HUMAN ANATOMY AND PHYSIOLOGY

UNIT 3 NOTES

BODY FLUIDS & BLOOD

- BLOOD
- HAEMOPOEISIS
- HAEMOSTASIS
- ANAEMIA
- BLOOD GROUPS
- LYMPHATIC SYSTEM

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Body Fluids

- In an average adult the body fluids composed of 55 - 60 % of the total body mass.
- The body fluids are present in two major compartment.

① Intracellular Fluid (Fluid inside cell)
② Extracellular Fluid (Fluid outside cell)

<table>
<tr><td rowspan="4">Total Body Weight</td><td></td><td colspan="2">40% Solids</td></tr>
<tr><td rowspan="3">60% Fluids</td><td rowspan="2">2/3 Intracellular Fluid</td><td></td></tr>
<tr><td rowspan="2">1/3 Extracellular Fluid</td><td>80% Interstitial Fluid</td></tr>
<tr><td>20% Plasma</td></tr>
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BLOOD

- Blood is a specialized liquid connective tissue.
- It consist of blood plasma and formed elements.
- It is the transporter of O_2 and CO_2 inside our body.
- It is circulated around the body through the blood vessels.
- Hematology is the branch of science in which we study about blood, blood forming tissues & disorders related to them.

Basic Properties of blood

- It is denser and more viscous than water
- It has a slightly alkaline pH range.
- The temperature of blood is 38°C.
- The colour of the blood varies with its oxygen content. Oxygenated blood appears bright red, while deoxygenated blood appears dark red.
- In Males, the volume is about 5-6 Litre.
- In Females, the volume of blood is about 4-5 litre.

Functions of blood

- The major function of blood is transportation of O_2 & CO_2 gases.
- It also helps in the transportation of nutrients & metabollic wastes.
- It regulates the body temperature.
- It regulates water balance.
- It provids protection against infection through WBCs.
- It also helps in blood clotting.

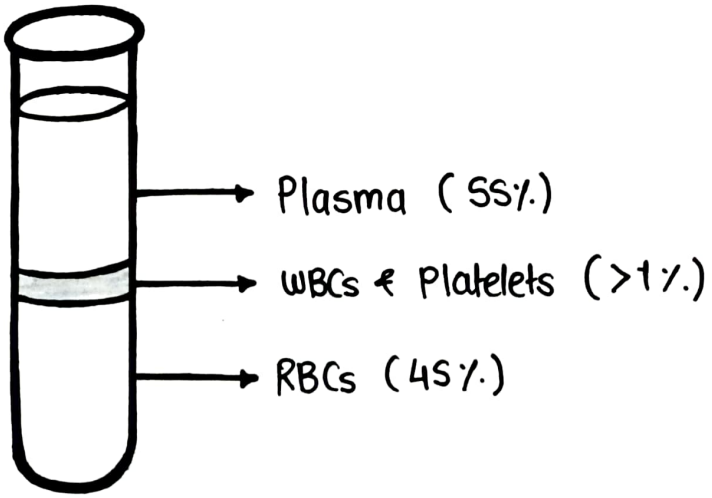
Components of blood

- BLOOD
  - FORMED ELEMENTS
    - Red blood Cells
    - White blood Cells
      - Granulocytes
        - Neutrophills
        - Eosinophills
        - Basophills
      - Agranulocytes
        - Monocytes
        - Lymphocytes
    - Platelets
  - BLOOD PLASMA
    - Water
    - Proteins
      - Albumin
      - Globulin
      - Fibrinogen
    - Other Solutes

A blood is composed of two components :

① Blood Plasma

② Formed Elements



Composition of Blood

① Blood Plasma

- Plasma is a pale yellow coloured liquid component of the blood.
- It is about 55% of total blood volume.
- It is composed of various components like water, proteins, minerals etc.
- When fibrinogen is removed from blood, then remaining part is known as Serum.

Components of Blood Plasma

Water : 90% of total plasma, helps in absorbtion & transportation.

Protein
- Albumins : Maintain osmotic pressure
- Globulins : Involve in the defense mechanism
- Fibrinogen : Helps in blood clotting.

Other solutes : Other solutes includes Na^+, Ca^{2+}, K^+, Cl^-, HCO_3^- etc which helps in muscle contraction, impulse generation acid- base balance etc.

② Formed Elements

Formed elements of blood is mainly composed of :

- Red Blood Cells (RBCs)
- White Blood Cells (WBCs)
- Platelets

Red Blood Cells

- Red blood cells (RBCs) also known as Erythrocytes.
- It is composed of 45% of total blood volume.
- Its shape is generally circular or biconcave.
- Its colour is red due to the presence of haemoglobin.
- Its count is about 5·4 million RBCs / µl in males and 4·8 million RBCs / µl in females.
- Its diameter is about 7-8 µm & thickness is about 2 µm.
- The total life span of RBCs is about 120 days.

- The major function of RBCs is transportation of O_2 & CO_2.

Haemoglobin

- Normal blood contains 13-15 g of Haemoglobin per 100 ml volume.
- In short it is represented by Hb
- 1 Hb = 4 Haem unit + 4 globin chain.

* 1 Hb molecule contains 4 atom of Iron (Fe^{2+})
* Now each atom of iron contain 1 molecule of O_2
* So, 1 Haemoglobin molecule contain 4 molecules of O_2

Now, One RBCs contain about 250 million Hb molecules.
So, 1 RBCs contain approx 1000 million molecules of O_2

White Blood Cells

- They are also known as as Leucocytes
- Its shape is generally amoeboid.
- It is colourless in nature.
- They are much less in number compared to erythrocytes.
- The normal count of WBCs are 5000-. 10,000 WBCs / ul..
- Increased level of WBCs leads to Leukemia (Blood Cancer).

Types of WBCs

WBCs are classified into two major categories :

① Granulocytes
② Agranulocytes

Granulocytes

- About 75 %. of WBCs are granulocytes & when observed under microscope these cells shows the presence of granules.
- They are also of three types :

Neutrophills : They are about 60-70 %. of total WBCs
They act as a first line defense against bacteria & viruses

Eosinophills : They are about 2-4 %. of total WBCs
They cause allergic reactions and play an important role in immune system.

Basophills : They are about 0.5 -1 %. of total WBCs
They secrete serotonin & histamine which involved in inflammation.

Agranulocytes

- They do not contain any type of granules
- They are of generally two types

Lymphocytes — They are 20-25% of total WBCs
They generally exist in two different forms
① B Lymphocytes (develop from bone marrow)
② T Lymphocytes (develop from thymus)

Monocytes — They are 3-8% of total WBCs
When monocytes enters into the tissues, it converts into macrophages.

Platelets

- They are also known as thrombocytes.
- The normal platelets count is approx 1,50,000 - 4,00,000 platelets/µl.
- They are of disc shaped.
- Their diameter is about 2-4 µm
- Their life span is about 5 to 9 days.

- It plays major role in Haemostasis (blood clotting)

HAEMOPOIESIS

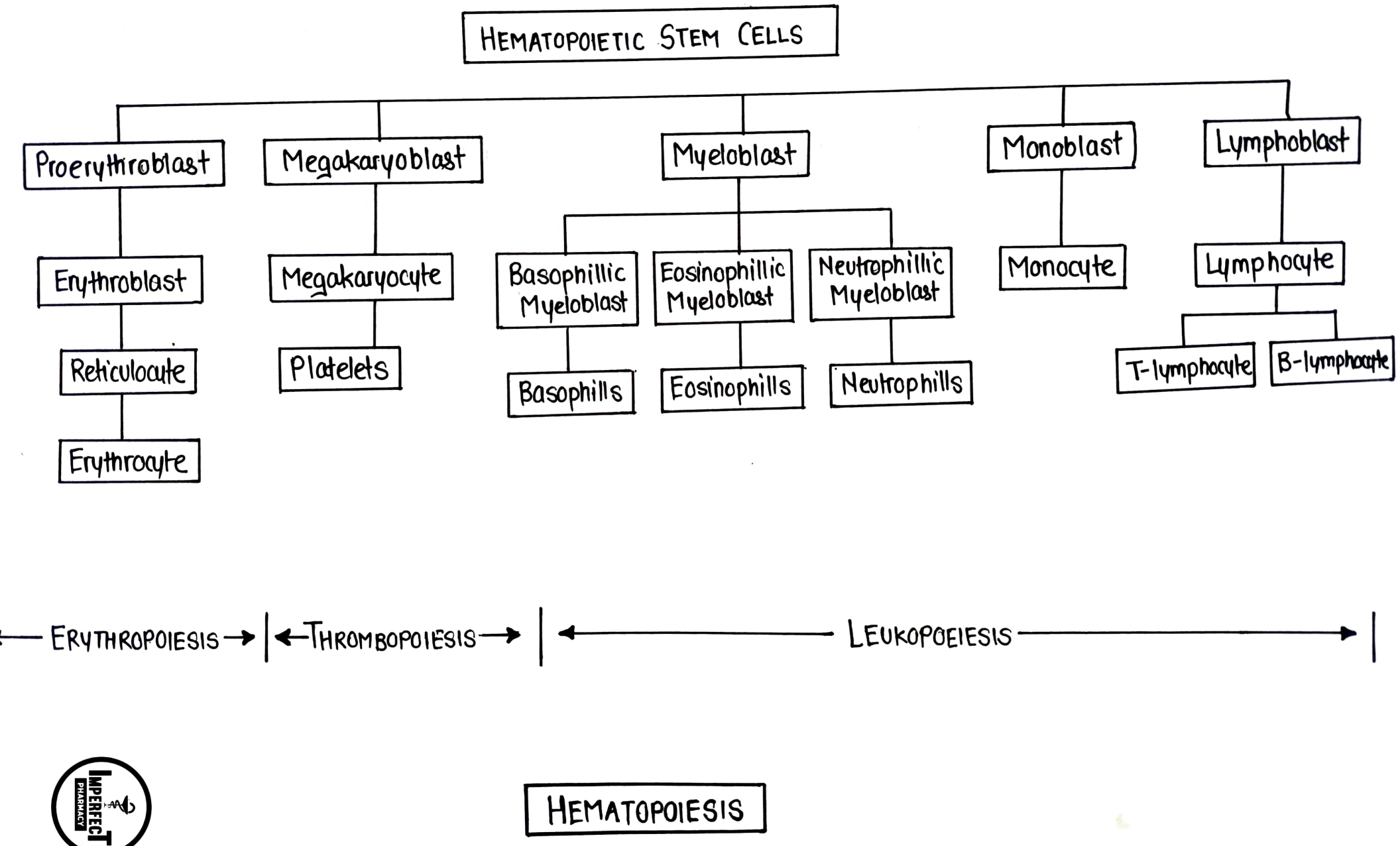
- In Haemopoiesis , Haemo : Referring to blood cells
  Poiesis : Referred to 'development'

- The word Haemopoiesis refers to the development & production of all the blood cells (RBCs, WBCs, Platelets)
- Haemopoiesis can also be known as 'Hemopoiesis' or 'Hematopoiesis'.
- In a healthy adult person, approxiamately $10^{11} - 10^{12}$ new blood cells are produced daily in order to maintain the constant level of blood in our body.
- Now, all these blood cells are developed from a special type of cell called Haematopoeitic stem cells

Site of Hematopoiesis

AGE	SITE
Fetus 0-2 months	Yolk Sac
2-5 months	Liver, Spleen
5-9 months	Liver, Spleen, Bone Marrow
After Birth	Bone Marrow

- Formation of RBCs (Erythrocyte) : Erythropoiesis
- Formation of WBCs (Leukocytes) : Leukopoiesis
- Formation of Platelets (Thrombocytes) : Thrombopoiesis



HEMATOPOIESIS

ERYTHROPOIESIS

- Formation of RBCs is called as Erythropoiesis
- Red blood cells are also known as erythrocytes which contain
- Haemoglobin that gives red colour to blood.
- The total life span of RBCs is around 120 days.
- The process of erythropoiesis takes place in the red bone marrow.

Process of Erythropoiesis

Hematopoietic Stem Cell

↓

Proerythroblast

↓

Early Normoblast

↓

Intermediate Normoblast

↓

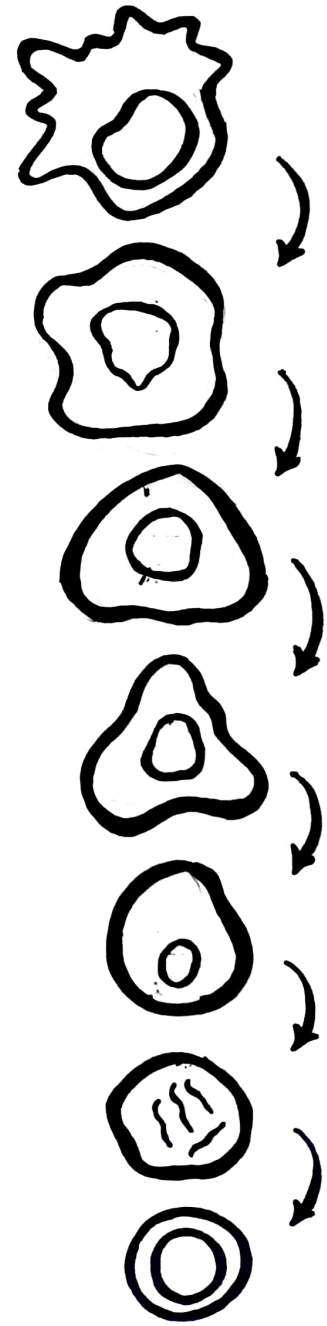
Late Normoblast

↓

Reticulocyte

↓

Erythrocyte



Changes during Erythropoiesis

- Reduction in size of the cell (from 25 to 7·2 microns)
- Disappearance of nucleus
- Appearance of hemoglobin
- Disappearance of cell organells

Important events during erythropoiesis

Stage of Erythropoiesis	Important Events
Hematopoietic Stem Cell	Erythropoiesis starts
Proerythroblast	Synthesis of hemoglobin start
Early Normoblast	Nucleoli Disappears
Intermediate Normoblast	Hemoglobin starts appearing
Late Normoblast	Nucleus Disappears
Reticulocyte	Reticulum is formed
Erythrocyte	Reticulum disappears, Cell → biconcave

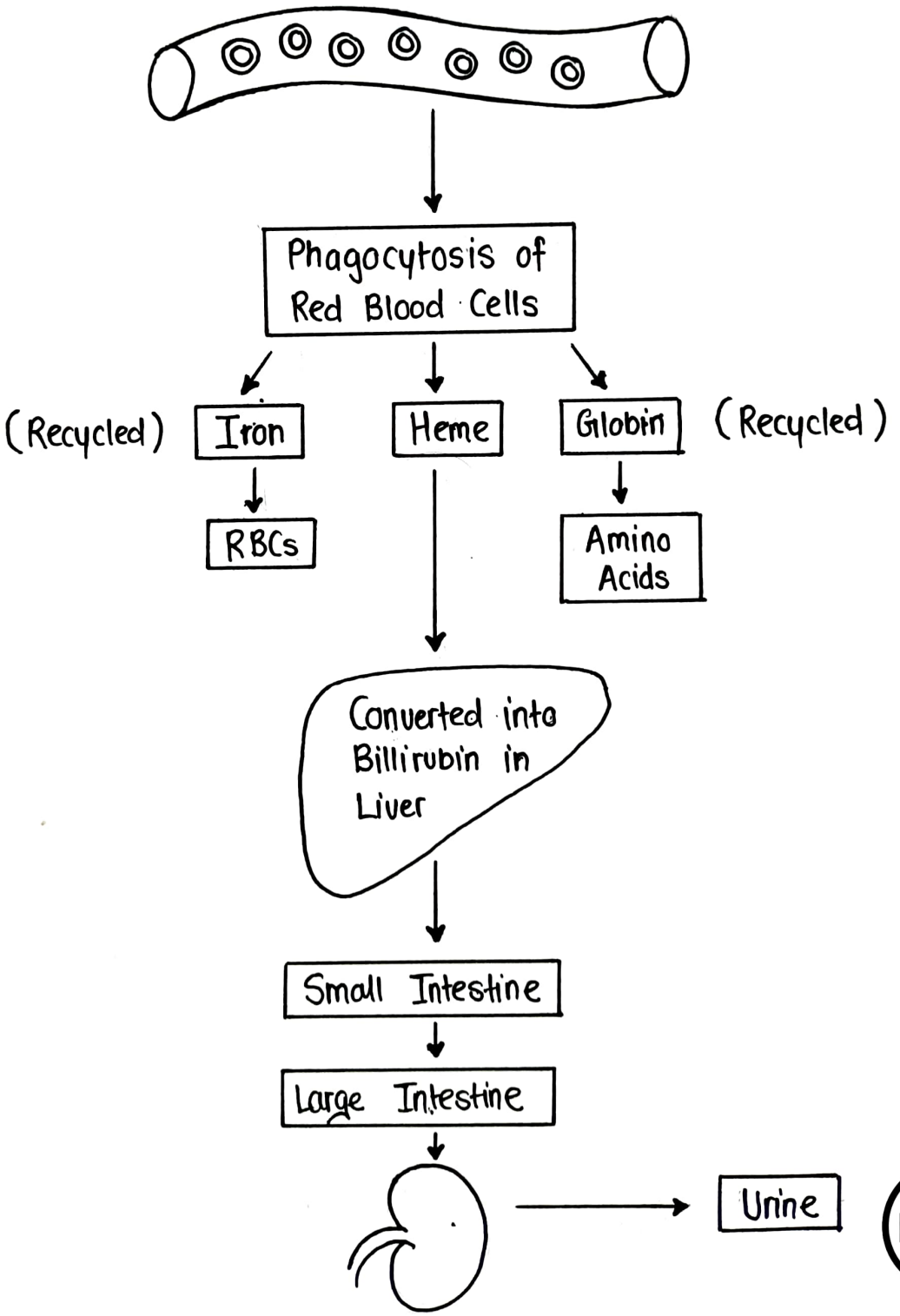
Regulation of Erythropoiesis

- Too few RBCs leads to tissue hypoxia
- Too many RBCs leads to increased blood viscosity.
- It is required to maintain a balance of RBCs production & destruction.
- Erythroprotein regulates the production of red blood cells.

- The number of red blood cells remains constant, because the bone marrow produces the red blood cells (erythrocytes) at the rate at which they are destroyed.

Destruction of Erythrocytes (Haemolysis)

- The total life span of RBCs is about 120 days and their breakdown or haemolysis carried out by phagocytic reticuloendothelial cells.
- Iron released by haemolysis is reused in the bone marrow to form haemoglobin.

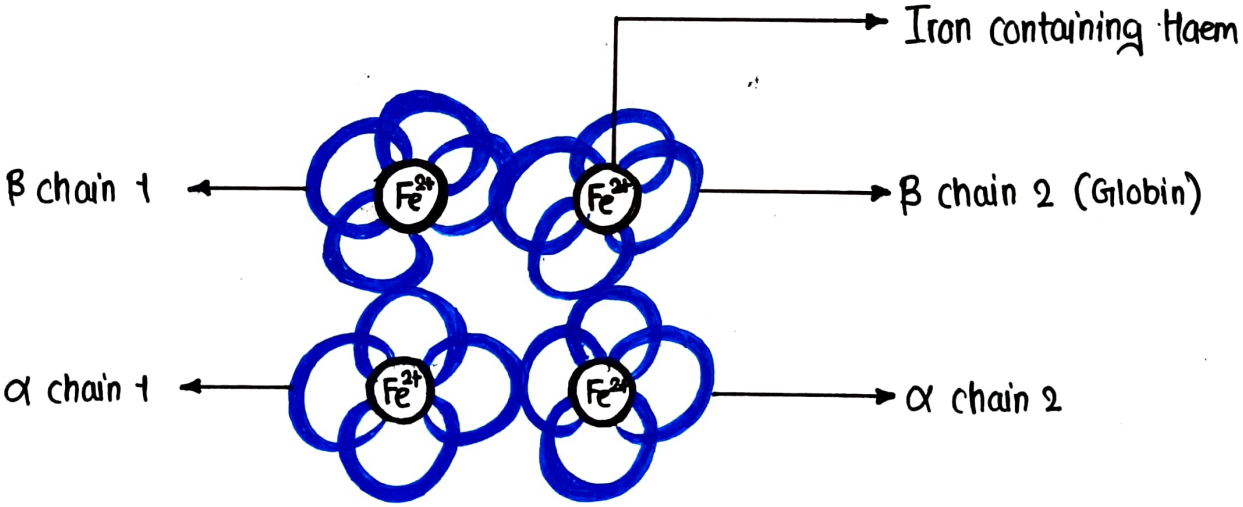


Formation Of Haemoglobin

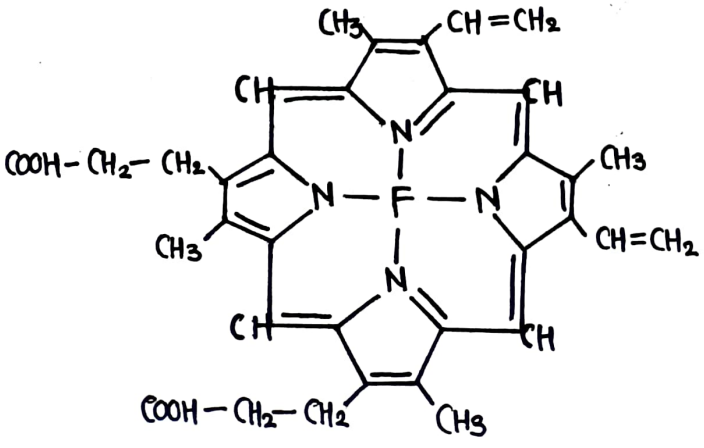
- Haemoglobin is a pigmented protein present in the RBCs of blood.
- It carries oxygen and gives red colour to RBCs
- It contains 4 Haem & 4 Globin chains.

Haemoglobin

- Globin Chains + Haem — Iron Atom — O_2
- Globin Chains + Haem — Iron Atom — O_2
- Globin Chains + Haem — Iron Atom — O_2
- Globin Chains + Haem — Iron Atom — O_2



Structure of Haem



Globin Chain

- 2 α Chain
- 2 β Chain

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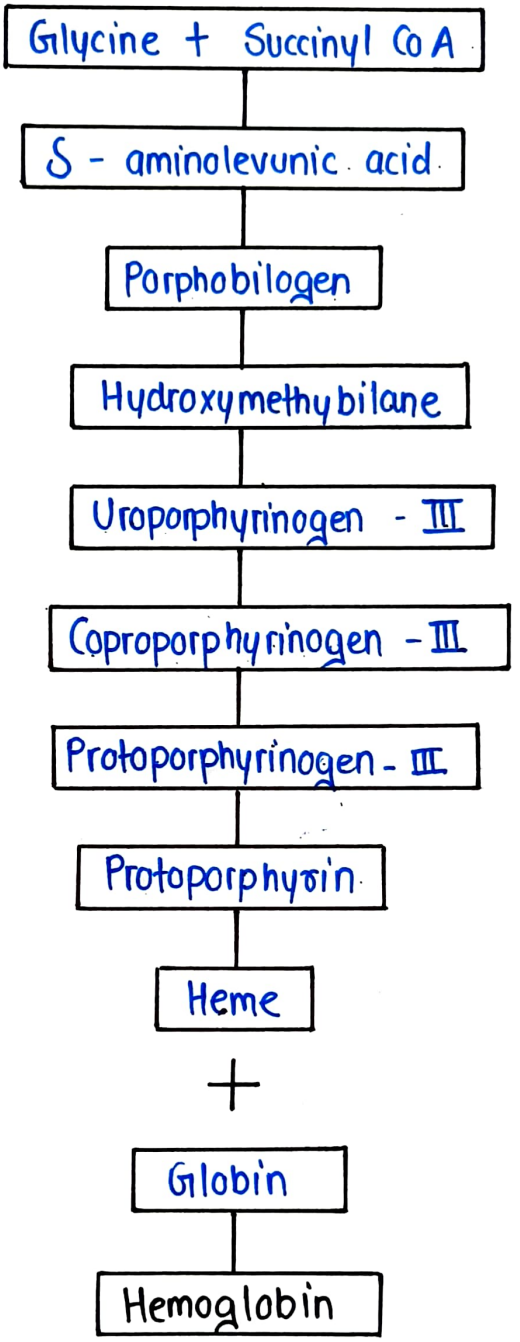
Synthesis of Haemoglobin



ANAEMIA

- Anaemia is a greek word meaning 'without blood.'
- It is simply defined as reduced haemoglobin concentration in blood due to which oxygen carrying capacity of blood decreases.

Symptoms of Anaemia

- Weakness
- Tiredness
- Pale skin
- Fast heartbeat
- Shortness of breath
- Chest Pain

Types of Anaemia

① Iron deficiency anaemia
② Aplastic Anaemia
③ Haemolytic Anaemia
④ Sickle Cell Anaemia
⑤ Pernicious Anaemia

Iron Deficiency Anaemia

- It is most common form of anaemia caused due to excessive blood loss.
- Women are at greater risk for iron deficiency anaemia due to the menstrual blood loss.
- In pregnancy, uses of iron increased due to the growth of children which also results in iron deficiency anaemia.

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Aplastic Anaemia

- Aplastic anaemia is a blood disorder in which the body's bone marrow doesn't make enough blood cells.
- Damage to the bone marrow's stem cells causes aplastic anaemia.
- It is caused due to toxins such as arsenic, benzene or due to radiations & diseases such as HIV

Haemolytic Anaemia

- Haemolytic anaemia is a condition in which red blood cells are destroyed and removed from the blood stream before their normal life span.
- It is caused due to early destructions of red blood cells or due to immune disorders and infections.

Sickle Cell Anaemia

- It is a serious anaemia im which body makes sickle (C) shaped red blood cells
- Sickle cells contain abnormal haemoglobin that causes the cell to have a sickle shape that tends to block the blood flow
- Sickle cells usually die after 10 - 20 days

Pernicious Anaemia

- Pernicious Anaemia is a condition in which the body doesn't make healthy RBCs, because it doesn't have enough vitamin B_{12}.
- In this absorbtion of Vitamin B_{12} gets decreases.

HAEMOSTASIS

- Haemostasis is also known as 'Blood Clotting' or 'Blood Coagulation'
- It is a fast series of action for the body to stop bleeding & loss of blood.
- Haemostasis occurs when blood is present outside the blood vessel.
- Haemostasis simply stands for prevention of blood loss from a broken blood vessel.
- It requires various clotting factors and chemicals released by platelets and injured tissues.

Steps of Haemostasis

- Vascular Spasm / Vasoconstriction
- Platelets Plug formation
- Blood Clotting

Vascular Spasm

- It is also known as vasoconstriction.
- It is the blood vessel's first response towards injury.
- As the name indicates in this step blood vessel gets contracted.
- The constriction of blood vessels reduces the amount of blood & limits the blood loss.
- It is a temporary response.
- It is most effective in smaller blood vessels.

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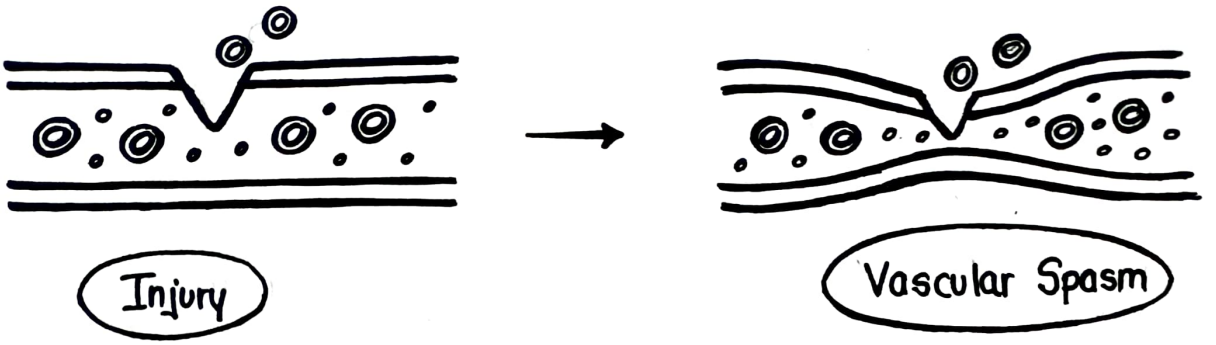
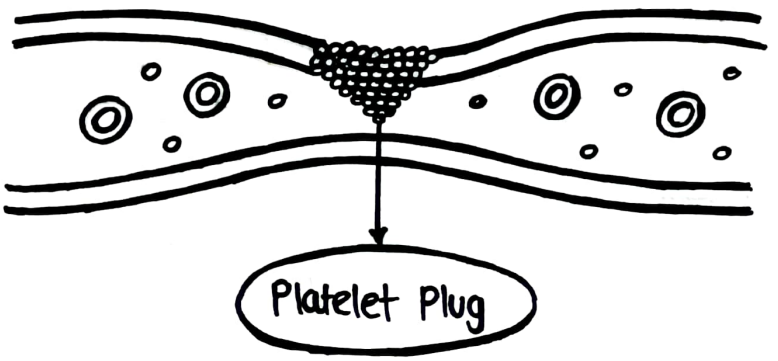


Platelet Plug Formation

- Platelets plays an important role in haemostasis process.
- In this step platelets stick together to form a plug that temporary seals the breakage in the walls of the blood vessels.
- The platelet plug formation is activated by a factor called Von Willebrand Factor (VWF)
- Platelets in the blood vessels attached with collagen fibres & become much more stickier.

- After that they release some chemical messengers such as ADP, Serotonine, Thromboxane A_2. This phase is called platelet release reaction.
- ADP cause more platelets to stick over vessels.
- Serotonine and thromboxane A_2 Enhances vascular spasm and platelet plug formation.



Blood Clotting

- It is the main and final process of blood clotting.
- It is the process by which blood clot forms.
- It is a complex procedure of enzymatic reactions in the presence of various clotting factors which results in the formation of clot over the injured blood vessels.

- It can be divided into three pathways :

① Intrinsic Pathway
② Extrinsic Pathway
③ Common Pathway

Clotting Factors

NUMBER	FACTOR NAME
I	Fibrinogen
II	Prothrombin
III	Tissue Factor (Thromboplastin)
IV	Calcium Ions
V	Proaccelerin / Labile Factor
VII	Proconvertin / Stable Factor
VIII	Antihaemophilic Factor A
IX	Christmas Factor / Antihaemophilic Factor B
X	Stuart Factor / Prower Factor
XI	Plasma Thromboplastin / Antihaemophilic Factor C
XII	Hageman Factor
XIII	Fibrin stabilizing Factor

- Clotting factors always written in roman numbers.
- Factor VI is not in the existence

Intrinsic Pathway

- This is a complex pathway & occurs slowly.
- This pathway occurs due to blood trauma.
- In this pathway when blood vessel gets injured, then endothelial tissue inside blood vessel also gets damaged and blood comes in direct contact with collagen fibres of connective tissue present around the endothelial tissue.
- Now damage to the endothelial tissue cause damage to platelets which results in the release of phospholipids by platelets.

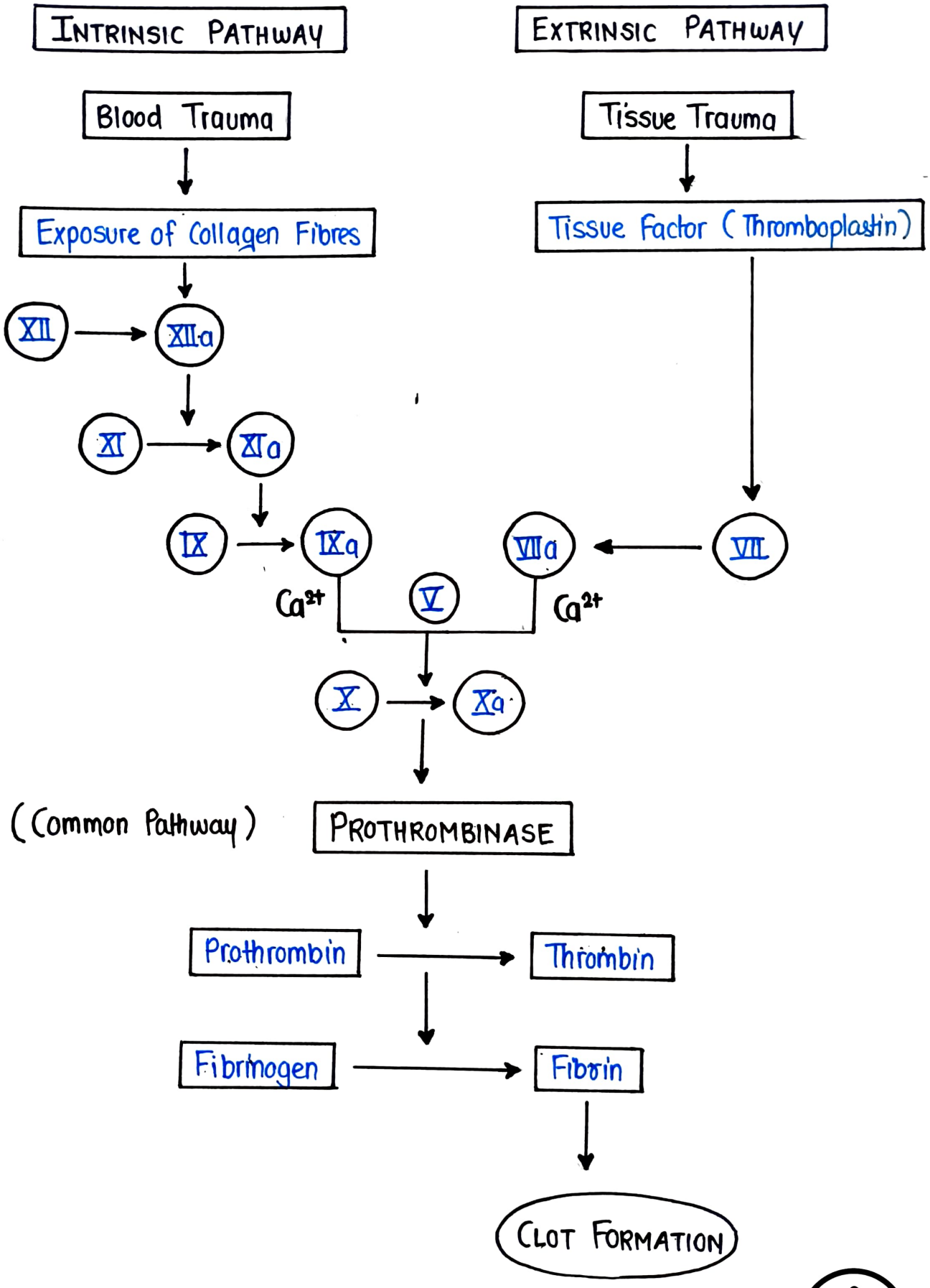
- Now all these events activates clotting factor XII which ultimately activates factor X in the presence of Ca^{2+} ions.
- Once factor X is activated, it combines with factor V & activate enzyme Prothrombinase.

Extrinsic Pathway

- It is a simple pathway & occurs rapidly
- This pathway occurs due to tissue trauma.
- In this pathway tissue factor (Thromboplastin) activates factor VII which ultimately activates factor X in the presence of Ca^{2+} ions.
- Once factor X is activated, it combines with factor V & activates enzyme Prothrombinase.

Common Pathway

- In common pathway enzyme prothrombinase converts Prothrombin into Thrombin.
- In final stage thrombin converts Fibrinogen into Fibrins in the presence of Ca^{2+} that forms clot over the damaged blood vessels.


INTRINSIC PATHWAY
EXTRINSIC PATHWAY
Blood Trauma
Tissue Trauma
Exposure of Collagen Fibres
Tissue Factor (Thromboplastin)
XII
XIIa
XI
XIa
IX
IXa
VIIIa
VII
Ca2+
V
Ca2+
X
Xa
(Common Pathway)
PROTHROMBINASE
Prothrombin
Thrombin
Fibrinogen
Fibrin
CLOT FORMATION

BLOOD GROUPS

- A blood group is a type of classification of blood, based on the presence and absence of various antigens & antibodies.
- The antigens presents on the surface of Red blood Cells
- These antigens may be proteins, carbohydrates, glycoproteins etc.

Types of Blood Group Systems

There are two main blood group systems

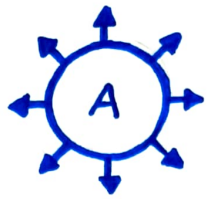
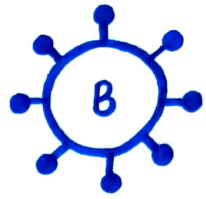
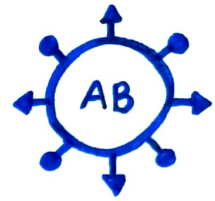
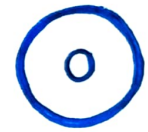
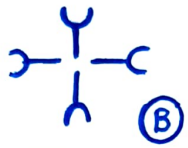
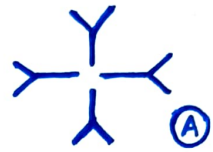
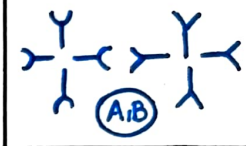
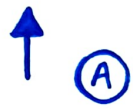
① ABO System
② Rh System

ABO SYSTEM

- The ABO System is the most important blood group system in human blood transfusion.
- Karl Landsteiner discovered the ABO blood group system in 1901.
- Adriano Sturli & Alfred Von Decastello who worked under Landsteiner discovered type AB in 1902.

Basics of ABO System

- Based on the presence and absence of antigen A and antigen B blood is divided into 4 groups.
- A, B, AB and O group.

	Group A	Group B	Group AB	Group O
Red Blood Cell Type				
Antibodies			None	
Antigens				None
Donor's Group	A, O	B, O	A, B, AB, O	O

Blood Group A

- RBCs of this blood group contains A- Antigens.
- These blood groups contains B- Antibodies.
- Can receive blood from Group A and O
- Can donate blood to Group A and AB

Blood Group B

- RBCs of this blood group contains B- Antigens.
- These blood groups contain A- Antibodies.
- Can receive blood from Group B and O
- Can donate blood to Group B and AB

LYMPHATIC SYSTEM

- A lymphatic system is a network of tissues, organs and vessels that help to maintain the body's fluid balance and protect it from viruses and bacterias.
- The lymphatic system is mainly consist of a clear watery fluid, called Lymph.
- The lymphatic system is an important part of circulatory system as well as Immune system. Without it neither the circulatory nor the immune system will work.
- The lymph travels only in one direction, it doesn't circulate.

Functions of Lymphatic System :

① Return Fluid from Tissues to Blood

In the daily basis approx 3 litres of fluid loss from blood capillaries that is absorbed / collected in the lymphatic vessels and again transferred into the blood.

② Absorb and Transport Fats & Large Molecules

Special lymphatic capillaries called lacteals in villi of small intestine absorb all lipids and fat soluble vitamins and also lymphatic capillaries collected 25-50% of blood proteins leak from blood capillaries.

③ Body Defense / Immunity

Lymphatic system is an important component of immune system. It contains WBCs that destroys bacteria and viruses.

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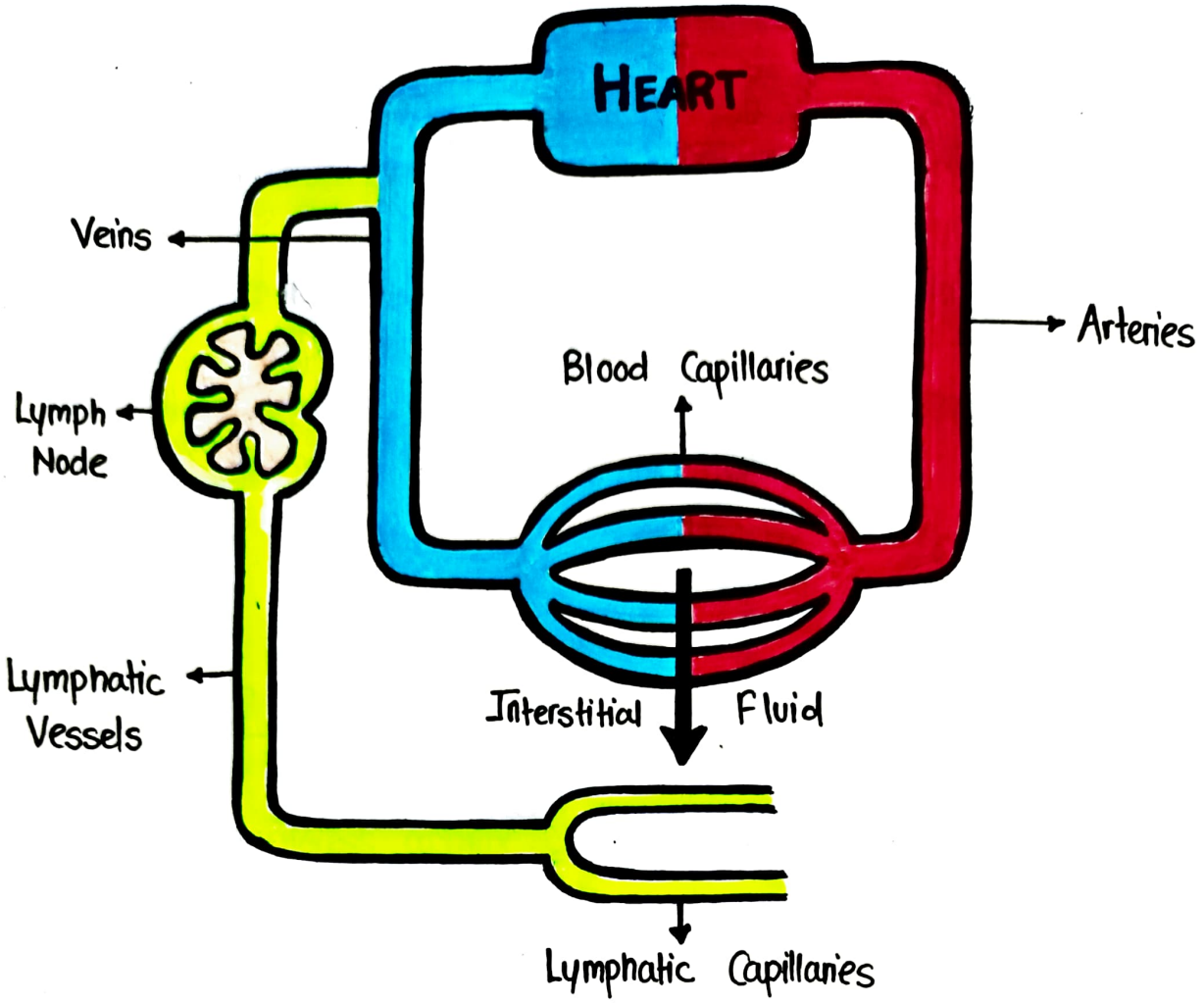


Parts of Lymphatic System

- Lymph
- Lymphatic Vessels
- Lymph Nodes
- Tonsils
- Spleen
- Thymus Gland

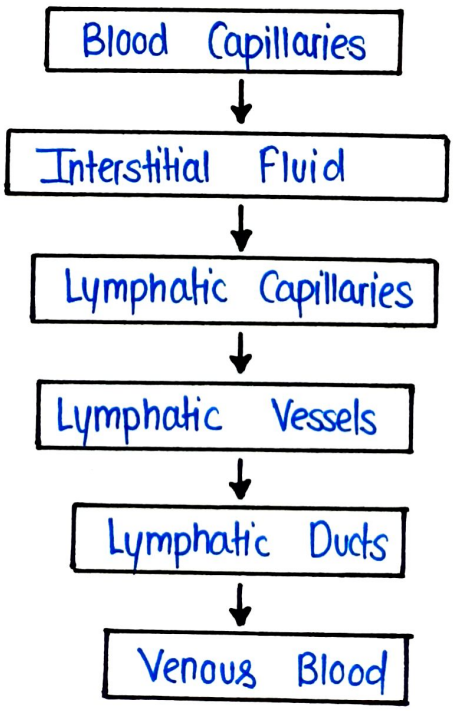
Lymph

- Lymph is a clear watery fluid that flows through the lymphatic vessels.
- The composition of lymph is similar to plasma.
- It mainly contains water (95%) and WBCs specially Lymphocytes, plasma proteins, fat, lipids etc.
- Generally lymph is colourless, but in small intestine large amount of fat gets absorbed into the lymph, which gives lymph a milky appearance.

Formation of Lymph

Approx As we know that blood circulates through the body but during this process approx 3 litres of fluid drains out from blood capillaries that is collected into a vessel called as lymphatic vessels and this excess 3 litres fluid is called Lymph.

Flow of Lymph

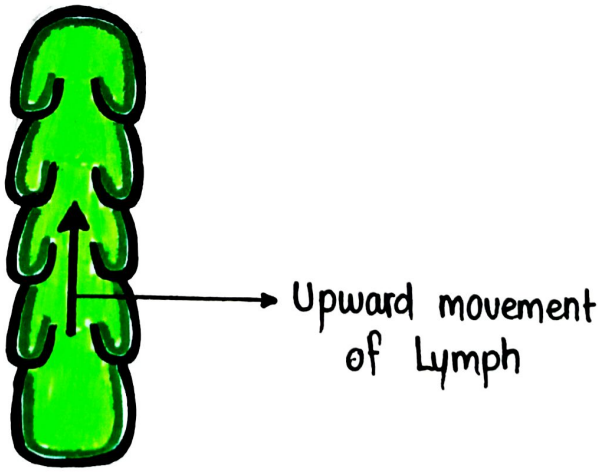


LYMPHATIC VESSELS

- Lymph vessels are thin walled, valved structures that carry lymph.
- Structurally they are similar to blood vessels.
- Lymphatic vessels begin as lymphatic capillaries which joins up to form lymphatic vessels.
- Now, these lymph vessels joins together to form two larger ducts:

① The right lymphatic duct
② The thoracic duct (left lymphatic duct)

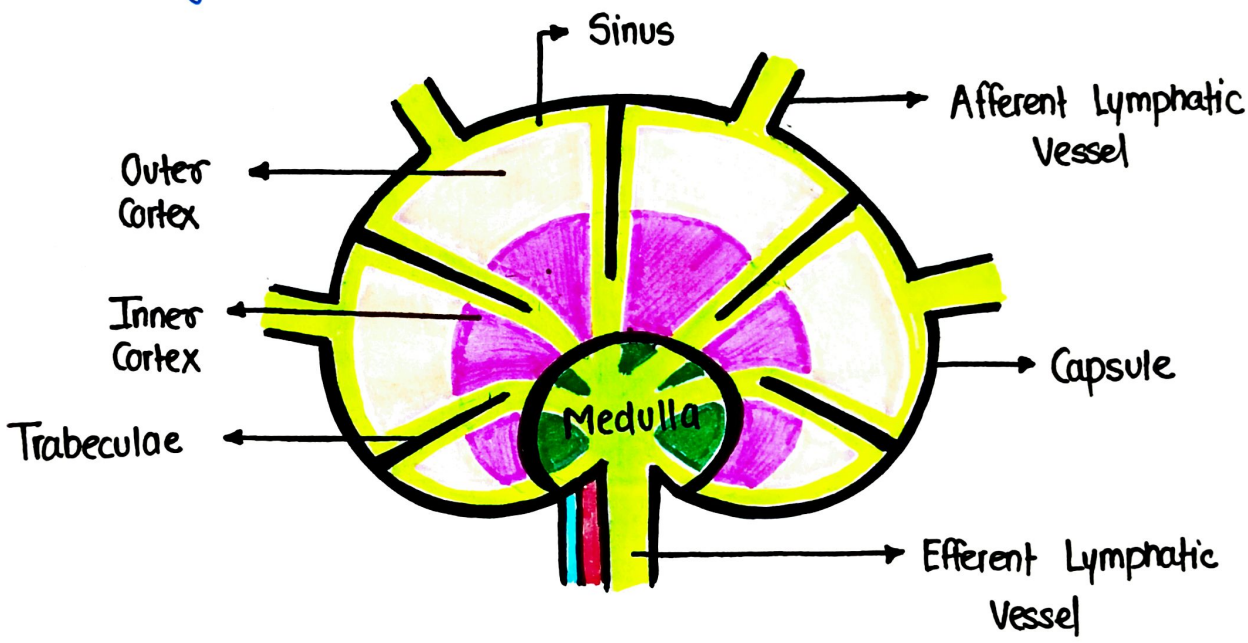
- The wall of lymphatic vessels is made up of endothelial tissue.
- In small intestine, a specialized lymphatic capillaries present called as Lacteals which absorbs fats and lipids.
- Lymphatic vessels contains lymph nodes.
- Lymphatic vessels found in all tissues and organs of the body except the central nervous system, internal ear, epidermis layer, bones, teeth and cartilage etc.



Lymphatic Vessel

Lymph Nodes

- A lymph node is a small oval or bean shaped organ present along the lymphatic vessels.
- It filters lymph before it is return into the blood.
- They are greyish pink in colour
- There are approxiamately 500- 600 lymph nodes in human body.
- These nodes vary in size : Some are as small as pin head & some are as large as an almond.



Structure of Lymph Nodes

- It's structure is bean or kidney shaped
- It's length vary from 1- 25 mm.
- There are five majos parts in the structure of lymph node

① Afferent lymphatic vessel
② Capsule
③ Cortex
④ Medulla
⑤ Efferent lymphatic vessel

Afferent Vessel : These are the lymphatic vessels through which lymph enters into the lymph nodes.

Capsule : It is the outer covering of lymph nodes

Cortex : It is the upper part inside the lymph nodes contains mainly lymphocytes & macrophages & further divided into 2 parts.
Outer Cortex
Inner Cortex

Medulla : It is the inner part inside the lymph node contains mainly B- lymphocytes, plasma cells and macrophages

Efferent Vessel : These are the lymphatic vessels that carries lymph away from the lymph node.

Special Characteristics of lymph nodes

- The lymph node is the only lymphoid organ present in the path of lymphatic vessels.
- The only lymphoid organ having afferent & efferent lymphatic vessels.
- The only organ that filters the lymph.

Functions of Lymph Nodes

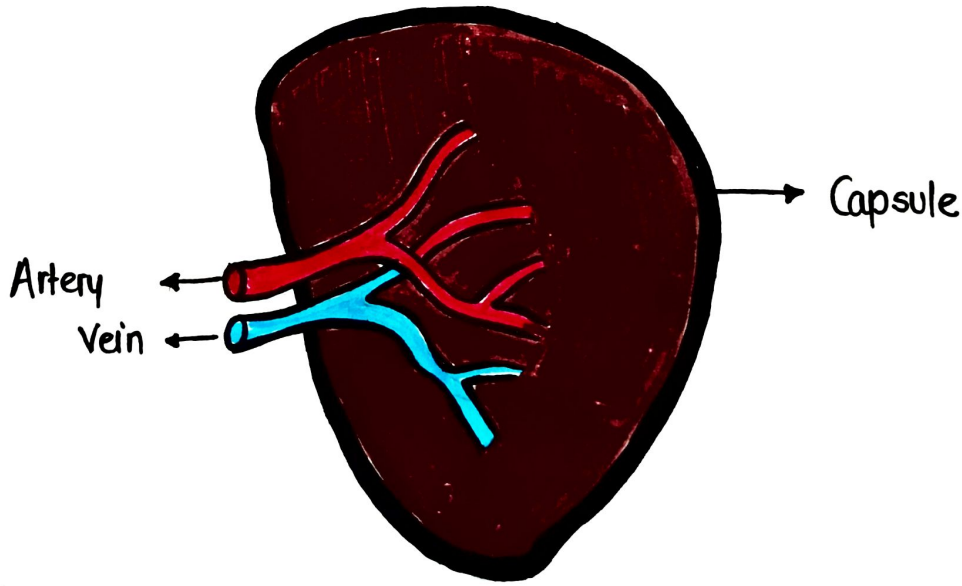
- The lymph node filters the foreign substance from the lymph.
- The lymph node contains B & T lymphocytes (WBCs) which help in the defense mechanism.
- They also helps in the production of plasma proteins like globulin.
- They contain macrophages that destroys the foreign substances by phagocytosis.

SPLEEN

- Spleen is the largest lymphatic organ.
- It is slightly oval in shape
- It is located below the diaphragm behind the stomach
- It mainly contains lymphocytes, monocytes and neutrophills

Functions

- It plays an important role in phagocytosis of bacteria, damaged RBCs and platelets.
- It helps in the formation of blood before birth.
- It stores and releases blood in times of demand.
- The spleen contains B and T lymphocytes which helps to produce antibodies.



Spleen

THANK YOU

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