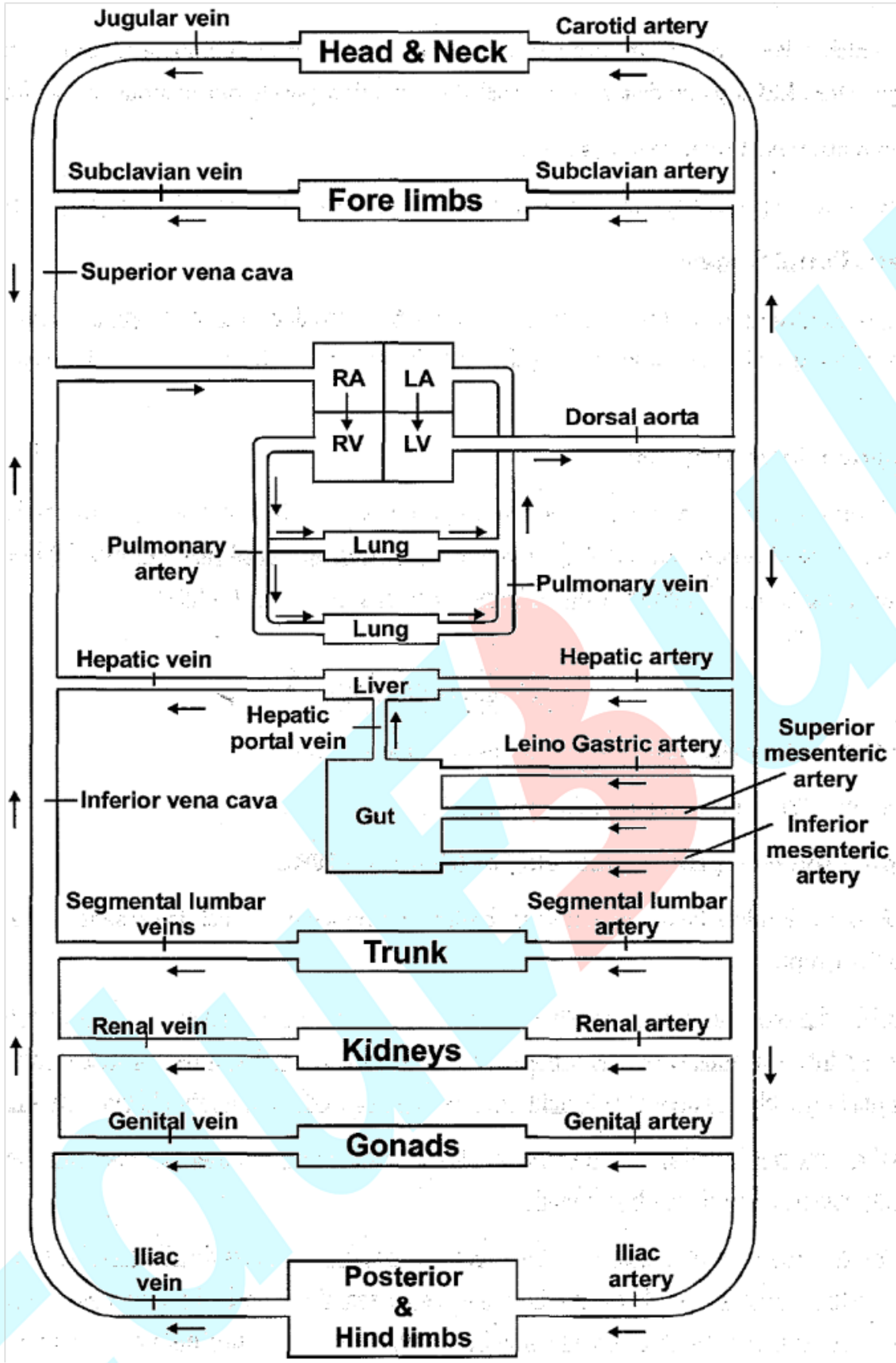
ARTERY		VIEW	
1.	It carries blood from the heart to the organs.	1.	It carries blood from organs to the heart.
2.	All the arteries carry pure blood except pulmonary artery which carries impure blood.	2.	All the veins carry impure blood except pulmonary vein which carries pure blood.
3.	Blood flows with a high pressure& speed.	3.	In the vein, blood flows with a low pressure & speed.
4.	Arteries are deeply situated in the body.	4.	Veins are superficial just below the skin.
5.	Their lumen is constricted.	5.	Their lumen is wide.
6.	Valves are absent in the walls of arteries.	6.	Walls of veins contain valves.
7.	These are pinkish or bright red in colour.	7.	These are deep red or bluish in colour.
8.	Their tunica media layer is much thicker as compared to veins.	8.	Their tunica media layer of wall is thiner as compared to arteries.

♦ Capillaries are present in the organs and these are the vessels through which exchange take place.

GOLDEN KEY POINTS

♦ A thin network of blood capillaries is present in the walls of blood vessels itself which supply blood and other necessary substances to the blood vessels. This blood supply is known as Vasa-vasorum.

Flow chart of Circulation of blood



PORTAL SYSTEM

When the vein of any organ of the body does not open in the caval vein or heart but it divides into capillaries in any other organ and its blood is transported by vein of that other organs to the heart, then this type of system is termed as portal system.

It is of following types:-

(I) Renal portal system, (II) Hepatic portal system, (III) Hypophysial portal system

(I) Renal portal system:-

Veins which collect blood from posterior parts of the body and legs combine to form a renal portal vein. This vein goes into kidney and divides into capillaries kidneys separate nitrogenous wastes from this blood.

- ♦ In mammals, renal portal system is absent.
- ♦ In Frog both the portal systems ; renal portal system and hepatic portal system are present

(II) Hepatic Portal System.

It is a portal system which brings venous blood directly from digestive tract, spleen, pancreas and gall bladder to liver for extraction of nutrients and other metabolites by breaking up into single celled thick capillaries and sinusoids.

(III) Hypophysial Portal System

It is a portal system formed by a vein from hypothalamus which breaks up into capillaries in ant. lobe of pituitary gland (Adenohypophasis). The Vein is called hypophysial portal vein. Hypothalamus produces a number or hormones for controlling endocrine activity of adenohypophysis.

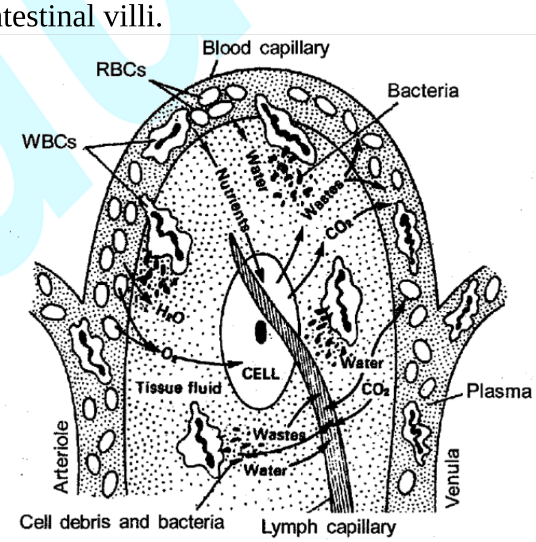
LYMPHATIC SYSTEM

Lymphatic Circulatory System : It is comprises by following parts.

(1) Lymph (2) Lymph vessels (3) Lymph nodes

Lymph :- [Blood – (RBC + platelets)] or (Plasma + WBC)

- ♦ Lymph is a colourless fluid containing specialised lymphocytes. Which is present in the lymphatic system is called the lymph.
- ♦ As the blood passes through the capillaries in tissues some water along with many small water soluble substances move out into the spaces between the cells of tissues leaving the larger proteins and most of the formed elements in the blood vessels. This fluid released out is called the interstitial fluid or tissue fluid.
- ♦ It has the same mineral distribution as that in plasma. Exchange of nutrients gases, etc., between the blood and the cells always occur through this fluid.
- ♦ An elaborate network of vessels called the lymphatic system collects this fluid and drains it back to the major veins. which are responsible for the immune responses of the body. Lymph is also an important carrier for nutrients, hormones, etc. Fats are absorbed through lymph in the lacteals present in the intestinal villi.

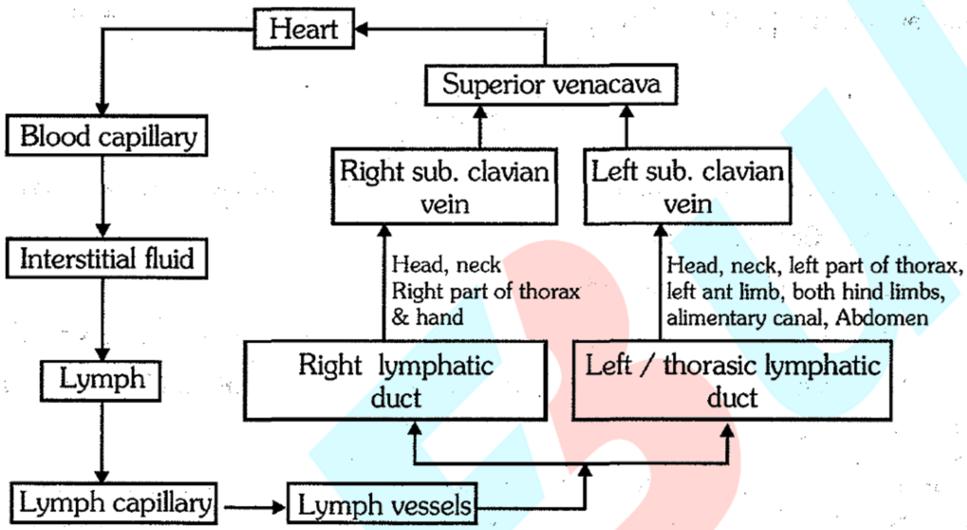


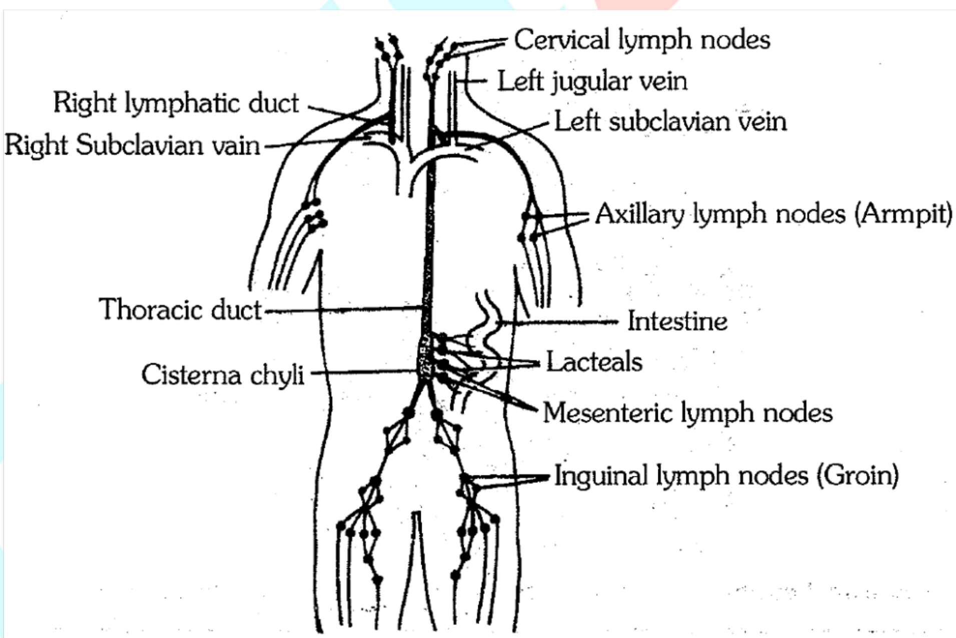
Chemical exchange between blood, tissue fluid and tissue cells

Blood	Lymph
1. It forms circulatory system. 2. R.B.Cs. present	1. It forms lymphatic system. 2. R.B.Cs. absent

3. Neutrophills more	3. Lymphocytes in largest amount
4. Soluble proteins in large amount but insoluble proteins in small amount.	4. Soluble proteins in small amount but insoluble proteins in large amount.
5. O_2 & nutrients in large amount but CO_2 very less.	5. O_2 & nutrients in small amount CO_2 in large amount.
6. It is of red colour.	6. It is of colourless, just like water.
7. More WBC	7. Lesser WBC
8. Clotting time: less	8. Clotting time : Comparatively more.

Circulation of Lymph in Lymph Vessels :-





Lymphatic system of mammals shown in man (ventral view)

Lymph nodes :- At many places lymphatics may intersect with each other forming a knob or node like structure called the lymph node. The vessels entering the lymph node carrying lymph from the interstitial space are called afferent lymphatics. The lymphatic leaving the lymph node and draining the lymph in vein or thoracic duct is called efferent lymphatic.

The lymph node thus act as a filter apparatus which filter the lymph coming from the interstitial space and remove cellular debris etc. from it.

Their other functions are as follows-

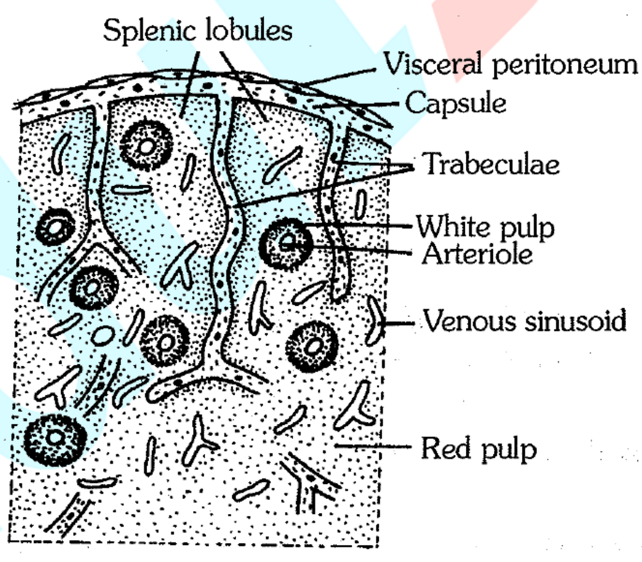
1. These form lymphocytes and pour into lymph.
2. Filter and clean the lymph.
3. Synthesize the antibodies.
4. Destroy bacteria and other harmful substance by feeding upon (phagocytize)

- ♦ Lymph nodes are present in all parts of body, but their number is comparatively more in armpits of hands legs, groins, neck and abdomen. Their number is much more in neck region
- ♦ Amphibians have open type of lymphatic system, which include lymphatic heart (which is absent in mammals)

Spleen

- ♦ Spleen is known to be the largest lymph node of body. It is the blood bank of the body.
- ♦ Spleen is also called "Graveyard of RBC".
- ♦ Spleen originates from embryonal mesoderm.
- ♦ Spleen is red-coloured lymph node, it is found attached by mesentery to the lateral side of stomach.
- ♦ A special type of connective tissue is filled in the spleen which is called reticulo endothelial tissue or splenic pulp
- ♦ Splenic pulp has 2 parts-

(1) **White pulp :-** It is scattered in the form of patches (in the splenic pulp) it contain numerous splenic cells, lymphocytes. The splenic cells are mostly aggregated around arterioles forming nodules which appear whitish and hence recognized as white pulp.



T. S. Spleen

(2) **Red Pulp :-** It forms the maximum part of spleen. It is reddish due to excess number of RBCs. Red pulp of spleen contains erythrocytes (dead and alive) and blood filled sinuses.

- ♦ Cord of Billroth found in spleen are big blood venous sinuses.
- ♦ In the pulp of spleen, there are found some large sized phagocytes which are called macrophage cells.

Functions of spleen :-

1. Its macrophages engulf or phagocytize and destroy wornout blood cells, pathogens, cell debris etc.
2. In the embryonal stage it produces RBCs.
3. Some antibodies are synthesised here.
4. Spleen stores iron.
5. [Spleen + liver + kidneys] These three are called blood filter apparatus of blood.
6. [Spleent + liver] – RBC filtering apparatus.

BEGINNER;S BOX - 5

1. Atherosclerosis refers to the ailment of:
(1) Lungs (2) Heart (3) Kidney (4) Liver

2. The correct sequence of layers found in the walls of arteries from inside to outward is:
(1) Tunica adventitia, tunica interna & tunica media
(2) Tunica interna, tunica externa & tunica media
(3) Tunica interna, tunica media & tunica externa
(4) Tunica media, tunica externa & tunica interna

3. The smallest blood vessel in the body is :-
(1) Capillary (2) Artery (3) Vein (4) Vena cava

4. Cords of billroth are found in :-
(1) Liver (2) Kidneys (3) Spleen (4) Tonsils

5. Filter apparatus for dead R.B.C is :
(1) Spleen+ Kidney (2) Liver + Kidney
(3) Spleen + Liver + Kidney (4) Liver + Spleen

6. A vein differ from an artery in having :
(1) Strong muscular walls
(2) Narrow lumen
(3) Valves prevent direction of blood flow opposite to heart
(4) Valves prevent direction of blood flow towards heart

7. If spleen of Human is removed from body then :
(1) Animal will die
(2) Number of blood platelets will increase
(3) Number of blood platelets will decrease
(4) There will be no effect on the number of blood platelets

8. Which one of the following is the main graveyard of RBC :-
(1) Bone marrow (2) Spleen (3) Liver (4) Kidney

ANSWERS KEYS

BEGINNER'S BOX - 1

1.	(1)	**2.**	(4)	**3.**	(1)	**4.**	(1)	**5.**	(1)	**6.**	(3)

BEGINNER'S BOX - 2

1.	(1)	**2.**	(2)	**3.**	(1)	**4.**	(2)	**5.**	(3)	**6.**	(3)	**7.**	(2)
8.	(2)	**9.**	(3)										

BEGINNER'S BOX - 3

1.	(1)	**2.**	(2)	**3.**	(2)	**4.**	(1)	**5.**	(2)	**6.**	(4)	**7.**	(2)
8.	(1)												

BEGINNER'S BOX - 4

1.	(1)	**2.**	(2)	**3.**	(3)	**4.**	(4)	**5.**	(4)	**6.**	(3)	**7.**	(3)
8.	(3)												

BEGINNER'S BOX - 5

1.	(2)	**2.**	(3)	**3.**	(1)	**4.**	(3)	**5.**	(4)	**6.**	(3)	**7.**	(4)
8.	(2)												