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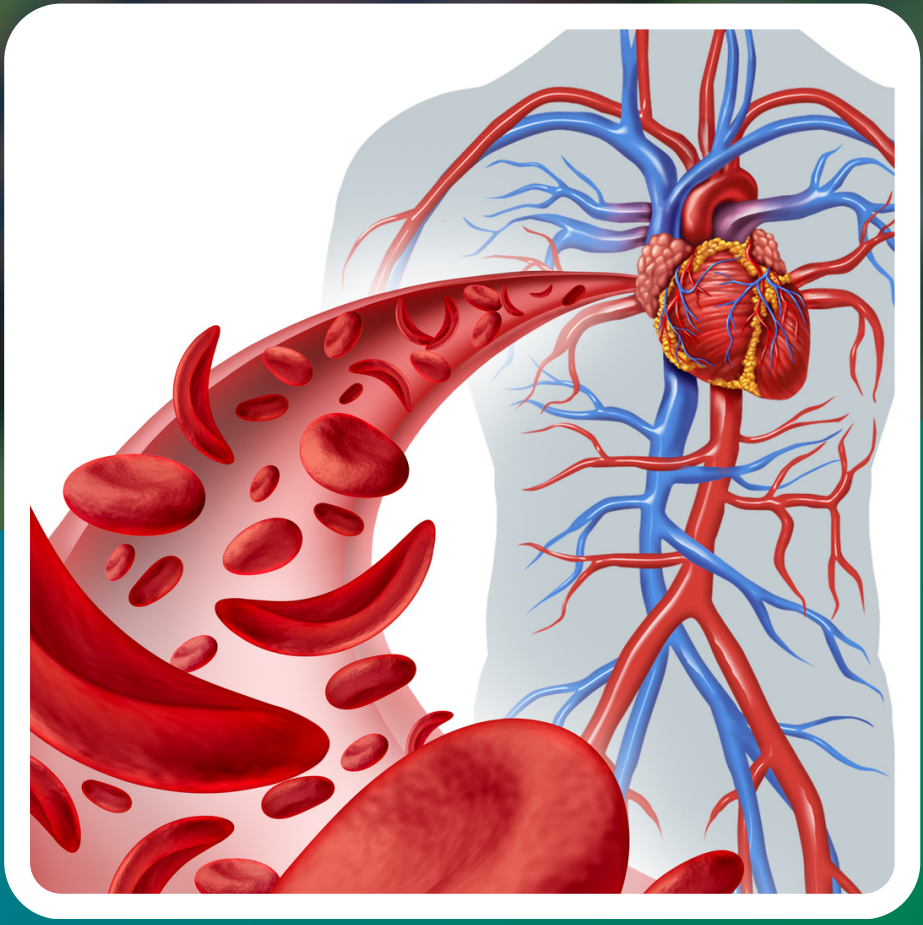

STUDY MATERIAL

Body fluids and circulation

ENGLISH MEDIUM

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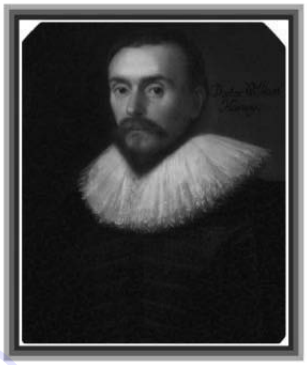


WILLIAM HARVEY (1 April 1578 - 3 June 1657) was an English physician who made contributions in anatomy and physiology. He was the first known to describe completely and in detail the systemic circulation and properties of blood being pumped to the brain and body by the heart, though earlier writers, such as Miguel Servet (aka Michael Servetus, Michel de Villeneuve) in: 'Restitutio Christianismi', Paris, 1546, and Jacques Dubois, had provided precursors of the theory.[1][2] After his death the William Harvey Hospital was constructed in the town of Ashford, several miles from his birthplace of Folkestone.

DR. PANANGIPALLI VENUGOPAL, is an Indian Cardiovascular surgeon and hospital administrator from Rajahmundry, Andhra Pradesh, India and widely regarded as a pioneer in many innovations in cardiac surgery.[1] The Government of India honored him , in 1998, with the Padma Bhushan, the third highest civilian award, for his services to the field of Medicine.

DR. NARESH TREHAN is a renowned Indian cardiovascular and cardiothoracic surgeon.[2] After graduating from King George Medical College, Lucknow, India, he went on to practice at New York University Medical Center Manhattan USA from 1971 to 1988. After a successful career in the US, he returned to India and started Escorts Heart Institute and Research Centre.[3] At present, he serves as the chairman and managing director and chief cardiac surgeon of MedantaTM-The Medicity. He has served as personal surgeon to the President of India since 1991, has received numerous awards, including the Padma Shri, Padma Bhushan and Lal Bahadur Shastri National Award.

BODY FLUIDS AND CIRCULATION

01. INTRODUCTION

- **Introduction**
- **Blood**
- **Lymph (Tissue Fluid)**
- **Circulatory Pathways**
- **Double Circulation**
- **Regulation of Cardiac Activity**
- **Disorders of Circulatory System**

You have learnt that all living cells have to be provided with nutrients, O_2 and other essential substances. Also, the waste or harmful substances produced, have to be removed continuously for healthy functioning of tissues. It is therefore, essential to have efficient mechanisms for the movement of these substances to the cells and from the cells. Different groups of animals have evolved different methods for this transport. Simple organisms like sponges and coelenterates circulate water from their surroundings through their body cavities to facilitate the cells to exchange these substances.

More complex organisms use special fluids within their bodies to transport such materials. Blood is the most commonly used body fluid by most of the higher organisms including humans for this purpose. Another body fluid, lymph, also helps in the transport of certain substances. In this chapter, you will learn about the composition and properties of blood and lymph (tissue fluid) and the mechanism of circulation of blood is also explained herein.

02. VASCULAR CONNECTIVE TISSUE

There are two types of vascular connective tissue :

- Blood
- 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. Fibres are completely absent in blood.

  b. Matrix of blood is produced & synthesized by liver and lymphoid organs.

Composition of Blood :

- Liquid Part — Matrix — Plasma — 55%
- Solid Part — Blood corpuscles — 45% (RBC, WBC & Platelets)

(A) Plasma :

- Matrix of blood is called Plasma.
- It is straw (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.

Inorganic part has Na^+, Ca^{++}, Mg^{++}, HCO_3^-, Cl^- etc.

Organic Part of Plasma — 7 - 9%

Proteins

- 6 -8%

(i) Albumin → 4% (Max.)

- Produced & synthesized by liver.
- Smallest Plasma Protein.
- Responsible to maintain BCOP

(ii) Globulin :- 2 - 2.5%.

- Ratio of albumin & globulin is 2 : 1.
- Produce and secreted by liver and lymphoid organs.
- Transport or carry substance in body.
- Destory bacteria virus & toxic substances.
- In blood 3 type of globulins are present.

(a) **α–Globulin** — Produced by liver .

Eg. Ceruloplasmin — Cu carrying protein.

(b) **β–Globulin** — Produced by liver

Eg. Transferin — Fe carrying protein.

(c) **γ–Globulin** — Produced by lymphoid organs

- Present in the form of antibodies which destroy bacteria, virus & toxic substance. Also called **Immunoglobulins**.

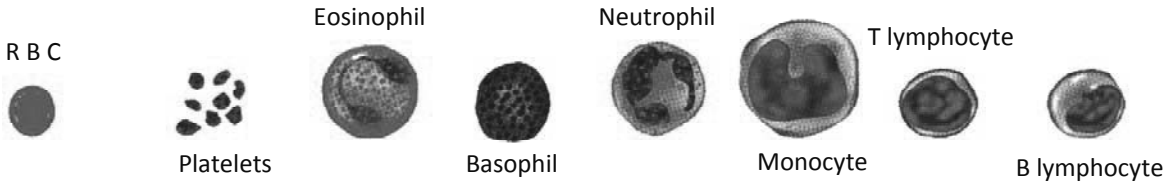
(iii) Prothrombin – 0.3% Produced and secreted by liver

(iv) Fibrinogen – 0.3% Produced and secreted by liver

- Largest plasma protein.
- Help in blood clotting.

(B) Formed Elements :

- Erythrocytes, leucocytes and platelets are collectively called formed elements (Figure) and they constitute nearly 45 per cent of the blood.



Diagrammatic representation of formed elements in blood

NCERT XI Page No. 279, Figure No. 18.1

(i) Erythrocytes (Red blood Corpuscles) :

(a) Mammalian RBC's are biconcave, circular & non nucleated.

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

(c) Biconcave shape of RBC increases surface area.

(d) In RBC higher cell organelles like mitochondria, golgi complex and ER is absent.

(e) Due to absence of nucleus and other cell organelles more Haemoglobin can be filled in RBC.

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

(f) 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.

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

(h) Due to absence of mitochondria anaerobic respiration takes place in RBC.

(i) In RBC enzyme of glycolysis process are present, while enzyme of Krebs cycle are absent.

(j) Antigen of blood group (ABO and Rh factor) are present on the surface of RBC.

(k) Single RBC is pale yellow in colour while group of RBC appear red in colour.

(l) In RBC red coloured respiratory pigment **haemoglobin** is present.

Haemoglobin

It is composed of two components

(a) Haem - 5%

(b) Globin - 95% Protein part

Haem (Iron and Porphyrin)

(a) Iron present in the form of Fe^{+2}

(b) 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 4 types.

(a) α polypeptide chain having 141 amino acids.

(b) β polypeptide chain having 146 amino acids.

(c) γ polypeptide chain having 146 amino acids.

(d) 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

Shape of RBC –

(a) Biconcave

(b) Sickle cell anaemia–RBC become sickle shaped.

(c) If RBC is kept in hypertonic solution it will shrink.

(d) In Hypotonic solution it will burst.

Life span of RBC is 120 days

RBC count

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

Human (Male)	5.5 million	$\pm$1Million
Human (Female)	4.5 million	
Newly born baby	6.8 million	

- Decrease in RBC count condition is called **Anaemia**.

(a) **Macrocytic anaemia** – Due to Vit. B_9 and B_{12} deficiency macroytes are formed which are destroyed in spleen.

(b) **Microcytic anaemia** – Due to Fe deficiency microcytes are formed.

(c) **Normocytic anaemia** – Excess blood loss.

Formation of RBC

(a) Process of formation of RBC is called **Erythropoiesis**.

(b) Organs which produce RBC's called **Erythropoietic organs.**

(c) Hormone which stimulate Erthyropoiesis is called **erythropoetin** synthesized by Kidney & little quantity by liver.

(d) 1st RBC produced by yolk sac.

(e) During embryonic life RBC are produced by Liver, Spleen, Placenta, Thymus gland.

(f) In adult stage RBC is produced by some bones having RBM which filled in between trabeculae of spongy bones.

(h) Destruction of RBC occur in spleen. So spleen is called **Graveyard** of RBC.

(i) Spleen stores excess blood corpuscles so it is called **Blood Bank of body**.

BEGINNER'S BOX — PLASMA AND RBC

1. Which of the following is most abundant in blood?
(1) RBC (2) WBC (3) Platelets (4) All are equal

2. Mammalian mature RBC does not contain :-
(1) Membrane bounded cell organelles (2) Carbonic anhydrase
(3) Haemoglobin (4) Enzyme of glycolyte pathway

3. Organisms which circulate water from their surrounding through their body cavities to facilitate the cells to exchange the substances are
(1) Porifera (2) Sponges (3) Both 1 and 2 (4) Insects

4. Blood is a
(1) Special connective tissue (2) Liquid connective tissue
(3) Both 1 and 2 (4) Semisolid connective tissue

5. Human blood consists of
(1) Fluid matrix (2) Plasma (3) Formed elements (4) All the above

6. Match the following columns.

	Column-I		Column-II
A.	Fibrinogen	1	Clotting or coagulation of blood
B.	Globulin	2	Defence mechanism of Body
C.	Albumin	3	Osmotic balance

	A	B	C
(1)	3	2	1
(2)	3	1	2
(3)	2	1	3
(4)	1	2	3

7. Formed elements present in the human blood are :-
I. Erythrocytes II. Leucocytes III. Platelets
IV. Plasma V. Lymph
Choose the correct option.
(1) I, II and III (2) II, III and IV (3) III, IV and V (4) I, II, III, IV and V

8. Formed element constitutes what percentage of the blood?
(1) 55% of blood (2) 45% of blood (3) 35% of blood (4) 25% of blood

9. In humans, RBCs are formed in :-
(1) Red bone marrow (2) Heart (3) Lungs (4) Yellow bone marrow

10. Properties of human RBCs are :-
I. Devoid of nucleus II. Formed in bone marrow
III. Possess healing properties IV. Biconcave in shape
V. Help in blood clotting.
Choose the option with correct properties.
(1) I, II and III (2) I, II and IV (3) III, IV and V (4) III, II and IV

11. RBCs have an average life span of :-
(1) 90 days (2) 100 days (3) 120 days (4) 140 days

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	Faint stain by any dye (acidic/basic/neutral)		
Shape of nucleus	Bilobed	Two or three lobed, S-shape	3 to 5 lobed (PMNL)	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.	2 Types 1) T-cell → Cell mediated immunity 2) B-cell → Antibody mediated immunity
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, Asthma		– Due to their smaller size and phagocytic nature they are called micropoliceman of blood	Macropoliceman	
Diagram					

(ii) Leucocytes :

- WBC (White Blood Corpuscles) are also called as **leucocytes** because they are colourless. **TLC**- Total leucocyte count. Number of WBC /mm^3 → 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.**

  (a) Granulocytes

  - In their cytoplasm granules are present which can be stained by specific dye.
  - Nucleus is multilobed and lobes are interconnected by protoplasmic strand.
  - Produced in Bone marrow –

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

  (b) Agranulocytes

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

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

(iii) Platelets :

- Size 2 - 3 μ.
- Life span - 2 - 5 days.
- Count - 1.5 - 3.5 lakh/mm^3.
- Also known as Thrombocytes, present only in mammals.
- They are non nucleated and derived from **megakaryocyte** cells of bone marrow.
- In shape platelets are disc like, oval shaped or biconvex.
- In their cytoplasm basophilic granules are present which can be stained by methylene blue.
- Decrease in number of blood platelets is called **Thrombocytopenia**.
- Critical count of thrombocytes is 40,000/mm^3. If number is less than critical count then red spot or rashes appears on the skin called **Purpura disease**.

Function

- Repair endothelium of blood vascular system by the formation of platelet plug because they have tendency to attach on gelatinous or mucilagenous surface.
- Release a variety of substances (Thromboplastin), most of which are involved in the coagulation or clotting of blood.
- Synthesize serotonin (5-hydroxytriptamine).

BODY FLUIDS AND CIRCULATION

BLOOD

Special connective tissue (Fibre free fluid matrix)

Plasma
- Matrix
- Straw coloured
- 55% of blood

90-92% water

Other

Proteins (6-8%)

- **Fibrinogen :-**
  - Needed for clotting/coagulation of blood (other clotting factor are also present in plasma in inactive form)
  - Serum = Plasma – Clotting factor
- **Globulin :-** Primarily involved in defense mechanism (Antibodies)
- **Albumin :-** Help in osmotic balance (BCOP)

Minerals (small amount) (Na^+, Ca^{++} HCO_3^-, Cl^-)

Nutrients (Glucose, Amino acids, Lipids)

Formed Elements
- Erythrocytes, Leucocytes, Platelets
- 45% of Blood

Erythrocytes/RBC :-
- Most abundant
- Count (Adults):- 5–5.5 million/mm^3
- Formed in red bone marrow
- Devoid of nucleus
- Biconcave in shape
- Have red coloured, iron containing gases transporting pigment heamoglobin (12-16 gm Hb/100 ml blood)
- Average life span = 120 days (Destroyed in spleen/graveyard)

Leucocytes/WBC :-
- Relatively less in number
- Count (Adult) = 6000-8000/mm^3
- Colourless due to lack of Hb
- Nucleated
- Life span = short lived
- 2 main categories

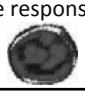
Granulated
- Eosinophil = 2-3% = Resist infection, allergic reactions

- Basophil = 0.5-1% = Histamine, Serotonin, Heparin
- Involved inflammatory relation

- Neutrophil = 60-65% = Phagocytic

Agranulated
- Monocyte (6-8%) = Phagocytic

- Lymphocytes (20-25%) < T, B = Responsible for immune response



Platelets (Thrombocytes) → Cell fragments

- **Produced from megakaryocytes (special cells in bone marrow)**
- **Count = 1.5-3.5 Lakh platelets/mm^3**
- **Involved in coagulation/clotting of blood**
- **Reduction in their number → Clotting disorders (Excessive loss of blood)**

BEGINNER'S BOX — WBC AND PLATELETS

1. In DLC neutrophil found as :-

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

2. 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

3. Macropolice man of blood :-

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

4. Leucocytes are colourless due to :-

(1) Lack of water (2) Lack of haemoglobin

(3) Presence of extra water (4) Presence of haemoglobin

5. Leucocytes are characterised by :-

I. They are nucleated. II. They are denucleated like RBC.

III. They are 6000-8000 mm^{-3} of blood. IV. They are long lived.

V. they are short lived.

Choose the appropriate option with correct properties.

(1) I, III and V (2) II, IV and V (3) I, IV and V (4) I, III and IV

6. Granulocytes and agranulocytes are the two main categories of :-

(1) RBC (2) WBC (3) Thrombocyte (4) Blood platelets

7. I. Neutrophils II. Eosinophils III. Basophils IV. Lymphocytes

V. Monocytes

Identify wheather the given cell types are granulocytes

(A) and agranulocytes (B) and choose the correct option accordingly :-

	A	B
(1)	I,II, III	IV,V
(2)	I,III,IV	II, V
(3)	IV,V	I,II, III
(4)	II, V	I, III, IV

8. Lymphocytes (20-25%) are of two major types B and T forms. They are responsible for :-

(1) Blood coagulation (2) Thickness of blood (3) Immune responses (4) All of these

9. Platelets are :-

(1) Also called thrombocytes (2) Cell fragments

(3) Produced from megakaryocytes (4) All of the above

03. BLOOD CLOTTING

- Blood flows from cut or wound but after some time it stops automatically, it is called clotting of blood.
- Bleeding time 1 -3 min.

  Clotting time 2 - 8 min.

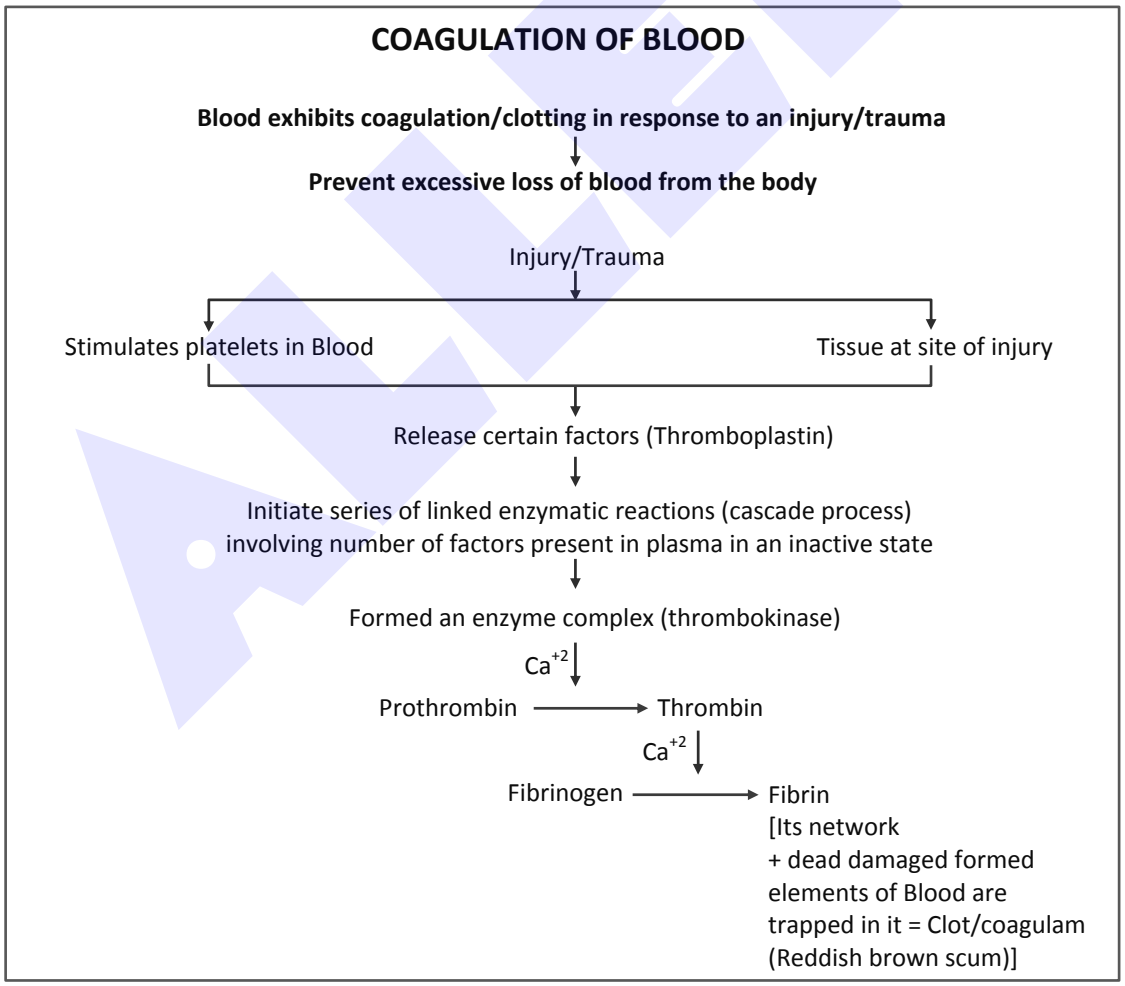
  Some times clots are also formed in intact blood vessels which are of two types.

Thrombus Clot

- Static clots which grow bigger & bigger & ultimately block the blood vessels.
- If this clot is formed in the coronary vessels then called as coronary thrombosis which can cause heart attack.
- If found in brain, then called as cephalic thrombus and causes paralysis.

Ambolus clot

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



Mechanism of blood clotting

(Enzyme Cascade theory)

- According to this theory there are 3 steps in blood clotting.

(a) **Release of Thromboplastin :-**

- Injured tissue synthesize exothromboplastin and platelets synthesize endothromboplastin.
- Both these thromboplastin react with plasma proteins in the presence of Ca^{++} ions to form **Prothrombinase enzymes**. (Thrombokinase)
- This enzyme inactivates heparin. (Antiheparin)

(b) **Conversion of Prothrombin into Thrombin :-**

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

(c) **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 (clotting factor)	= Serum

Clotting Factors :-

(a) 13 factors help in blood clotting.

(b) These factors are mainly produced in liver.

(c) Vitamin K is required in the synthesis of these clotting factors (Prothrombin).

(d) Ca^{++} ions play a very important role in blood clotting.

04. BLOOD GROUPS

(1) ABO GROUPING

As you know, blood of human beings differ in certain aspects though it appears to be similar. Various types of grouping of blood has been done. Two such groupings – the ABO and Rh – are widely used all over the world.

ABO grouping is based on the presence or absence of two surface antigens (chemicals that can induce immune response) on the RBCs namely A and B. Similarly, the plasma of different individuals contain two natural antibodies (proteins produced in response to antigens). The distribution of antigens and antibodies in the four groups of blood, A, B, AB and O are given in Table. You probably know that during blood transfusion, any blood cannot be used; the blood of a donor has to be carefully matched with the blood of a recipient before any blood transfusion to avoid severe problems of clumping (destruction of RBC). The donor's compatibility is also shown in the Table.

- A, B, O discovered by **Landsteiner**.

Blood Groups and Donor Compatibility

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, anti-B	O

From the above mentioned table it is evident that group 'O' blood can be donated to persons with any other blood group and hence 'O' group individuals are called 'universal donors'. Persons with 'AB' group can accept blood from persons with AB as well as the other groups of blood. Therefore, such persons are called 'universal recipients'.

(2) Rh GROUPING

- Discoverd in Rhesus monkey.
- Rh antigen is due to dominant gene. So if one of the gamete possess gene of Rh factor, its offspring will be Rh +Ve.
- Rh antigen found on the surface of RBC.

Another antigen, the Rh antigen similar to one present in Rhesus monkeys (hence Rh), is also observed on the surface of RBCs of majority (nearly 80 per cent) of humans. Such individuals are called **Rh positive** (Rh+ve) and those in whom this antigen is absent are called Rh negative (Rh-ve).

Population	Rh antigen	Rh antibody in plasma	% Ratio in India	% Ratio in world
Rh^+ Persons	Present	Absent	97%	80%
Rh^- Persons	Absent	Absent	3%	20%

An Rh-ve person, if exposed to Rh+ve blood, will form specific antibodies against the Rh antigens. Therefore, Rh group should also be matched before transfusions. A special case of Rh incompatibility (mismatching) has been observed between the Rh-ve blood of a pregnant mother with Rh+ve blood of the foetus. Rh antigens of the foetus do not get exposed to the Rh-ve blood of the mother in the first pregnancy as the two bloods are well separated by the placenta. However, during the delivery of the first child, there is a possibility of exposure of the maternal blood to small amounts of the Rh+ve blood from the foetus. In such cases, the mother starts preparing antibodies against Rh in her blood. In case of her subsequent pregnancies, the Rh antibodies from the mother (Rh-ve) can leak into the blood of the foetus (Rh+ve) and destroy the foetal RBCs. This could be fatal to the foetus or could cause severe anaemia and jaundice to the baby. This condition is called erythroblastosis foetalis. This can be avoided by administering anti-Rh antibodies to the mother immediately after the delivery of the first child.

★ Golden Key Points ★

- **Packed cell volume** (PCV) **:-** % volume or total number of blood corpuscles in blood.
- **Haematocrit Volume :-** % volume or only number of RBC in blood.
- PCV ≈ HV because 99% of packed cell volume is contributed by RBC & in rest 1% WBC & Platelets are present.
- Increase in the RBC count condition is called **polycythemia**. This condition occurs at hill station.
- In female neutrophils barr body is attached with lobe of nucleus which is formed by the modification of x-chromosome. It help in sex detection.
- AB blood group is discoverd by De-costello and Sturli.
- In each RBC 26.5 crores molecules of Hb are present.
- Molecular weight of each molecule of haemoglobin – 67,200 Dalton.
- In composition of RBC 60% H_2O & 40% solid part is present. Only Hb constitutes 36% of total weight of RBC and 90% on dry weight.

BEGINNER'S BOX — BLOOD CLOTTING AND BLOOD GROUP

1. Blood clot is mainly due to :-

(1) Fibrin + Corpuscles (2) Heparin + Corpuscles
(3) Plasma + Thrombocytes (4) Plasma + RBC

2. Factors for coagulation or clotting of the blood are present in the ...A... in an ...B... form. Plasma without the clotting factors is called ...C... .
Choose the correct option for the blanks A, B and C :-
(1) A-Plasma, B-inactive, C-serum (2) A-Plasma, B-active, C-serum
(3) A-Plasma, B-inactive, C-lymph (4) A-Plasma, B-active, C-lymph

3. Clotting disorders occur mainly due to the reduction in the number of :-
(1) Granulocytes (2) RBC
(3) WBC (4) Platelets

4. Which of the following option describes all the components of human blood :-
(1) Formed elements (2) Plasma
(3) Formed elements and plasma (4) Lymph and Serum

5. Grouping of ABO blood is based on the :-
(1) Surface antigens present on RBCs (2) Surface lipids present on the cell membrane
(3) Nature of all constituents (4) Nature of RBC and WBC

6.

Blood group	Antigen on RBCs	Antibody in Plasma	Donor's Group
A	A	anti b	A,O
B	B	anti A	B,O
AB	X	Nil	Z
O	Nil	Y	O

Choose the correct option for X, Y and Z :-
(1) X-B; Y-A; Z-A, B (2) X-A, B; Y-Nil; Z-A, B,AB, O
(3) X-A, B; Y-anti-A, B; Z-A, B, AB, O (4) X-A, B; Y-anti A, B; Z-A, B, AB

7. Universal donors and universal recipients are :-

(1) A, B and O blood groups respectively

(2) O and AB blood groups respectively

(3) O and A blood groups respectively

(4) AB and O blood groups respectively

8. The name Rh blood group is derived from :-

(1) Chimpanzee (2) monkey (3) man (4) primitive man

9. Individuals having Rh antigen are called :-

(1) Rh negative (Rh–ve) (2) Rh positive (Rh+ve)

(3) Rh (±) (4) Rhesus positive

10. Blood without corpuscles and fibrinogen is called :-

(1) Lymph (2) Serum (3) Plasma (4) Platelets

05. CIRCULATORY PATHWAYS

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 and closed.

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

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

(a) Blood circulatory system : It consist of :- Blood , Blood vessels , Heart.

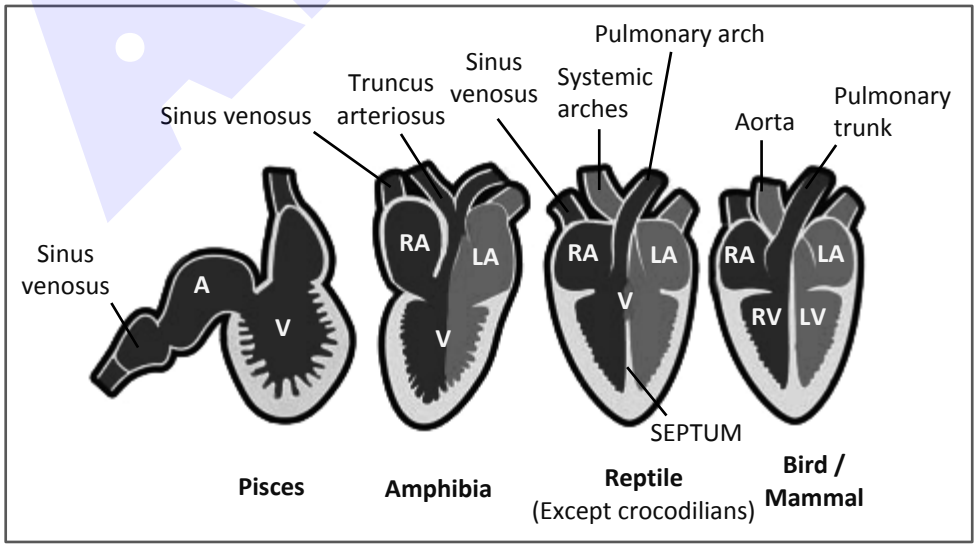
(b) Lymphatic system : It consist of lymph, lymph vessels , lymph nodes.

TYPE OF BLOOD CIRCULATION AND HEART IN VERTEBRATES

	Fishes	Amphibians	Reptiles	Crocodiles, Aves, Mammals
No. of heart Chambers	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.

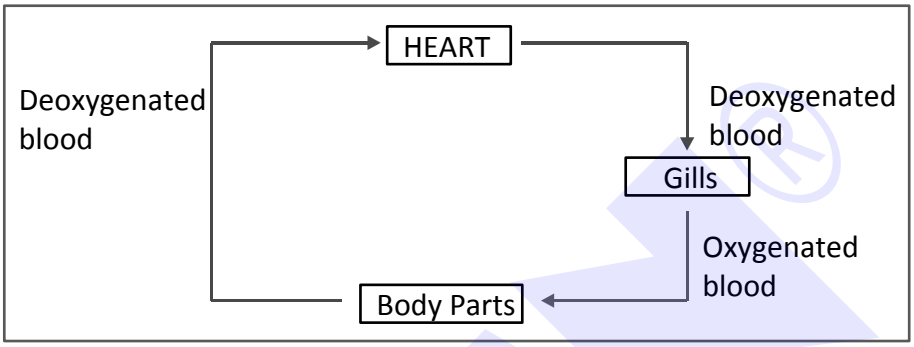
- Fishes have **"Venous-Heart"** in their heart, deoxygenated blood enters from one side and from the other side to the gills for oxygenation. This is called the **"Single Heart Circuit."**
- In **amphibians** and **Reptiles** the auricles are divided into right and left. Right auricle gets deoxygenated 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.**
- 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.



- **Sinus Venosus 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

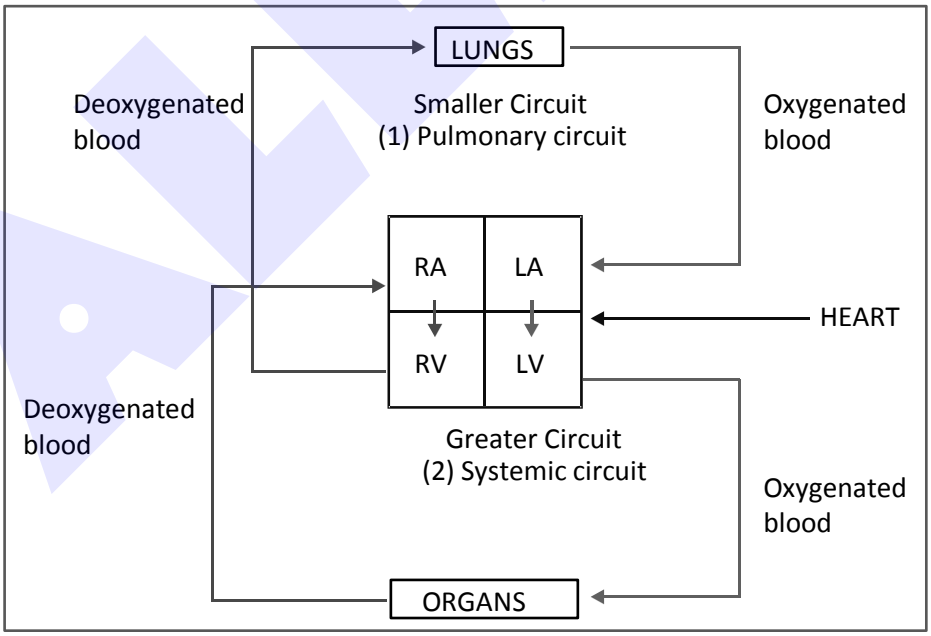
(a) Single Circulation :- Example : Fishes



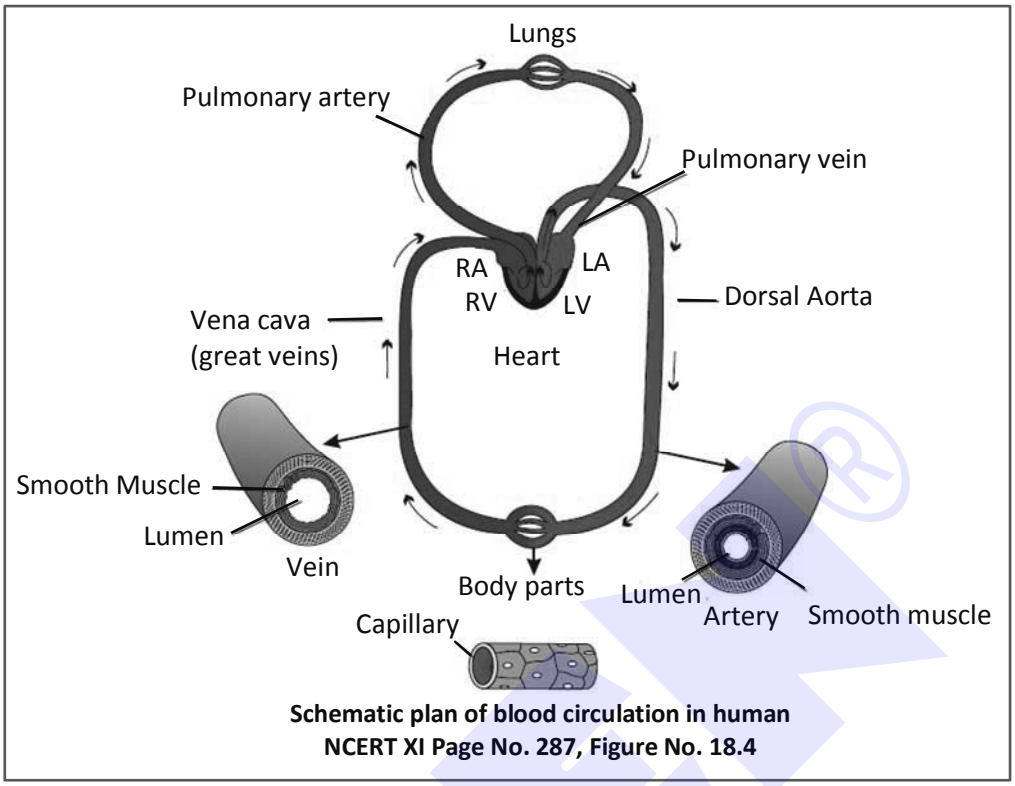
(b) Incomplete double circulation :– Two circuits are not completely separate.

– Amphibia, Reptiles

(c) Double Circulation :- Example – Birds, Mammals



Path of Blood in Double Circuit (Human)



Schematic plan of blood circulation in human
NCERT XI Page No. 287, Figure No. 18.4

BEGINNER'S BOX — TYPES OF BLOOD CIRCULATION

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

4. Heart of fishes:-
(1) Two chambered (2) Venous heart (3) Both (1) & (2) (4) 3 chambered

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

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

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

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

9. Closed circulatory system is present in
(1) Annelids and Chordates (2) Arthropods and Annelids
(3) Arthropods and Chordates (4) Molluscs and Annelids

06. HUMAN CIRCULATORY SYSTEM

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

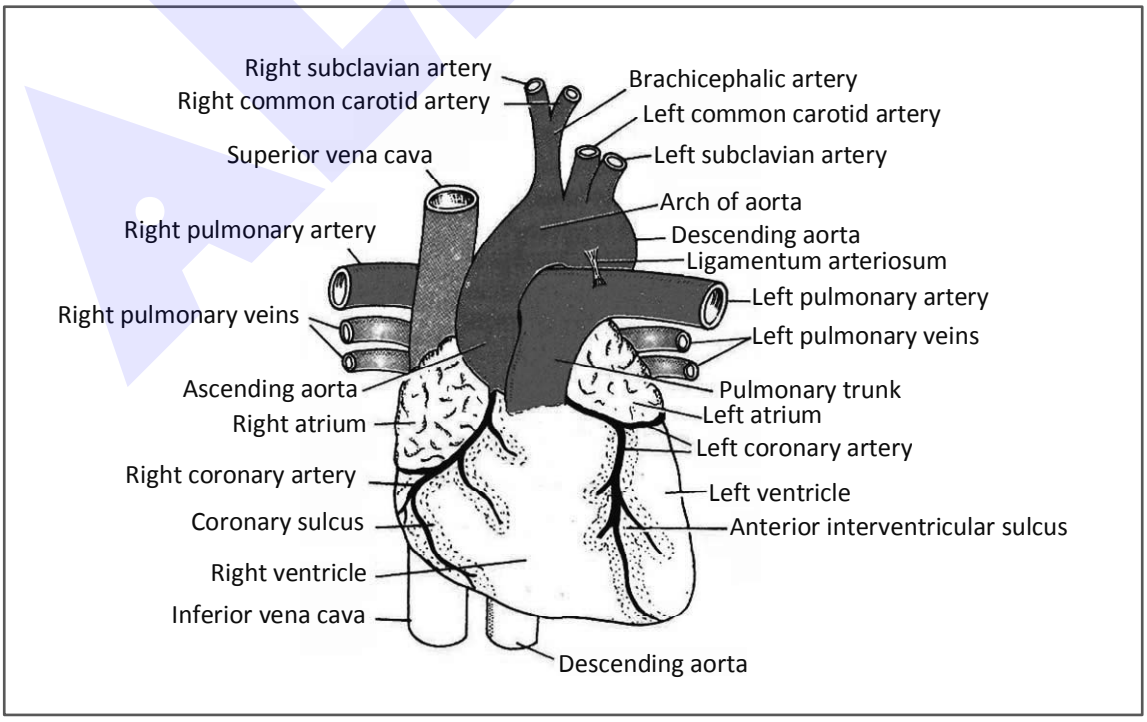
  Wall of Heart : The wall of heart is made of three layers.

  (a) **Epicardium** – outermost layer, Made of simple squamous epithelium.

  (b) **Myocardium** – middle layer, thickest, Made of cardiac muscles which are striated but involuntary .

  (c) **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 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 shifted slightly 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 **Inter-ventricular 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.

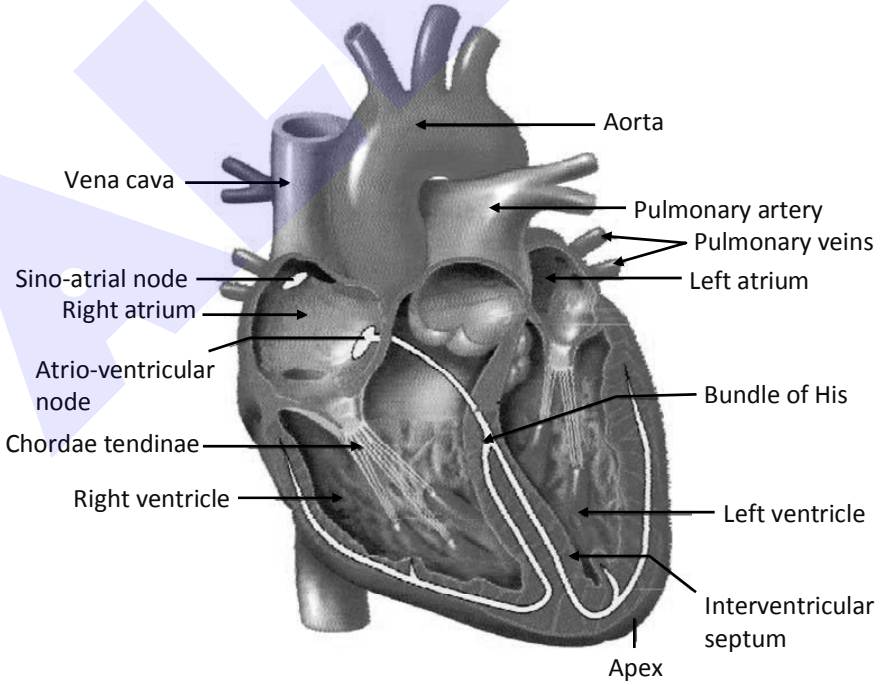
- Left ventricle is the largest chamber of heart.

Systemic heart -

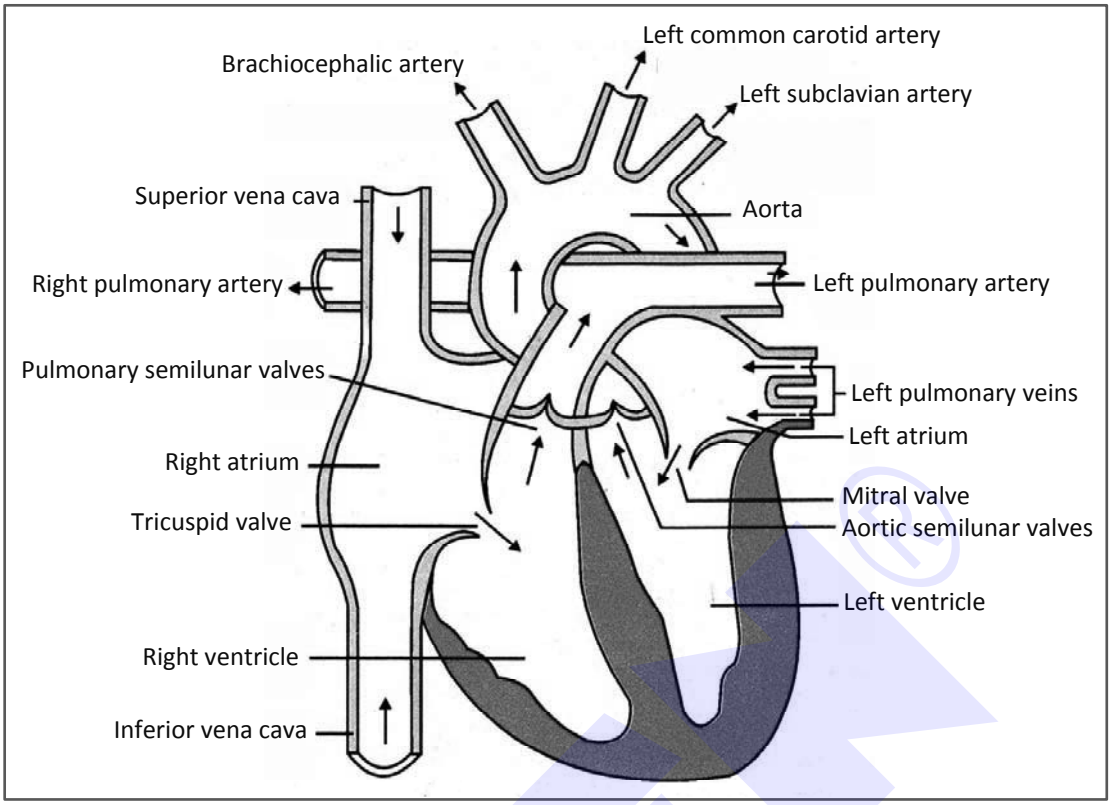
Left part of the heart (i.e. **left atrium** and **left ventricle**) contain the blood which is to be pumped into the ***systemic circulation***, therefore it is called systemic heart. The main purpose of such a circulation is to transport oxygen ,as well as nutrients to the body tissues, and to remove carbon dioxide 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.



Section of a human heart
NCERT XI Page No. 283, Figure No. 18.2



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 .

Walls

- **Atrium** - The inner wall surface here presents a series of transverse muscular ridges called ***musculi pectinati***. 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 chordae 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

- **Right Atrium** : Superior vena cava, inferior vena cava and coronary sinus open in right atrium.
- **Left Atrium** : At its inlet is pulmonary vein, 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**).
- **Right Ventricle** : Its outlet is in the pulmonary artery . it is guarded by a **pulmonary semilunar valve**
- **Left 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.

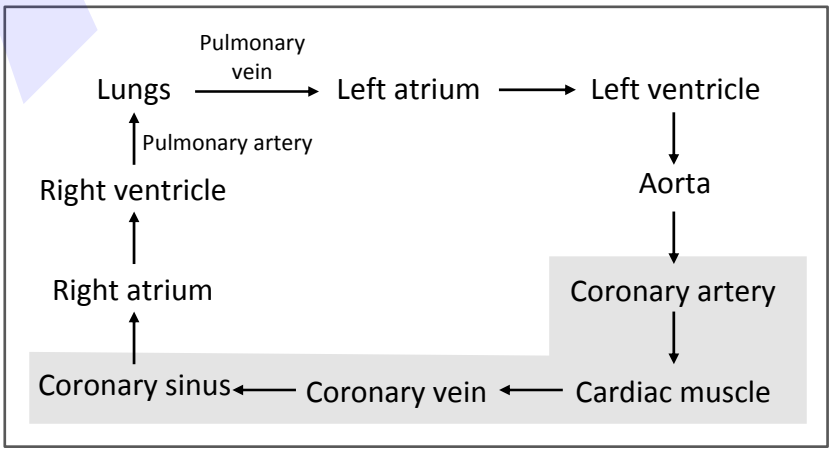
The valves in the heart allows the flow of blood only in one direction from atria to the ventricles from the ventricles to the pulmonary aorta. These valves prevent any backward flow.

Golden Key Points

- 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.
- In embryonic heart small opening, foramen ovale is present at interatrial septum which after birth is modified to fossa ovalis.
- 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)

A special coronary system of blood vessels is present in our body exclusively for the circulation of blood to and from the cardiac musculature.



BEGINNER'S BOX — STRUCTURE OF HEART

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

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

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

4. Number of valves presents in human heart :-
(1) 1 (2) 6 (3) 4 (4) 3

5. Opening of the right ventricle to the pulmonary artery and left ventricle to the aorta is provided with :-
(1) Bicuspid valve (2) Tricuspid valve
(3) Semilunar valve (4) All of these

6. The wall of the ventricles are much thicker than that of atrium because :-
(1) It has to pump the blood (2) It has to receive the blood
(3) It is present below the atrium (4) It has to store the blood

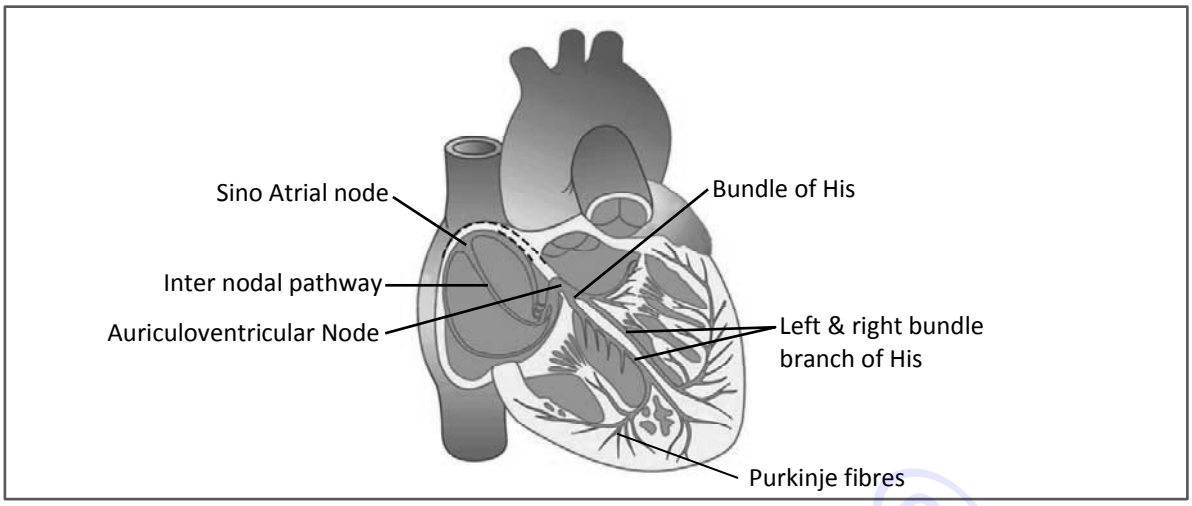
(2) HEART BEAT

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 specialised cardiac musculature. e.g. Molluscs and vertebrates

The conducting system of Myogenic Heart

It is made of myocardium that is specialised 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

- **Speed of conduction is fastest in Purkinje fibres and slowest in AV node**
- **Sino Atrial node (SA node).** It is known as the "pacemaker" of the heart. It is present in right upper corner of the right atrium. It generates impulses at the rate of about 72 per minute and initiates heart beat.
- **Internodal pathway** that connects the SA node to the AV node.
- **Atrioventricular node (AV Node).** It is situated in the lower left corner of the right atrium close to the atrio-ventricular septum.
- **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.
- **The Purkinje fibres.** These are distributed through the endocardium of the ventricles and propagate the impulse in the entire ventricle musculature.
- The nodal musculature has the ability to generate action potentials without any external stimuli, i.e., it is autoexcitable. However, the number of action potentials that could be generated in a minute vary at different parts of the nodal system.

- 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 rate,

  Adult human - 72 per min.

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

(3) REGULATION OF CARDIAC ACTIVITY

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

  (a) Cardio- accelerator centre **(b)** 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, 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 Points			
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 :-

(a) Temperature.

(b) Stimulation by sympathetic nerves

(c) Weak condition of the heart

(d) Shock/loss of blood

(e) Exercise

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

Common causes of bradycardia :-

(a) Temperature

(b) Stimulation by parasympathetic Vagus nerve

(c) Stronger condition of the heart

BEGINNER'S BOX — CONDUCTING SYSTEM OF HEART

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

2. How many nodes are found in heart of Human :-
(1) One (2) Two (3) Many (4) All of these

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

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

5. Which nodal fibres lies in between the right and left ventricles :-
(1) Bundle of His (2) S.A. Node (3) Neural tissue (4) A.V. Node

6. Autoexitable fibres/nodes are called :-
(1) Nodal musculature (2) Cardiac nerves (3) Neurons (4) All of these

7. Pacemaker is :-
(1) Instrument for measuring the heart beat
(2) Instrument for measuring the pulse beat
(3) AV node that provides impulse for the heart beat
(4) Sino atrial node that provides impulse for the heart beat

8. Heart of human is :-
(1) Myogenic (2) Neurogenic (3) 3 chambered (4) All the above

(4) CARDIAC CYCLE

The cardiac events that occur from the beginning of one heart beat to beginning 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 1/10th 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.

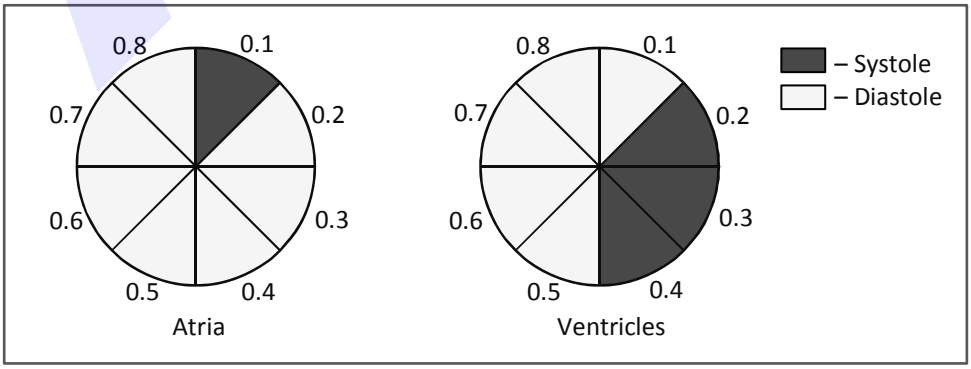
Thus the atria are the primer pumps for the ventricles, and ventricles then provide the major source of power for moving blood through the vascular system.

Cardiac-Cycle :-

The process of heart -beat begins from the time of embryonic development. Once the heart beat starts, it continues throughout 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.

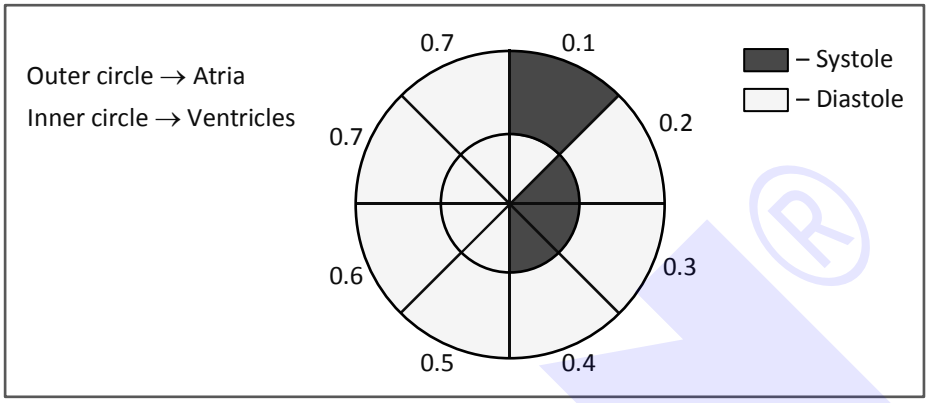
Cardiac Events



Joint Diastole 0.8 – 0.4 = 0.4 sec. (Period during which entire heart is in Diastole)

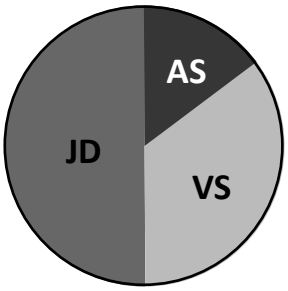
In a single cardiac cycle of human-			
(1) Atrial systole	=	0.1 sec	0.8 sec
(2) Atrial diastole	=	0.7 sec	
(3) Ventricular systole	=	0.3 sec	0.8 sec
(4) Ventricular diastole	=	0.5 sec	

- Following events are related to the Cardiac-cycle-



Common diagram showing events of both atria & ventricles
Events of both auricles & ventricles

1. ATRIAL SYSTOLE



- The SAN now generates an action potential which stimulates both the atria to undergo a simultaneous contraction – the atrial systole.
- This increases the flow of blood into the ventricles by about 30 per cent.

2. VENTRICULAR SYSTOLE

- The ventricular muscles contract, (ventricular systole), the atria undergoes relaxation (diastole), coinciding with the ventricular systole.
- Ventricular systole increases the ventricular pressure causing the closure of tricuspid and bicuspid valves due to attempted backflow of blood into the atria.
- As the ventricular pressure increases further, the semilunar valves guarding the pulmonary artery (right side) and the aorta (left side) are forced open, allowing the blood in the ventricles to flow through these vessels into the circulatory pathways.
- As the ventricular pressure increases further, the semilunar valves guarding the pulmonary artery (right side) and the aorta (left side) are forced open, allowing the blood in the ventricles to flow through these vessels into the circulatory pathways.

3. JOINT DIASTOLE

- All the four chambers of heart are in a relaxed state.
- As the tricuspid and bicuspid valves are open, blood from the pulmonary veins and vena cava flows into the left and the right ventricle respectively through the left and right atria.
- The semilunar valves are closed at this stage.

- **"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.
- **"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.
- **"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" close producing "LUBB' sound.
  - **(b) "Period of Ejection" –** During the cycle when pressure increases in the ventricles, then the semi-lunar valves 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.
- **"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 receive 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 valves are open but semilunar valves are closed.

Volumes of blood related with cardiac cycle.

During diastole, filling of the ventricles normally increases the volume of each ventricle to about 120 millilitres. This volume is known as ***end diastolic volume***. Then as the ventricles empty during systole, the volume decreases by about 70 millilitres, 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 millilitres 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.

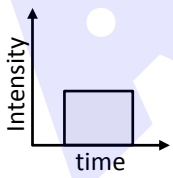
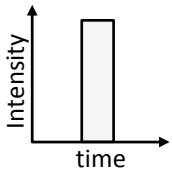
Cardiac output = stroke volume x heart rate.

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

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

(5) 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**.

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 beginning of Ventricular Systole	● At the beginning of ventricular diastole
4. Caused by Closure of AV valves	● Caused by Closure of Semilunar valves

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

BEGINNER'S BOX — CARDIAC CYCLE AND HEART SOUND

1. One of the following nerves inhibit the rate of heart beat :-
(1) Vagus nerve (2) Sympathetic nerve (3) Occulomotor (4) All of the above

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

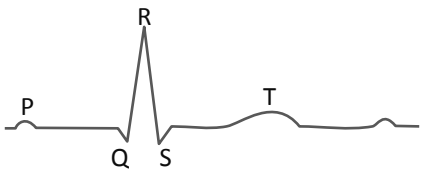
7. The 'Lubb' and 'Dupp' heart sound are due to :-
(1) Opening of heart valves (2) Action of papillary muscles
(3) Closing of heart valves (4) Activity of pace maker

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 Pulmonary & Aortic Valve

9. Atrial diastole takes place when :-
(1) Right atrium is filled with blood (2) Left atrium is filled with blood
(3) Both atria are filled with blood (4) Both ventricles are filled with blood

10. When two atria contract simultaneously and results in the blood pumping into ventricles, this is called :-
(1) Atrial diastole (2) Atrial systole
(3) Ventricular diastole (4) Ventricular systole

07. ELECTROCARDIOGRAPH (ECG)



Diagrammatic presentation of a standard ECG
NCERT XI Page No. 286, Figure No. 18.3

You are probably familiar with this scene from a typical hospital television show: A patient is hooked up to a monitoring machine that shows voltage traces on a screen and makes the sound "... pip... pip... pip..... eeeeeeeeeeeeeeeeeeeee" as the patient goes into cardiac arrest. This type of machine (electro-cardiograph) is used to obtain an electrocardiogram (ECG).

ECG is a graphical representation of the electrical activity of the heart during a cardiac cycle.

To obtain a standard ECG (as shown in the Figure), a patient is connected to the machine with three electrical leads (one to each wrist and to the left ankle) that continuously monitor the heart activity. For a detailed evaluation of the heart's function, multiple leads are attached to the chest region. Here, we will talk only about a standard ECG. Each peak in the ECG is identified with a letter from P to T that corresponds to a specific electrical activity of the heart.

- **The P-wave represents the electrical excitation (or depolarisation) of the atria, which leads to the contraction of both the atria.**
- **The QRS complex represents the depolarisation of the ventricles, which initiates the ventricular contraction. The contraction starts shortly after Q and marks the beginning of the systole.**
- **The T-wave represents the return of the ventricles from excited to normal state (repolarisation). The end of the T-wave marks the end of systole.**

Obviously, by counting the number of QRS complexes that occur in a given time period, one can determine the heart beat rate of an individual. Since the ECGs obtained from different individuals have roughly the same shape for a given lead configuration, any deviation from this shape indicates a possible abnormality or disease. Hence, it is of a great clinical significance.

08. 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.

- **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)
- **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. of a 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

09. DISORDERS OF CIRCULATORY SYSTEM

(1) HIGH BLOOD PRESSURE (HYPERTENSION)

Hypertension is the term for blood pressure that is higher than normal (120/80). In this measurement 120 mm Hg (millimetres of mercury pressure) is the systolic, or pumping, pressure and 80 mm Hg is the diastolic, or resting, pressure. If repeated checks of blood pressure of an individual is 140/90 (140 over 90) or higher, it shows hypertension. High blood pressure leads to heart diseases and also affects vital organs like brain and kidney.

(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.

(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.

DISORDERS OF CIRCULATORY SYSTEM

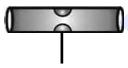
1. High blood pressure (Hypertension) :- Blood pressure that is higher than normal i.e. (140/90)

Blood pressure (BP) ⇒ Pressure exerted by blood on walls of Arteries

Systolic/Pumping pressure	Diastolic/Resting pressure
● Higher limit (during systole)	● Lower limit (during diastole)
● 120 mm of Hg	● 80 mm of Hg

● Normal BP (Adult) = 120/80 ● Instrument = Sphygmomanometer ● Brachial/radial Artery

2. Coronary artery diseases (CAD) :- Coronary Artery Disease, often referred to as atherosclerosis, affects the vessels that supply blood to the heart muscle. It is caused by deposits of calcium, fat, cholesterol and fibrous tissues, which makes the lumen of arteries narrower.

Atherosclerosis	Arteriosclerosis
	
Cholesterol, calcium, fat, fibrous tissues deposit in wall of vessels ↓ Narrowing of artery	Ca^{+2} deposition in walls ↓ Hardening of artery

3. Angina pectoris :- **Acute chest pain** → When no enough oxygen is reaching the heart muscle (Hypoxia). (More common among the middle aged and elderly)

4. Myocardial infarction/Heart attack :- **Sudden death of heart muscle** Due to inadequate blood supply (Anoxia).

5. Cardiac arrest :- **Heart stop beating**

6. Heart failure :- **Heart not pumping blood effectively** → To meet the needs of the body

BEGINNER'S BOX — BLOOD PRESSURE, DISORDERS

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

2. Which one indicates hypertension or high blood pressure (BP) :-
(1) 120/80 (2) 110/70 (3) 130/80 (4) 140/90

3. Atherosclerosis is called :-
(1) Coronary artery disease (2) Angina
(3) Heart failure (4) Hypertension

4. Atherosclerosis is caused by deposition of :-
(1) Calcium (2) Fat and cholesterol
(3) Deposition of fibrous tissue (4) All of the above

5. Angina occurs due to :-
(1) When enough oxygen is reaching to heart muscle
(2) When not enough oxygen is reaching to heart muscle
(3) The deposition of carbohydrates in artery
(4) The deposition of protein in artery

6. Coronary heart disease is due to the inadequate blood supply to :-
(1) Heart ventricle (2) Heart auricle (3) Heart valves (4) Heart muscles

10. BLOOD – VESSELS

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

- Arteries
- veins
- Capillaries

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

(a) **Tunica externa :-** 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.

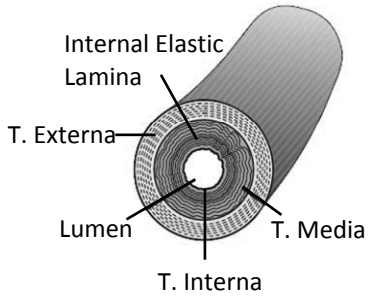
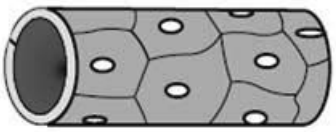
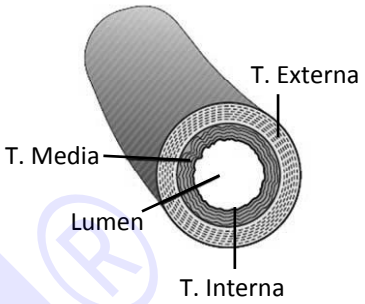
(b) **Tunica media :-** It is a thick layer of circular non striated muscles and a network of elastin fibres.

(c) **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-collapsible.**
- The walls of veins are thin, less muscular **non elastic** and **collapsible**.

- 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	CAPILLARY	VEIN
	 Maximum surface area is of Capillaries Capillary system discovered By Marcello Malpighi	

	ARTERY		VEIN
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.	Their tunica media layer is much thicker as compared to veins.	7.	Their tunica media layer of wall is thinner as compared to arteries.

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:-

(a) Renal portal system, **(b)** Hepatic portal system, **(c)** Hypophysial portal system

(a) 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.

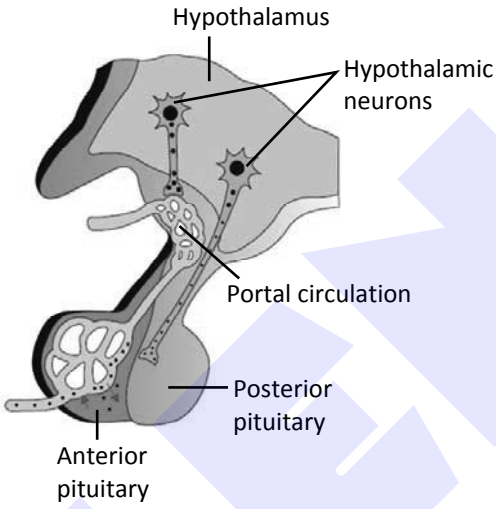
- In mammals, renal portal system is absent.

- In Frog both the portal systems ; renal portal system and hepatic portal system are present.

(b) Hepatic Portal System :-

A unique vascular connection exists between the digestive tract and liver called hepatic portal system. The hepatic portal vein carries blood from intestine to the liver before it is delivered to the systemic circulation.

(c) Hypophysial Portal System :-



Diagrammatic representation of pituitary and its relationship with hypothalamus

NCERT XI Page No. 333, Figure No. 22.2

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

11. LYMPHATIC SYSTEM

Lymphatic Circulatory System : It is comprises of following parts.

- Lymph
- Lymph vessels
- 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.

Blood		Lymph	
1.	It forms circulatory system.	1.	It forms lymphatic system.
2.	R.B.Cs. present	2.	R.B.Cs. absent
3.	Neutrophils more	3.	Lymphocytes in largest amount
4.	Comparatively more protein	4.	Comparatively less protein
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.

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 is red- coloured lymph node, it is found attached by mesentery to the lateral side of stomach.

Functions of spleen:-

(a) Its macrophages engulf or phagocytize and destroy worn-out blood cells, pathogens, cell debris etc.

(b) In the embryonic stage it produces RBCs.

(c) Some antibodies are synthesised here.

(d) Spleen stores iron.

(e) [Spleen + liver + kidneys] These three are called **blood filter apparatus** of blood.

(f) [Spleen + liver] – **RBC filtering** apparatus.

BEGINNER'S BOX
BLOOD VESSELS, PORTAL SYSTEM, LYMPH

1. 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

2. The smallest blood vessel in the body is :-

(1) Capillary (2) Artery (3) Vein (4) Vena cava

3. Filter apparatus for dead R.B.C is :-

(1) Spleen + Kidney (2) Liver + Kidney

(3) Spleen + Liver + Kidney (4) Liver + Spleen

4. 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

5. 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

6. Which one of the following is the main graveyard of RBC :-

(1) Bone marrow (2) Spleen (3) Liver (4) Kidney

7. Which blood vessel carry blood from the different part of your body to the heart :-

(1) Capillaries (2) Arteries (3) Veins (4) All of these

BEGINNER'S BOX — ANSWERS KEY

PLASMA AND RBC

Que.	1	2	3	4	5	6	7	8	9	10	11
Ans.	**1**	**1**	**3**	**3**	**4**	**4**	**1**	**2**	**1**	**2**	**3**

WBC AND PLATELETS

Que.	1	2	3	4	5	6	7	8	9
Ans.	**4**	**1**	**3**	**2**	**1**	**2**	**1**	**3**	**4**

BLOOD CLOTTING AND BLOOD GROUP

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	**1**	**1**	**4**	**3**	**1**	**3**	**2**	**2**	**2**	**2**

TYPES OF BLOOD CIRCULATION

Que.	1	2	3	4	5	6	7	8	9
Ans.	**1**	**2**	**2**	**3**	**3**	**2**	**2**	**3**	**1**

STRUCTURE OF HEART

Que.	1	2	3	4	5	6
Ans.	**2**	**2**	**4**	**3**	**3**	**1**

CONDUCTING SYSTEM OF HEART

Que.	1	2	3	4	5	6	7	8
Ans.	**1**	**2**	**2**	**1**	**1**	**1**	**4**	**1**

CARDIAC CYCLE AND HEART SOUND

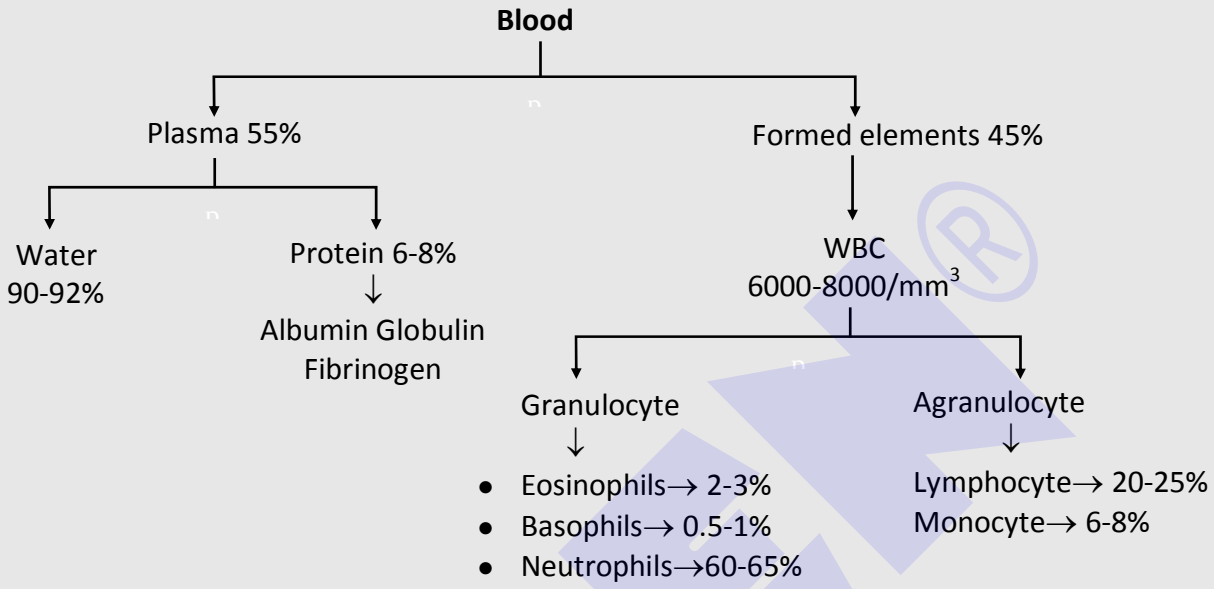
Que.	1	2	3	4	5	6	7	8	9	10
Ans.	**1**	**2**	**3**	**4**	**4**	**3**	**3**	**3**	**3**	**2**

BLOOD PRESSURE, DISORDERS

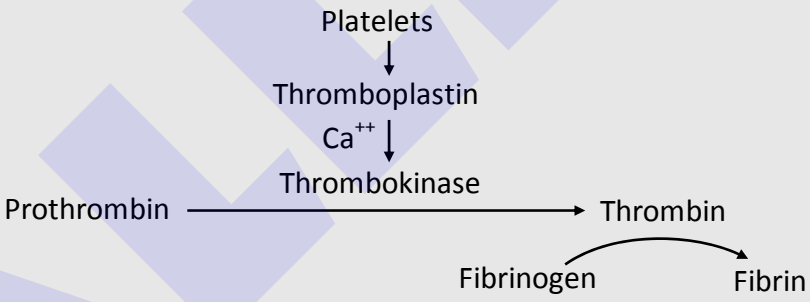
Que.	1	2	3	4	5	6
Ans.	**2**	**4**	**1**	**4**	**2**	**4**

BLOOD VESSELS, PORTAL SYSTEM, LYMPH

Que.	1	2	3	4	5	6	7
Ans.	**3**	**1**	**4**	**3**	**4**	**2**	**3**

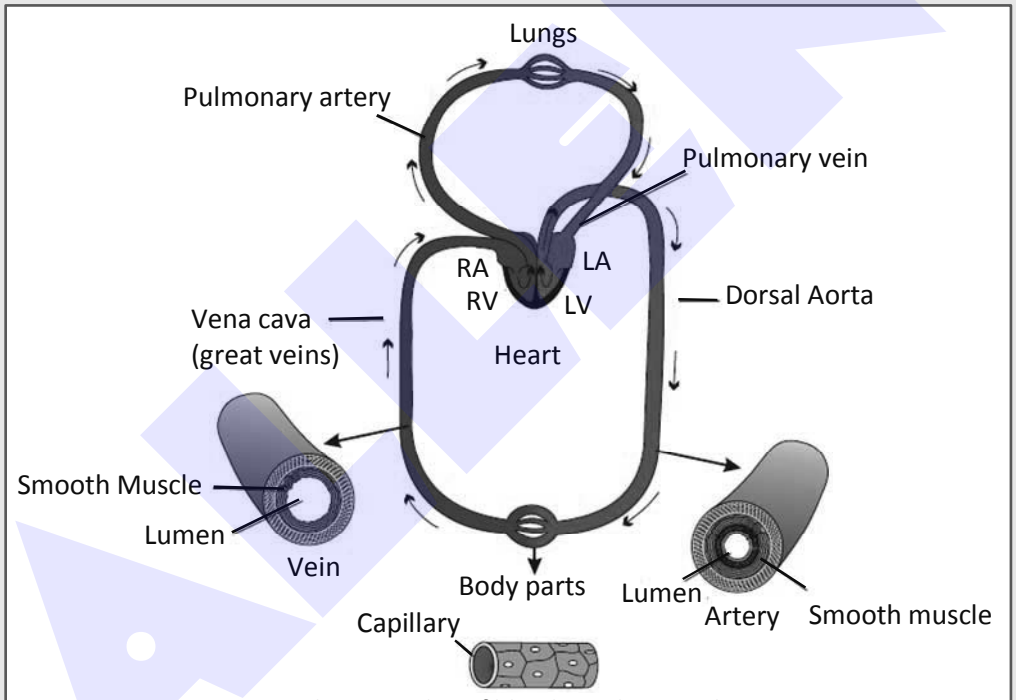


- Blood clotting :



- Blood Groups :
  - Universal donor blood group is O.
  - Universal acceptor blood group is AB.
  - Rh positive person can donate to Rh negative person only once.
  - If mother is Rh^- and foetus is Rh^+ then in second pregnancy foetus may suffer from erythroblastosis foetalis.
  - Heart is two chambered in fishes, three in amphibian and reptilian and four in Aves & mammals.
  - Human Heart is enclosed by pericardium.
  - Atrioventricular septum is fibrous, whereas inter atrial and inter ventricular septum are muscular.
  - Bicuspid (mitral) valve is between LA & LA.

- Tricuspid valve is between RA & RV.
- Semilunar valves are at base of aorta & pulmonary artery.
- SA node-Pacemaker.
- AV node-pacesetter.
- Joint diastole is for 0.4 sec. and at this time, AV valves are open, semilunar valves are closed.
- Atrial systole is for 0.1 sec. and remaining 30% of ventricular blood fills at this time.
- Ventricular systole is for 0.3 sec., at this time, AV valves are closed and semilunar valves are open.
- Cardiac output (5L/min) = Stroke volume (70 ml) × Heart rate (72 / min.).
- First heart sound (Lubb) is due to closure of AV valves and second (Dup) is due to closure of semilunar valves.
- P wave indicate depolarization of atria.
- QRS complex indicate depolarization of ventricles.
- T wave indicate repolarization of ventricles.



Schematic plan of blood circulation in human

- Cardiac centre is in medulla.
- Cardio accelerator send impulse by sympathetic fibres.
- Cardio inhibitory send impulse by para sympathetic fibres.
- Coronary artery disease-Narrowing of coronary artery.
- Heart failure → Heart is not pumping blood effectively.
- Cardiac arrest → Heart stops beating.
- Heart attack → Sudden death of heart muscle.
- Normal blood pressure → 120/80 mm Hg.