# Blood

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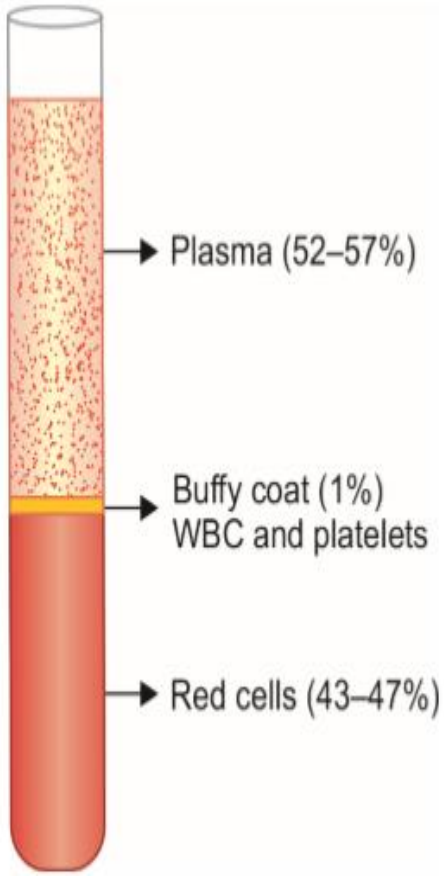
# Objectives

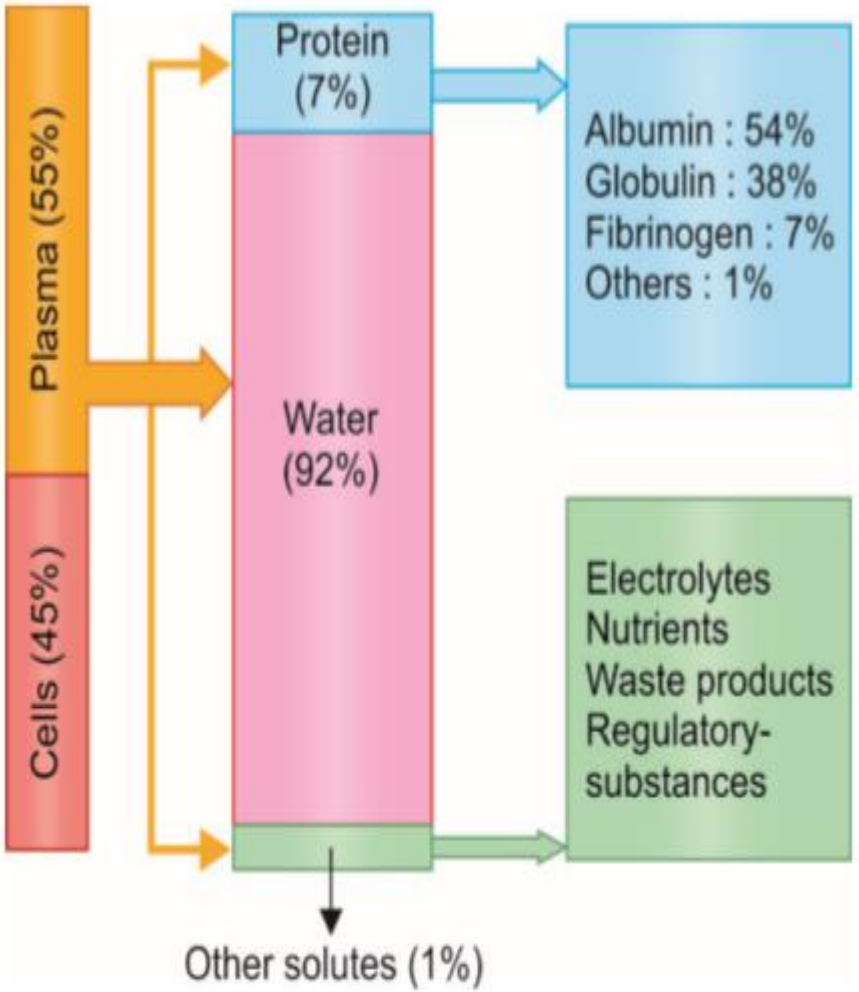
- To define blood
- To discuss composition of blood
- To describe the formation and life span of blood cells ( RBC, WBC and platelets)
- To understand destruction of Red Blood Cell

# Blood

- Liquid connective tissue
- Fills heart and blood vessels
- Red colour
- 5 L in adult
- 7.4 pH
- Specific gravity 1.052 to 1.061
- 5 times more viscous than water

# Composition of Blood



# Plasma Proteins

- Normal values of the plasma proteins are:
- Total proteins : 7.3 g/dL (6.4 to 8.3 g/dL)

I. Serum albumin : 4.7 g/dL
II. Serum globulin : 2.3 g/dL
III. Fibrinogen : 0.3 g/dL

Molecular weights:

- Albumin : 69,000
- Globulin : 1,56,000
- Fibrinogen : 4,00,000

# Functions of Plasma Protein

- Osmotic pressure: Osmotic pressure of plasma due to plasma proteins is called oncotic pressure.

- Immunity: Antibodies are plasma proteins. Antibodies mediate humoral immunity that protects the body from infections.

- Buffering: Plasma proteins form an important buffering system of the body called protein buffers.

- Transport: Plasma proteins serve as carrier molecule for transport of various substances like hormones, drugs, minerals, etc.

# Function Contd…

- Coagulation: Blood clotting depends on concentration of fibrinogen that forms fibrin thread, the final step in blood coagulation. Also, other clotting factors like prothrombin are plasma proteins.

- Viscosity: Plasma protein contributes to about 50% of the viscosity of blood.

- Protein store: Plasma proteins serve as mobile protein reserve of the body, which can be utilized for tissue growth, especially in situations of protein depletion.

# Functions of blood

- 1. Respiratory functions
- 2. Transport medium
- 3. Temperature regulation
- 4. Excretory function
- 5. Acid-base balance
- 6. Immunity
- 7. Storage
- 8. Body color
- 9. Nutritive functions:
- 10. Oncotic pressure

# Hemopoiesis

- Red bone marrow is the site of normal hemopoiesis after birth.
- During fetal life, hemopoiesis mainly occurs in the yolk sac ( till 2 months),spleen and liver(3$^{rd}$ month), and subsequently in red bone marrow ( 20$^{th}$ week)present in the medullary cavity of all bones.
- From childhood, red marrow is progressively replaced by fat tissues (yellow marrow). Therefore, normal hemopoiesis in adults is restricted to vertebrae, sternum, ribs, clavicles, pelvic bones, skull and ends of humerus and femurs.

# Hemopoiesis

- Red bone marrow is the site of normal hemopoiesis after birth.
- Pluripotential hematopoietic stem cells(PHSC) : Undifferentiated cells that are capable of giving rise to any of the precursor of different blood cells
- When the cells (PHSC) divide ,they either remain pluripotential cell or become committed stem cells
- Different types of blood cell follow separate lines of development. The process of blood cell formation is called haemopoiesis

# Hemopoiesis

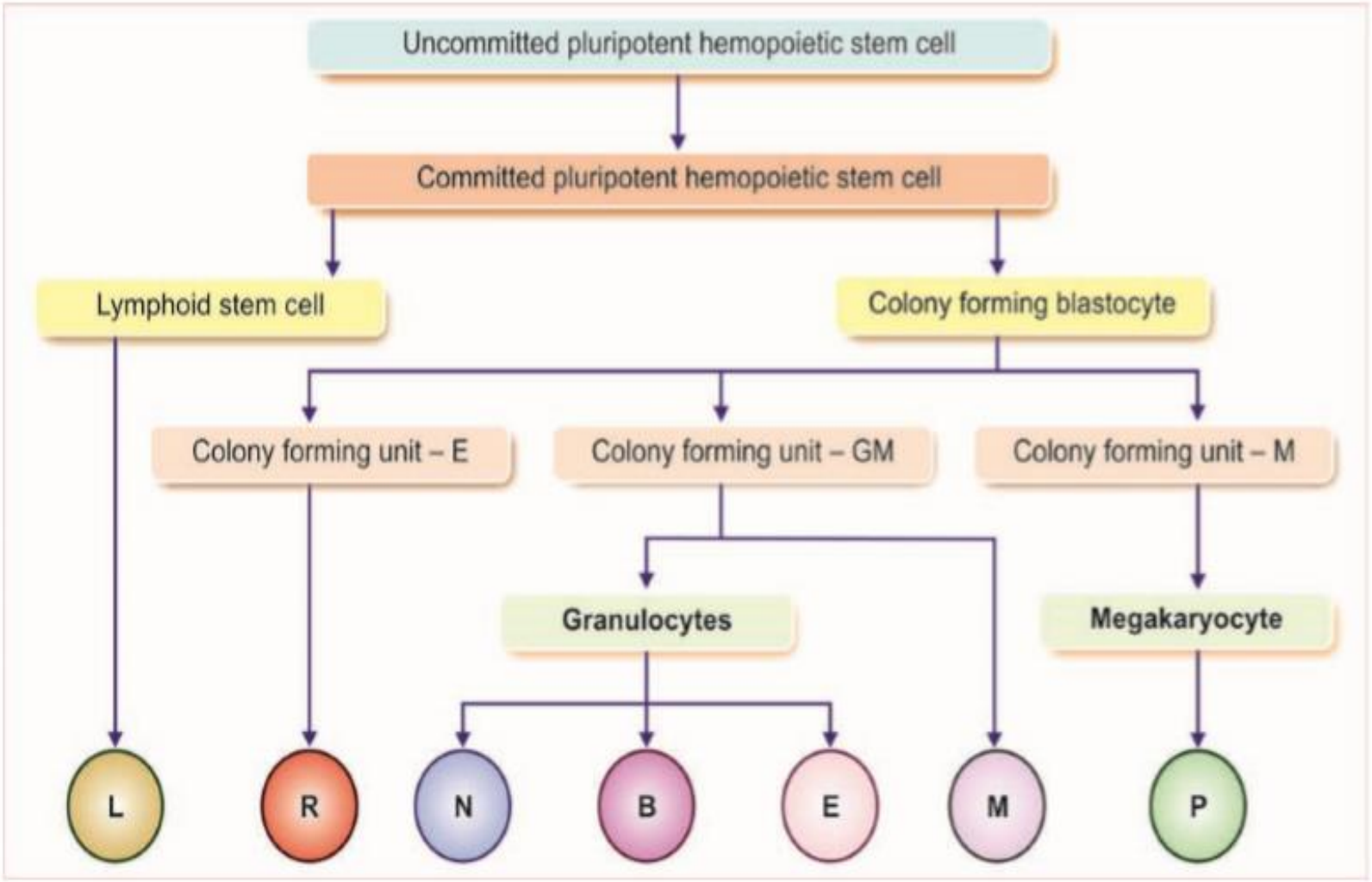
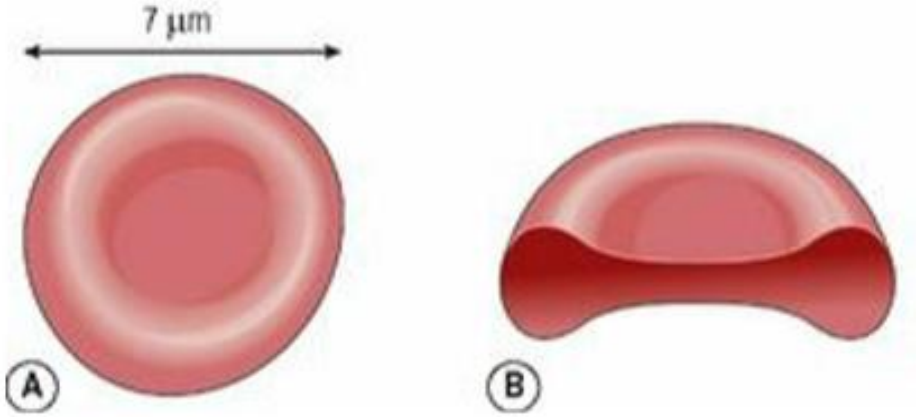



**FIGURE 10.1:** Stem cells. L = Lymphocyte, R = Red blood cell, N = Neutrophil, B = Basophil, E = Eosinophil, M = Monocyte, P = Platelet.

# Red Blood Cells (RBC) / Erythrocytes

- Non Nucleated
- Erythrocytes
- 4-5.5 million / $mm^3$

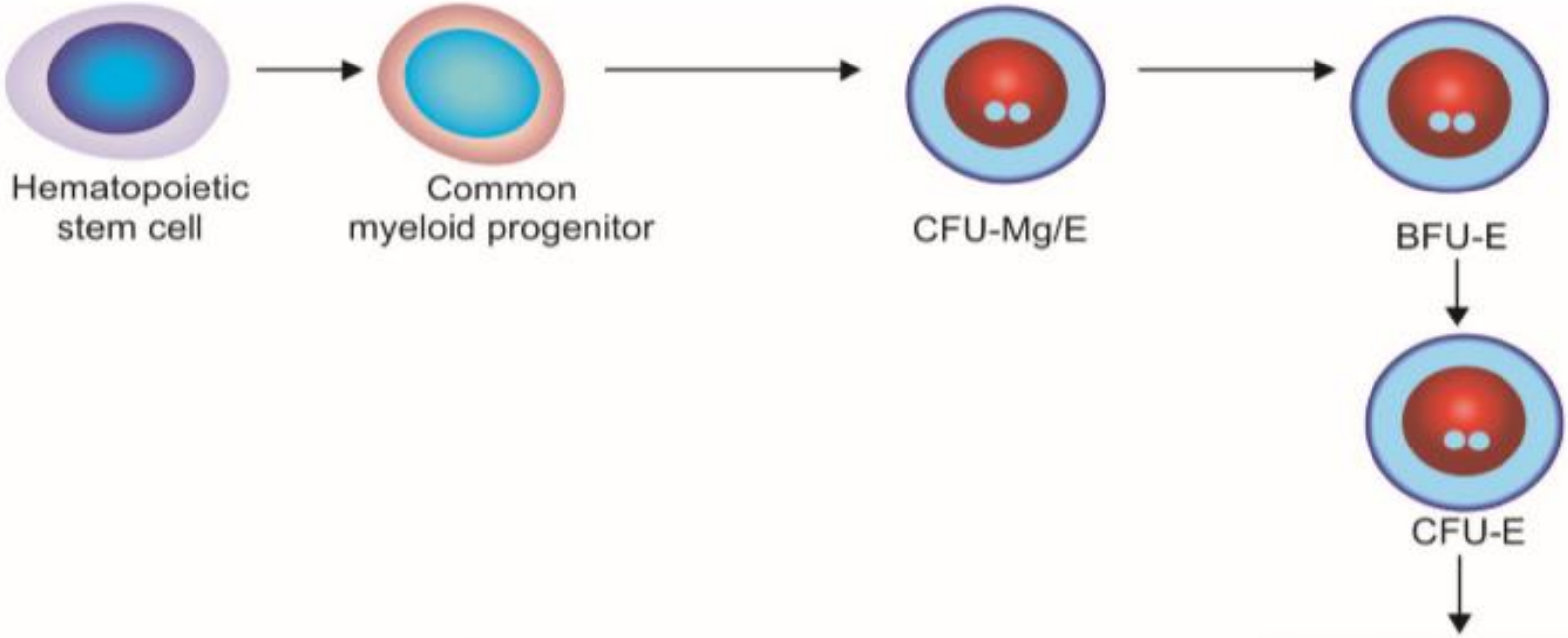



- Diameter : 7.2 µm (6.9 to 7.4 µm).
- Thickness : At the periphery it is thicker with 2.2 µm and at the center it is thinner with 1 µm
- Surface area : 140 µm2
- Volume : 87 µm3 (78 to 94 µm3)
- Life span 120 days

# Erythropoiesis

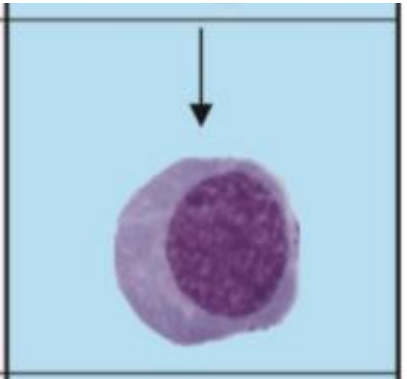
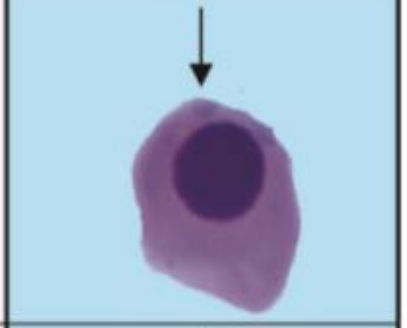
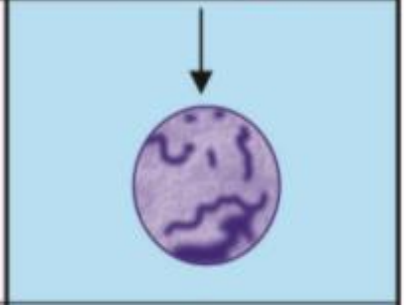
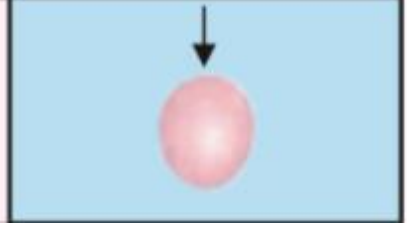
- The process of development of red blood cells from stem cells takes about 7 days and is called erythropoiesis
- The immature cells are released into the bloodstream as reticulocytes, and then mature into erythrocytes over a day or two within the circulation.
- During this time, they lose their nucleus and therefore become incapable of division

# Erythropoiesis




| Morphological features | | |
|---|---|---|
| Shape: | Round | Pronormoblast |
| Size: | 15–20 μm | |
| Cytoplasm: | Dark basophilic cytoplasm | |
| Nucleus: | Central nucleus with slightly clumped chromatin, 2–5 nucleoli | |
| Shape: | Round | Basophilic (early) normoblast |
| Size: | 12–18 μm | |
| Cytoplasm: | Less basophilic than pronormoblast | |
| Nucleus: | Coarse chromatin, nucleoli not seen | |

# Erythropoiesis

| | | |
|---|---|---|
| Shape: Round<br>Size: 10–15 μm<br>Cytoplasm: Polychromatic due to hemoglobinization of cytoplasm<br>Nucleus: Deep staining and coarse chromatin, no nucleoli | Polychromatic (intermediate) normoblast |  |
| Shape: Round<br>Size: 7–12 μm<br>Cytoplasm: Well hemoglobinized cytoplasm<br>Nucleus: Begins to condense and becomes pyknotic, eccentric or partially extruded | Orthochromatic (late) normoblast |  |
| Cells stain bluish and are larger than normal red cells<br>Demonstrated by supravital staining (brilliant cresyl blue or new methylene blue) | Reticulocyte |  |
| Normal RBC is biconcave disc 7–7.7 μm in diameter | Red blood cell |  |

# Factors controlling erythropoiesis

**A. Hormonal factors**

1. Erythropoietin
2. Androgens
3. Estrogen
4. Thyroxine
5. Anterior pituitary hormones
   - Growth hormone
   - TSH, ACTH, LH, FSH, Prolactin
6. Corticosteroid
7. Interleukins

**B. Dietary factors**

1. Vitamins (vitamin $B_{12}$, folic acid, vitamin C)
2. Proteins
3. Minerals (iron, copper, cobalt and nickel)

**C. Other factors**

1. Intrinsic factor
2. Chemical factor
3. Environmental factor (hypoxia)
4. Drugs

# Destruction of RBC

A) Intravascular Destruction

RBCs are destroyed in the circulation when their cell membrane is breached.

B) Extravascular Destruction

Macrophages differentiate young and senescent red cells. They ingest older red cells.

- 1. Decreased deformability
- 2. Alteration in surface properties.

# Fate of Destroyed Red Cells

A) Fate in Intravascular Destruction

- In plasma, Hb binds with haptoglobin
- Heme of Hb is converted into iron and biliverdin by heme oxygenase in liver.
- Biliverdin → Bilirubin
- Heme in plasma→Hemopexin

Albumin ( Methemalbumin)

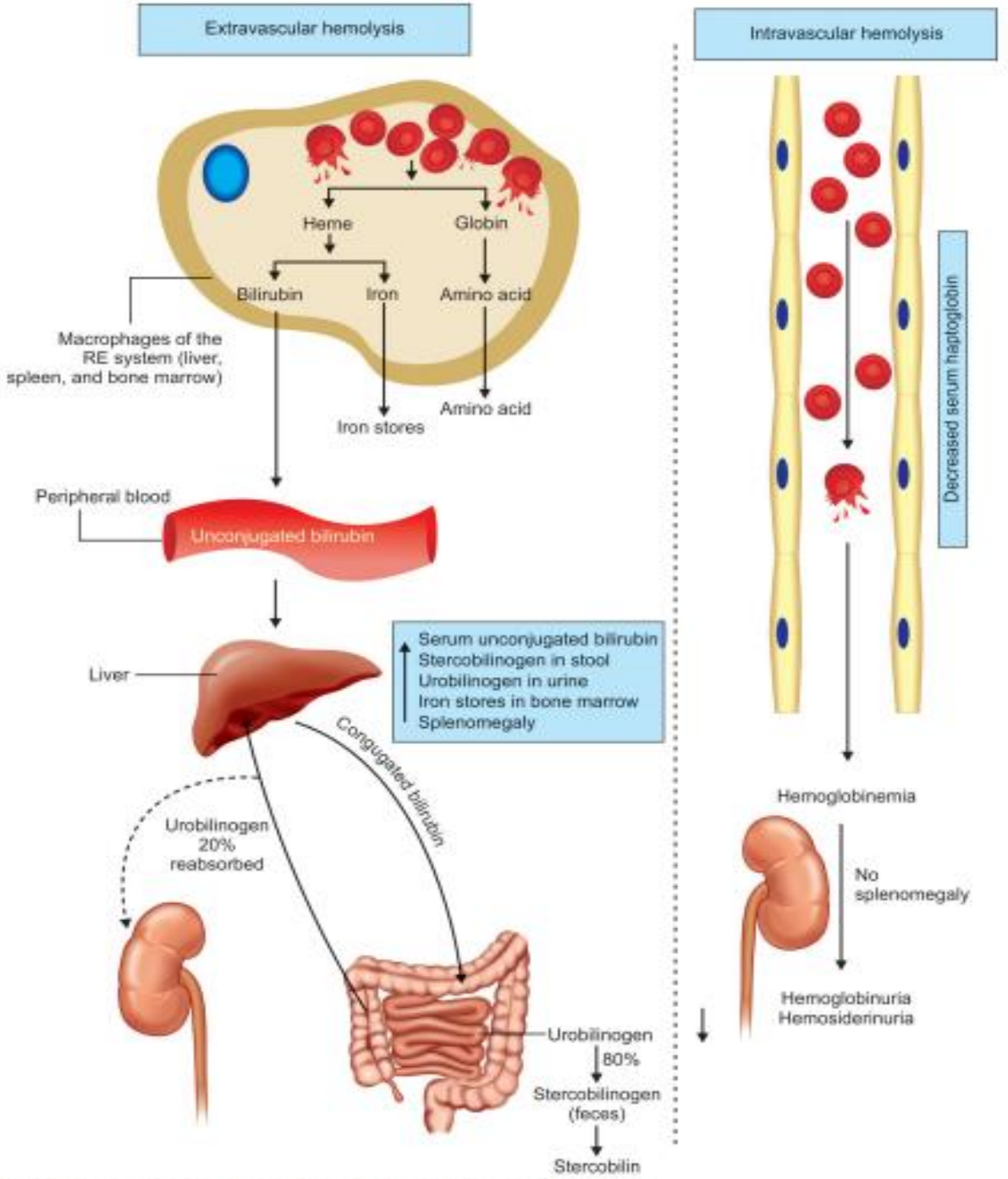



**Fig. 13.1:** Mechanism and consequences of extravascular and intravascular hemolysis.

# Fate of Destroyed Red Cells Contd…

B) Fate in Extravascular Destruction

Red cells -→ lipids, protein and heme.

Heme is catabolized to bilirubin, and

protein and lipids are reprocessed in their catabolic pathways.

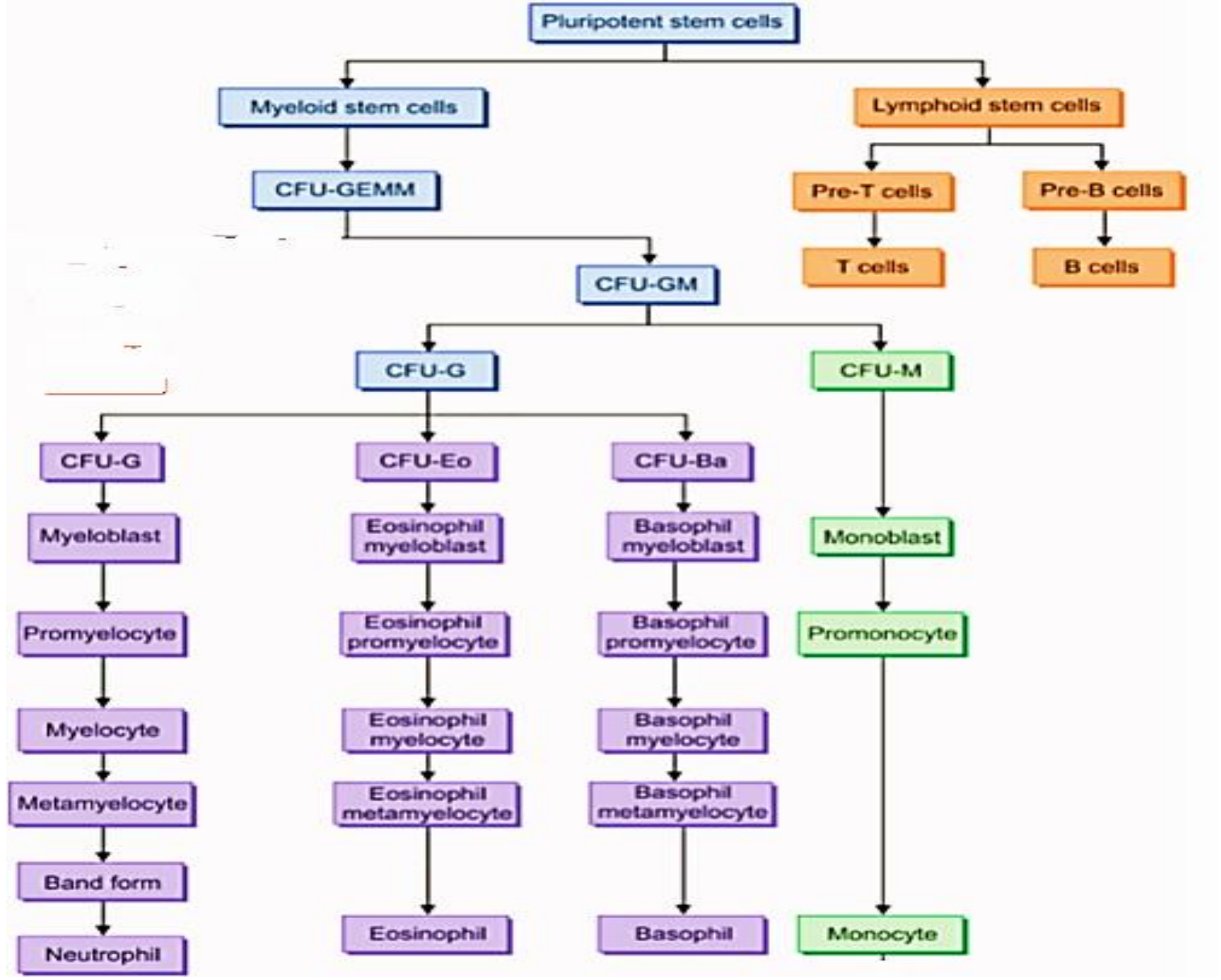
1. Bilirubin (through bile)-→ GI tract. In the intestine, bilirubin -→ urobilinogen by bacterial reduction. Urobilinogen → stercobilinogen and stercobilin
2. A small fraction of urobilinogen is excreted through urine as urinary urobilinogen

# White Blood Cells (WBC) / Leukocytes

- Colourless
- Nucleated cells
- Adults - 4,000-11,000/$mm^3$ of blood
- At birth – 10,000-25,000/$mm^3$ of blood
- Formed partly in bone marrow and partly in lymph tissue

| Granulocytes | Agranulocytes |
|---|---|
| Neutrophil | Monocyte |
| Eosinophil | Lymphocyte |
| Basophil | |

# Leucopoiesis

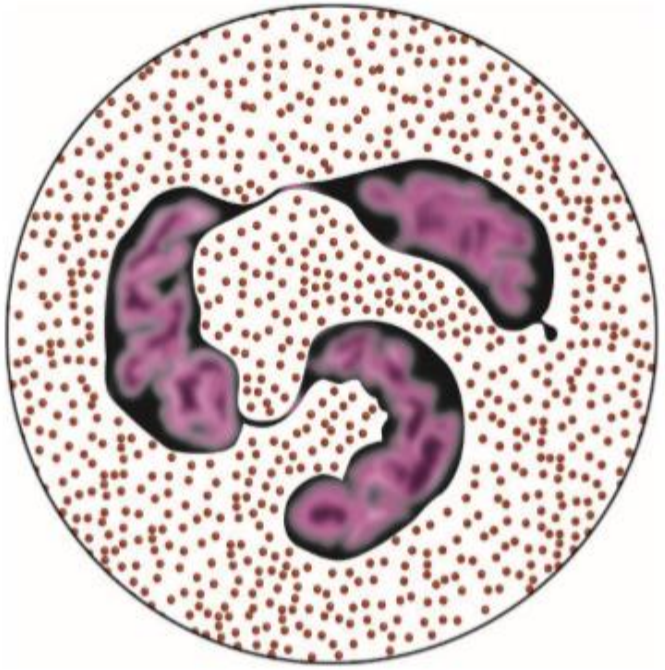


# Neutrophil

- Structure:
  - 10-12 μm in diameter
  - Cytoplasm contains fine pink coloured granules
  - Multilobed (4-6) nucleus connected by thin strand

- Functions
  - Phagocytosis
  - Inflammation conditions

- Count :50% – 70 %
- Life span : 10-12 days



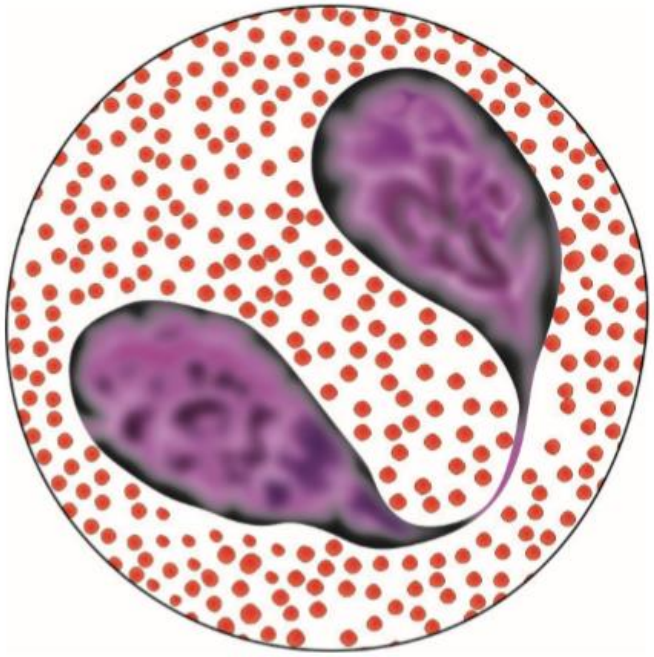
Structure of neutrophil. Note the presence of fine granules in the cytoplasm, and thin strand separating nuclear lobes.

# Eosinophil

- Structure
  - 10-12 μm in diameter
  - Granules are coarse and brick red in color in blood smear stained by Leishman stain.
  - Nucleus is usually bilobed and the lobes are separated by a thick strand.

- Functions
  - Against helminthic infection
  - Against allergic reaction

- Count :2% - 4%
- Life span : 7 to 12 days

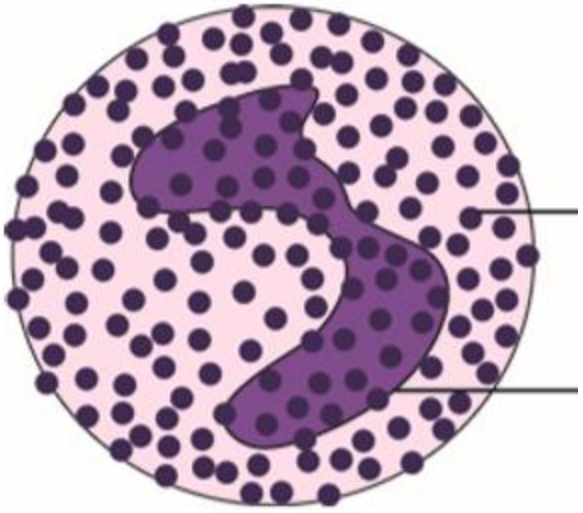


Structure of eosinophil. Note the presence of brick red coarse granules in the cytoplasm, and spectacular nuclear lobes.

# Basophil

- Structure
  - 10-12 μm in diameter
  - Nucleus is irregular with bi-lobed or tri-lobed
  - Cytoplasm is blue with coarse deep purple granules covering the nucleus

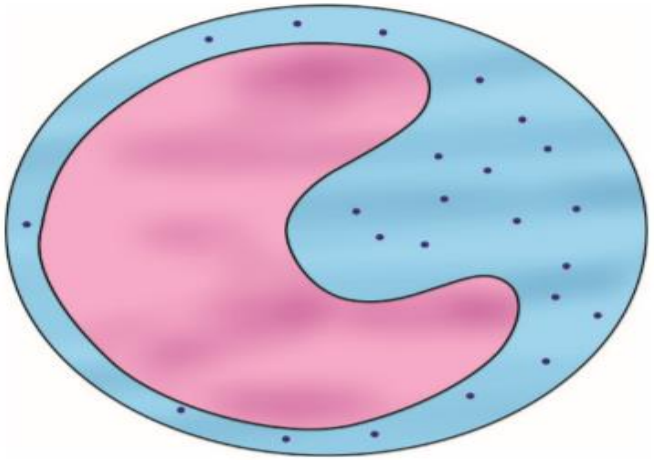
- Functions
  - Mild phagocytosis
  - Role in allergic reaction
  - Role in release of heparin



Structure of basophil.

- Count : 0% - 1%
- Life span : 12- 15 days

# Monocyte



Structure of monocyte.

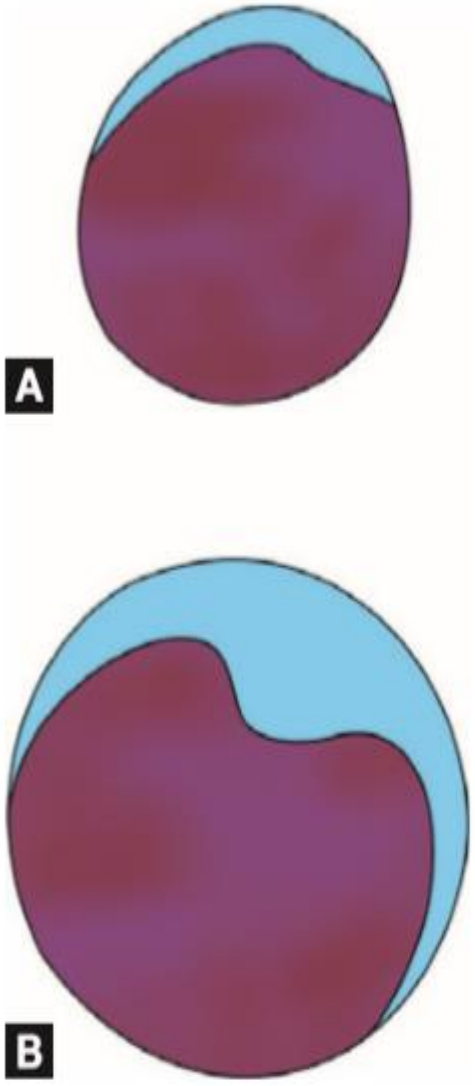
- Monoblast – similar to myeloblast
- Promonocyte –
  - 20µm in diameter.
  - Nucleus is large ,kidney shaped
  - Cytoplasm is basophilic , fine granules
- Monocyte –
  - 12-20µm diameter
  - Nucleus- large, single, eccentric, notched or indented
  - Cytoplasm –abundant ,pale blue ,clear
- Functions
  - Phagocytosis
  - Synthesis of cytokines
- Count : 2% - 6%
- Life span : 2 to 5 days

# Lymphocytes

- Lymphoblast
  - ✓ Resembles myeloblast except for nuclear membrane is dense and nuclear chromatin is clumped
- Prolymphocyte
  - ✓Diameter 9-18μm
  - ✓Nucleus round to indented, with coarse chromatin
  - ✓Cytoplasm is non granular
- Lymphocytes
- Structure
  - Large lymphocyte is 12-16 μm and small is 7-10 μm in diameter
  - Has large round single nucleus which completely fills the cell
  - Cytoplasm is scanty and light blue in color

# Lymphocytes

- Functions
  - Plays important role in immunity

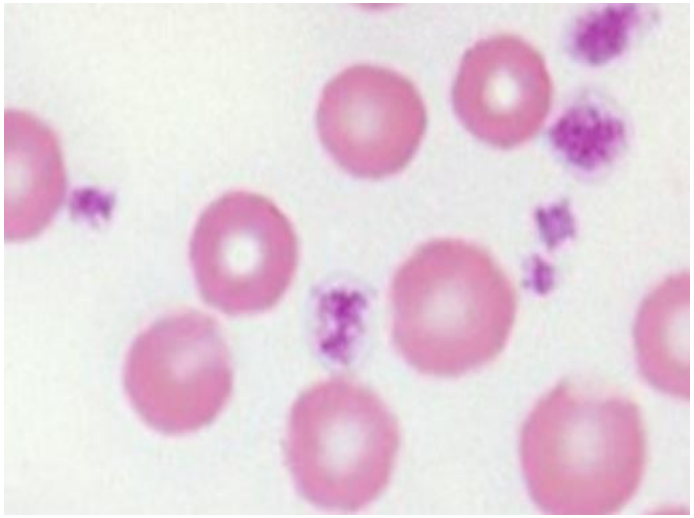



- Lymphocytes in the bone marrow mature into B cells
- They leave for the thymus gland, where they mature into T cells.

- Count : 20%- 30%
- Life span : 1 day

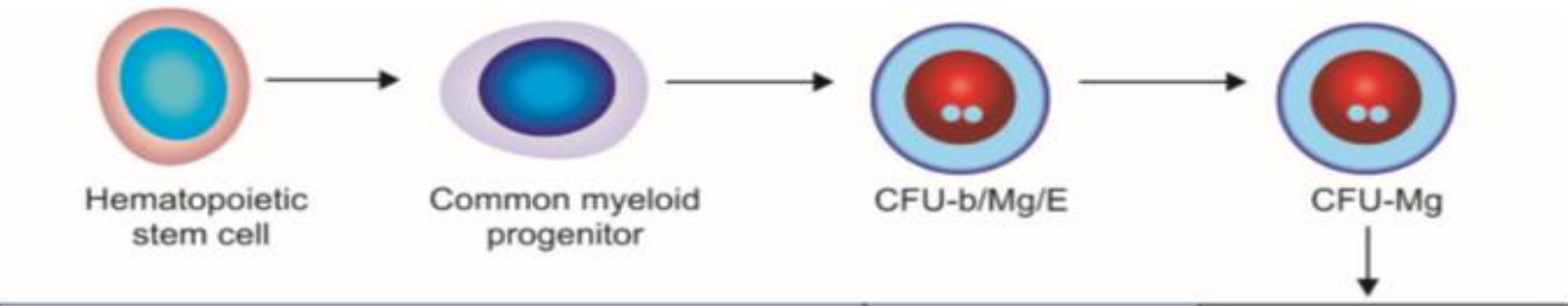
# Platelets

- Anucleated , Colourless
- Small, granulated, spherical, or oval bodies
- 2-4 μm in diameter
- Life span : 10 days



- Functions:
- Temporary hemostasis
- Blood coagulation
- Clot retraction
- Phagocytosis
- Storage and transport
- Vascular growth (PDGF)

# Thrombopoiesis




| | | |
|---|---|---|
| Size:<br>Cytoplasm:<br>Nucleus:<br>Nucleoli: | 15-20 μm<br>Basophilic cytoplasm<br>Round<br>Single to multiple nucleoli | Megakaryoblast |
| Size:<br>Cytoplasm:<br>Nucleus: | 20-30 μm<br>Abundant, less basophilic cytoplasm<br>Oval and elongated | Promegakaryocyte |
| Size:<br>Cytoplasm:<br>Nucleus: | 35-60 μm, largest cell in the bone marrow<br>Borders irregular and budding of platelets from the cytoplasmic border. Rich in granules.<br>Compact and dense, multi-lobated and pushed to one side. | Megakaryocyte |
| Size: | 2-3 μm,<br>Anucleated pale blue colored structures with purple granules | Platelets |

# Blood II

Dr. Aman Shakya

2080/02/29

# Objectives

- To Discuss about Blood Group and Rhesus factor
- To Describe Lymph Organ and Tissues (Lymph nodes, spleen, thymus)
- To Describe Lymph
- To Discuss Lymph Vessels ( Large and Small)

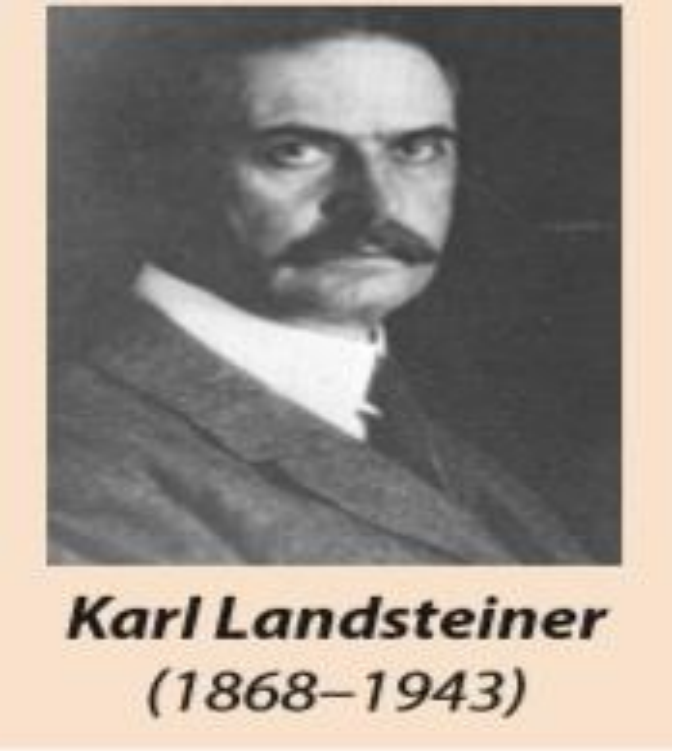
# Blood Group

- Human red cells contain numerous surface structures that are recognized as antigens ( agglutinogen)
- These surface structures are called blood group antigens.
- Corresponding antibodies (agglutinin) are absent in the plasma of that individual

- ABO and Rh systems
- Other major blood group systems that have medical and medicolegal importance are MNS, Lewis, Duffy, Kell, and Lutheran systems.

# Blood Group

- Isoagglutinin in human blood in 1900,
- Nobel Prize in Physiology or Medicine in 1930.




- The principle of presence or absence of agglutinogen and agglutinin in red cells and plasma in various blood groups is popularly known as Landsteiner Law

# Landsteiner Law

1. ***If an agglutinogen is present*** on the red cell membrane of an individual, the corresponding agglutinin must be absent in the plasma and
2. ***If an agglutinogen is absent*** from the cell membrane of RBCs of an individual, the corresponding agglutinin must be present in the plasma.

- This law holds good for ABO system.
- Second part of the law does not apply for Rh and many other blood group systems as there are no naturally occurring agglutinins in these systems.

# ABO System

| Group | Antigen in RBC | Antibody in serum |
|---|---|---|
| A | A | Anti-B ( β ) |
| B | B | Anti-A ( α ) |
| AB | A and B | No antibody |
| O | No antigen | Anti-A and Anti-B |

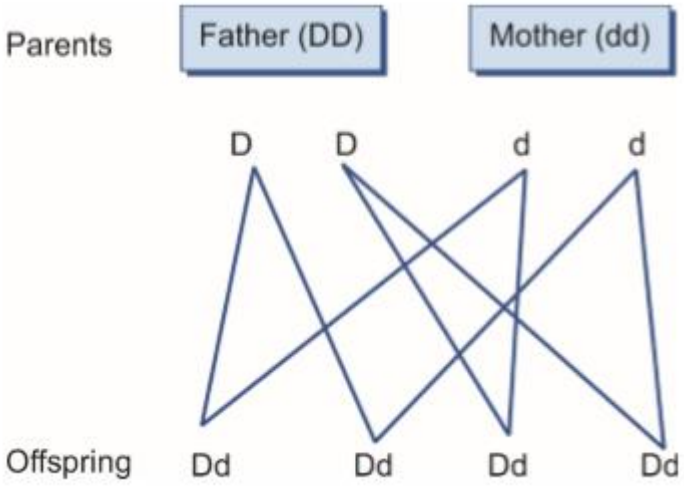
## Rhesus (Rh) System

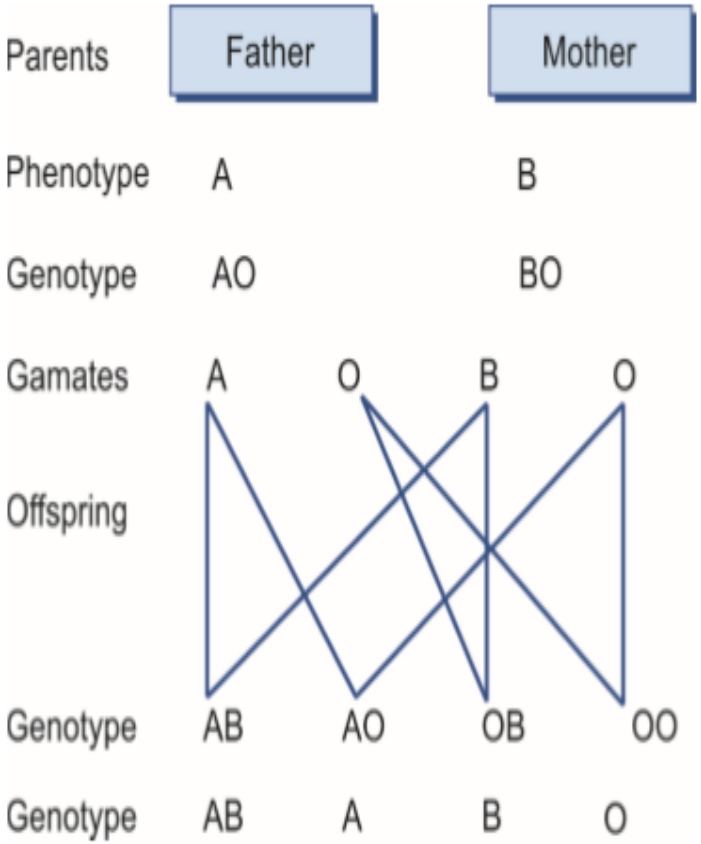
- first described in Rhesus monkeys in 1940 by Landsteiner and Weiner
- there are two blood groups: Rh positive (D antigen present) and Rh negative (D antigen absent).

# Inheritance

- Follows Mendel's Law

| Phenotype (blood group) | Genotype |
|---|---|
| A | AA, AO |
| B | BB, BO |
| AB | AB |
| O | OO |



# Uses of Blood Group

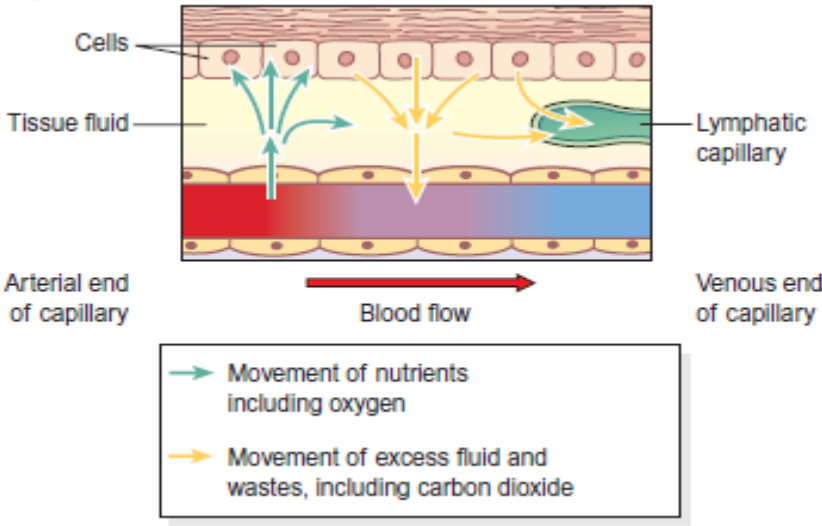
- Compatibility testing for blood transfusion.
- Understanding hemolytic diseases of the newborn and autoimmune hemolytic anemias
- Susceptibility to infections by malaria parasites and medical conditions.
- Medicolegal cases : Paternal and maternal disputes
- Associated with human behaviour ( personality)

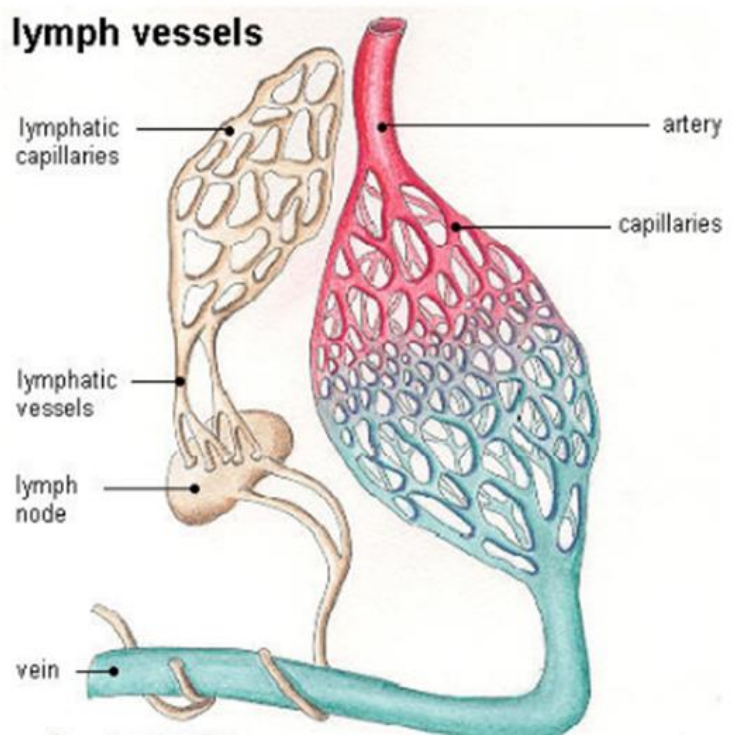
# Lymphatic system

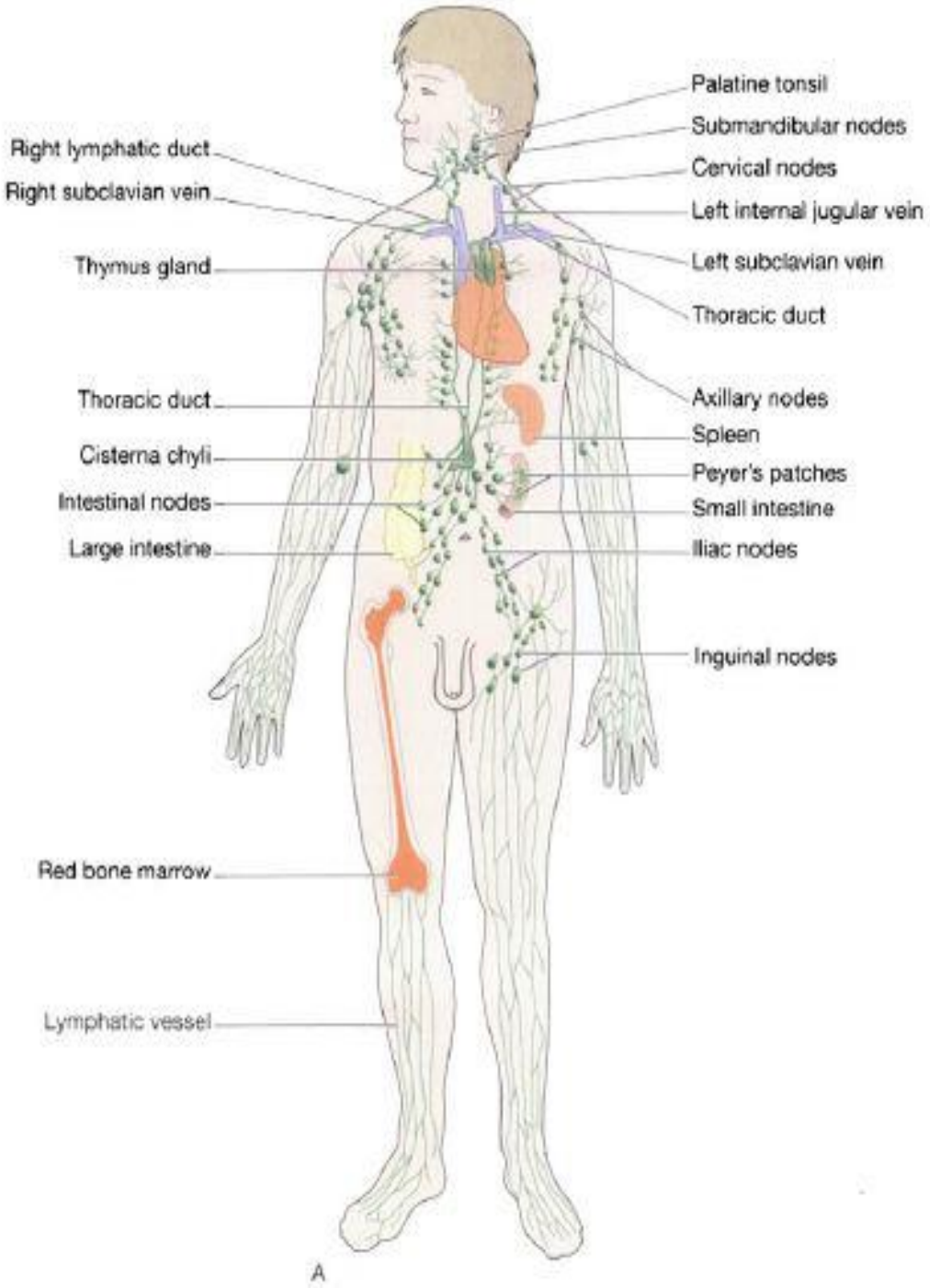
- Circulatory system  consist of:
  - CVS
  - Lymphatic system
- Network of lymphatic vessels that
  - Withdraw excess tissue fluid from body's interstitial fluid compartment
  - Filters it through lymph node
  - Returns it to blood stream

# Lymphatic system

- Interstitial/Tissue fluid - around all body tissues
  - Some - return to capillaries
  - Remainder - diffuses through *more permeable* walls of lymph capillaries and becomes lymph
- Lymph passes through vessels of increasing size and a number of lymph node before returning to blood






# Lymphatic system

- Lymphatic system consists of:
  - ❖ Lymph
  - ❖ Lymph vessels
  - ❖ Lymph nodes
  - ❖ Organs: Spleen and thymus
  - ❖ Diffuse lymphoid tissue eg. Tonsils
  - ❖ Bone marrow

# Lymphatic system-Functions

- Tissue drainage (3-4 L/day)
- Absorption in the small intestine
- Immunity-Lymphocytes

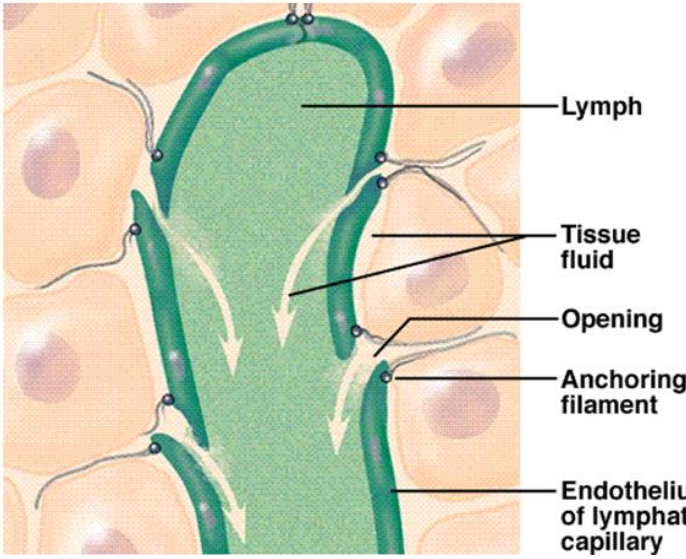
# Lymph

- Clear watery fluid, similar in composition to plasma
- Transports plasma proteins that seep out of capillary beds back to bloodstream
- Also carries away larger particles, e.g. bacteria and cell debris from damaged tissues
  - Filtered out and destroyed by lymph nodes
- Contains lymphocytes

# Lymph vessels

## Lymph capillaries

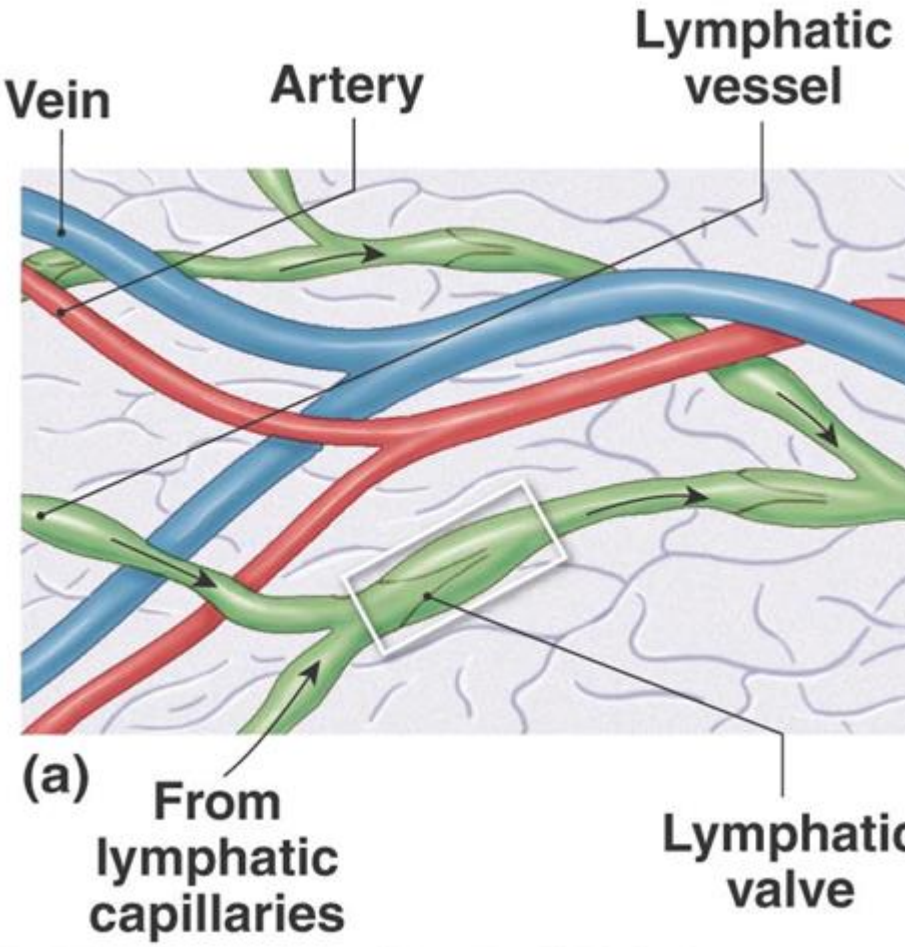
- Originate as blind-end tubes in interstitial spaces
- Same structure as blood capillaries….
- Join up to form larger lymph vessels
- **Exceptions**:
  - Central nervous system
  - Cornea of the eye
  - Bones
  - Most superficial layers of skin

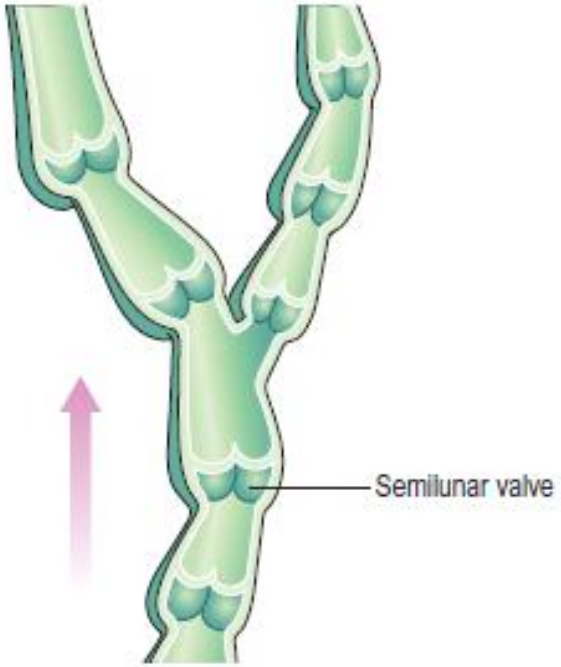


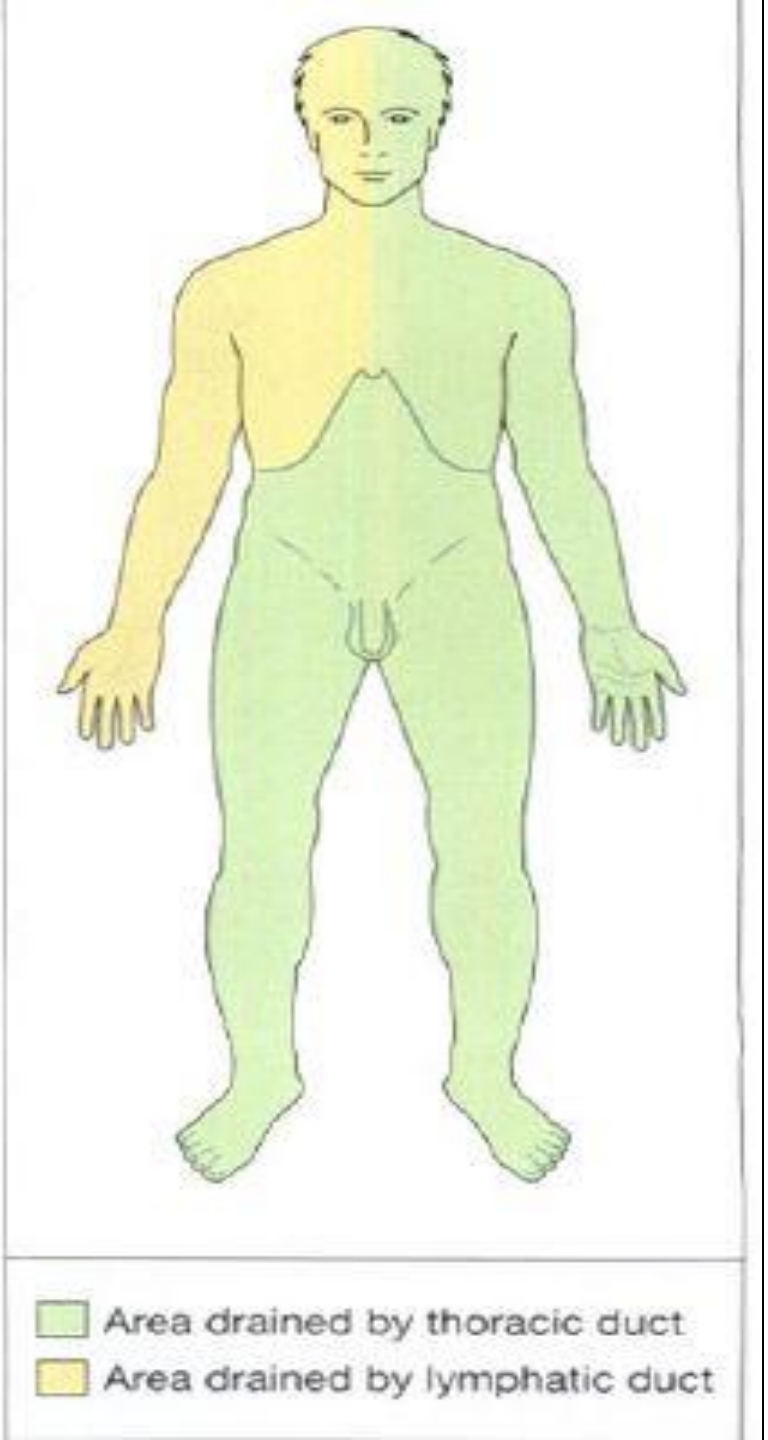
# Lymph vessels

- Found running **alongside** arteries and veins
- Walls are about same thickness as those of small veins and have same **3 layers**
- Have numerous cup-shaped **valves**
- Become larger as they join together**:**
  - ***Vessels*** ***Trunks*** ***Ducts***
  - ***Thoracic duct*** and ***right lymphatic duct***
  - Empty lymph into **subclavian veins**

# Lymph vessels






# Lymph vessels

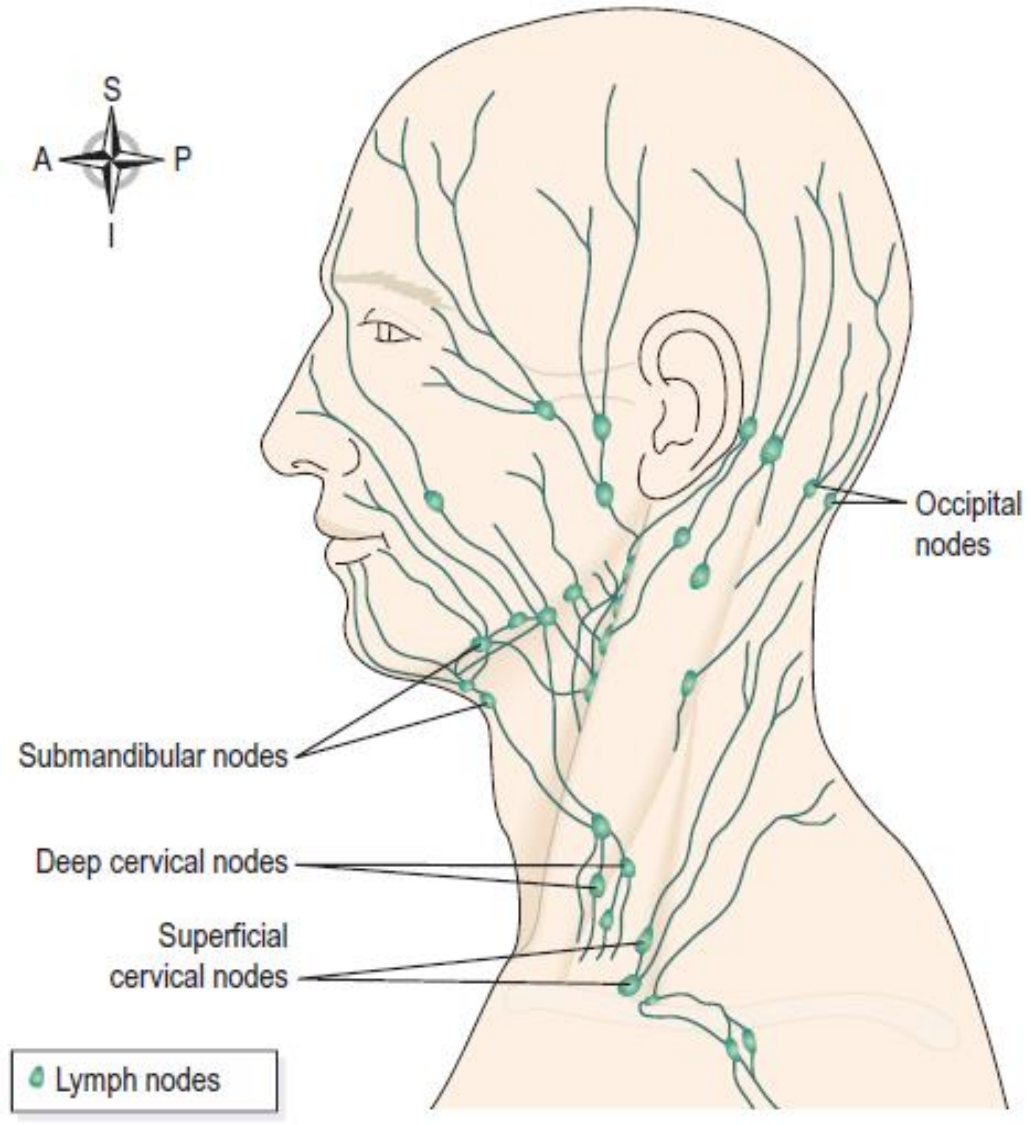
- **Thoracic duct**
- Begins at the **cisterna chyli** (L1-L2)
- 40 cm long
- Opens into **left subclavian vein**
- Drains lymph from both legs, the pelvic and abdominal cavities, the left half of the thorax, head and neck and the left arm

# Lymph vessels

## Right lymphatic duct

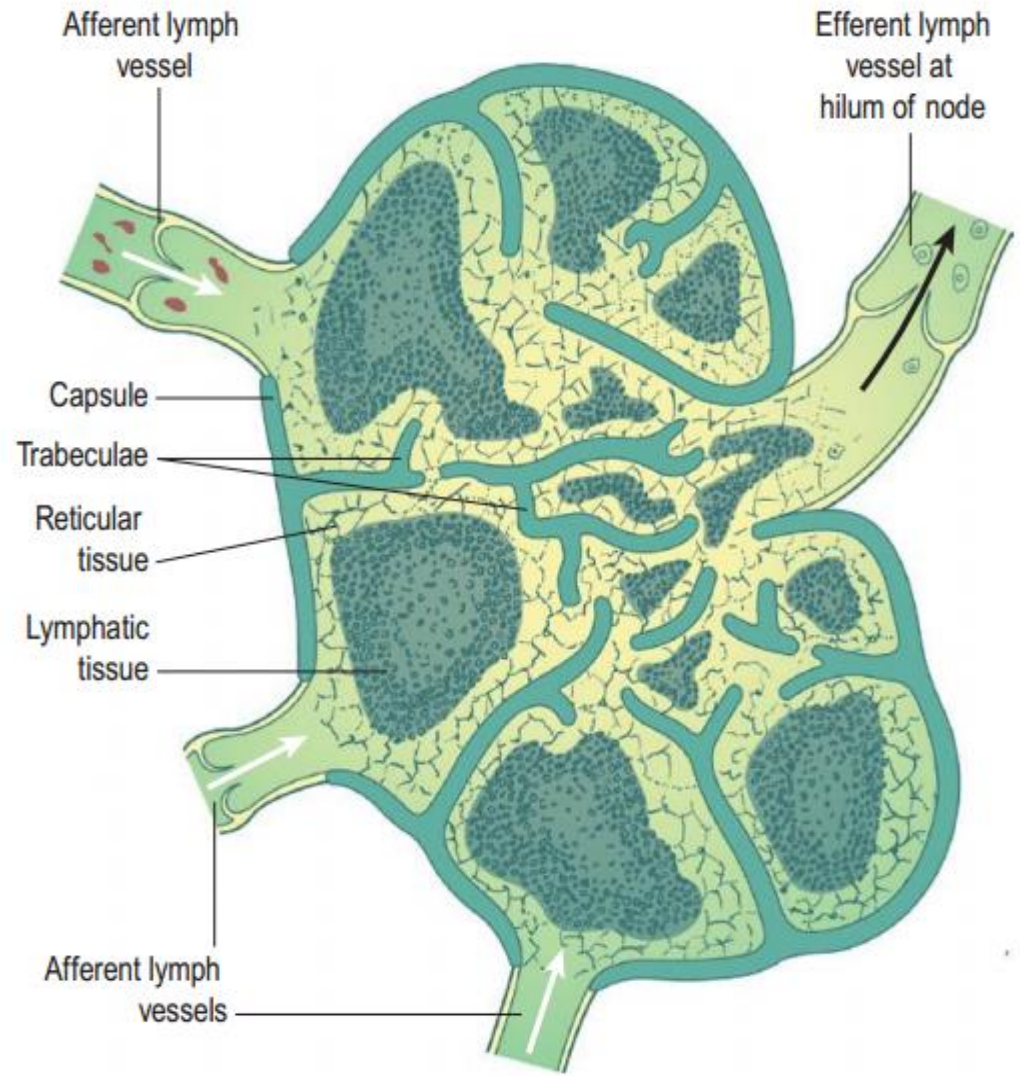
- A dilated lymph vessel about 1 cm long
- Opens into **right subclavian vein**
- Drains lymph from the right half of the thorax, head and neck and the right arm

# Lymph node



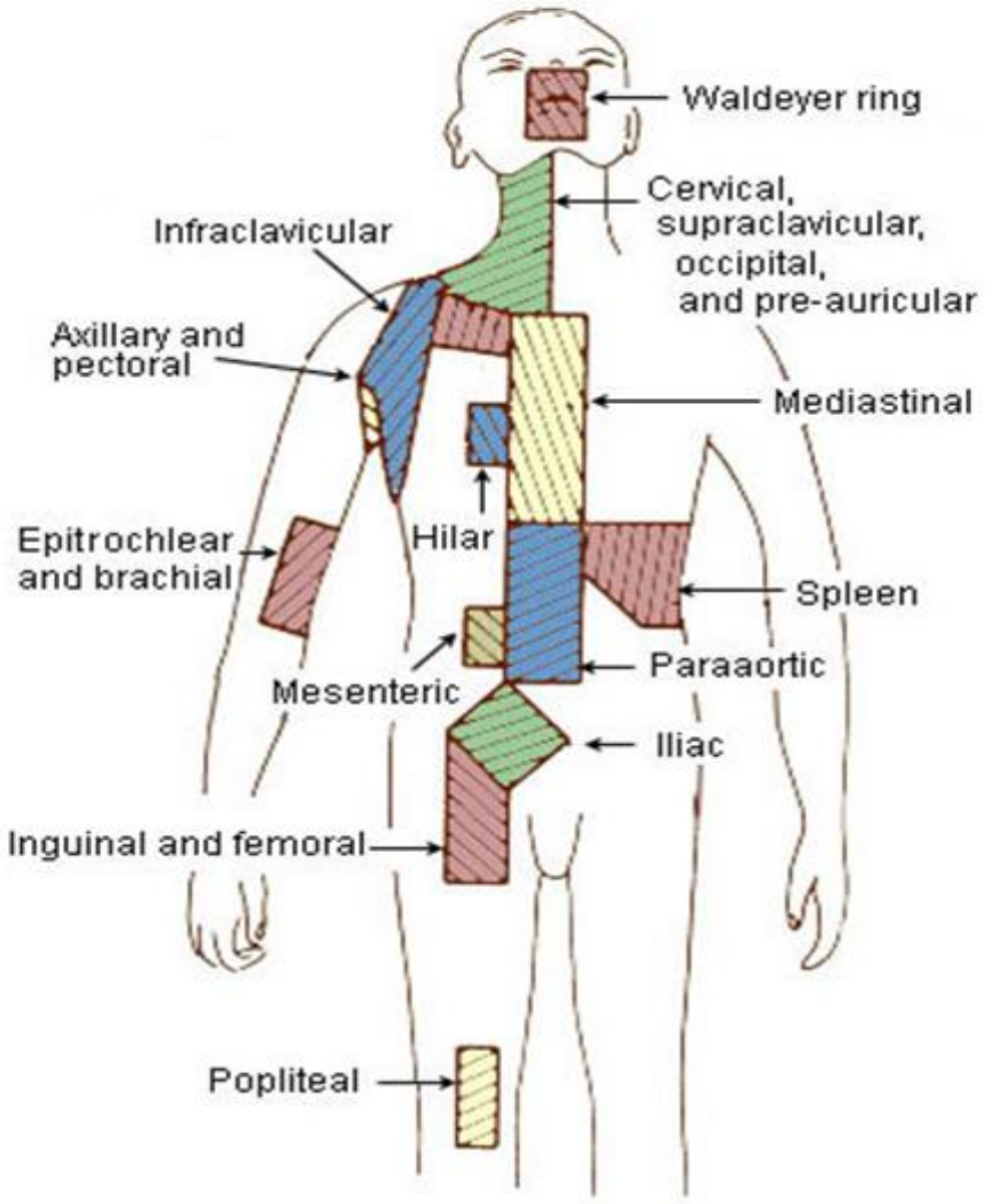

- Oval or bean shaped, often in groups, along length of lymph vessels
- Usually 8-10
- Size vary from pin head to almond
- Functions:
  - Filtering and phagocytosis
  - Proliferation of lymphocytes

# Lymph node-Structure



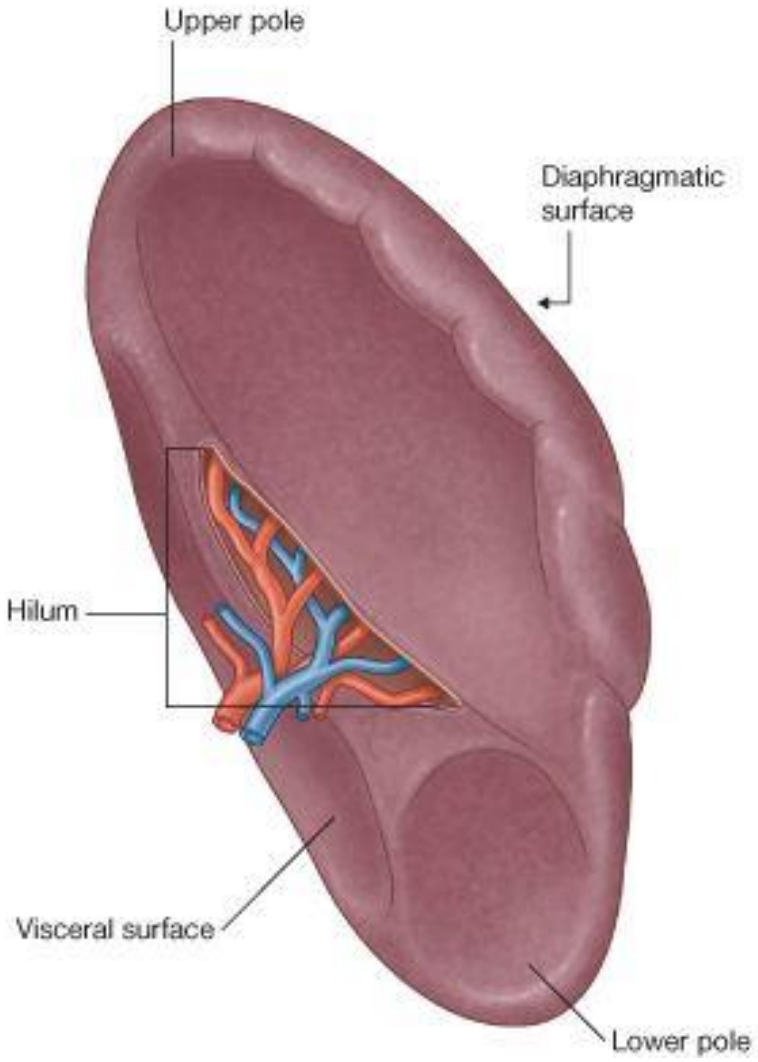

- Capsule: fibrous connective tissue
- Reticular tissue: support
- Lymphatic tissue: immunity
- Many afferent vessels, usually only one efferent vessel

# Lymph node-Structure contd…



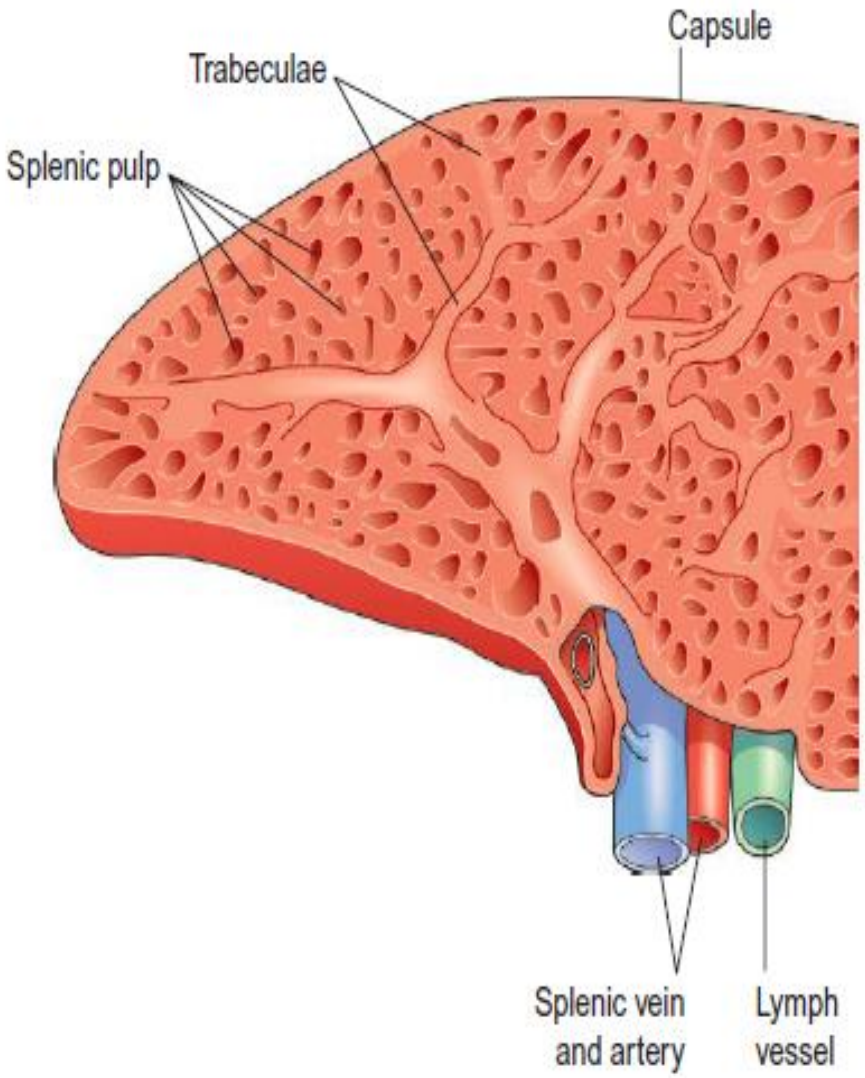

- Collection of lymph nodes:
  - Cervical
  - Axillary
  - Pre and para-aortic
  - Inguinal
- Clinical correlates:
  - Lymphadenopathy

# Spleen




- Largest lymph organ
- Left hypochondrium
- Between fundus of stomach and diaphragm
- 12*7*2.5 cm
- 200 g

# Spleen -Structure



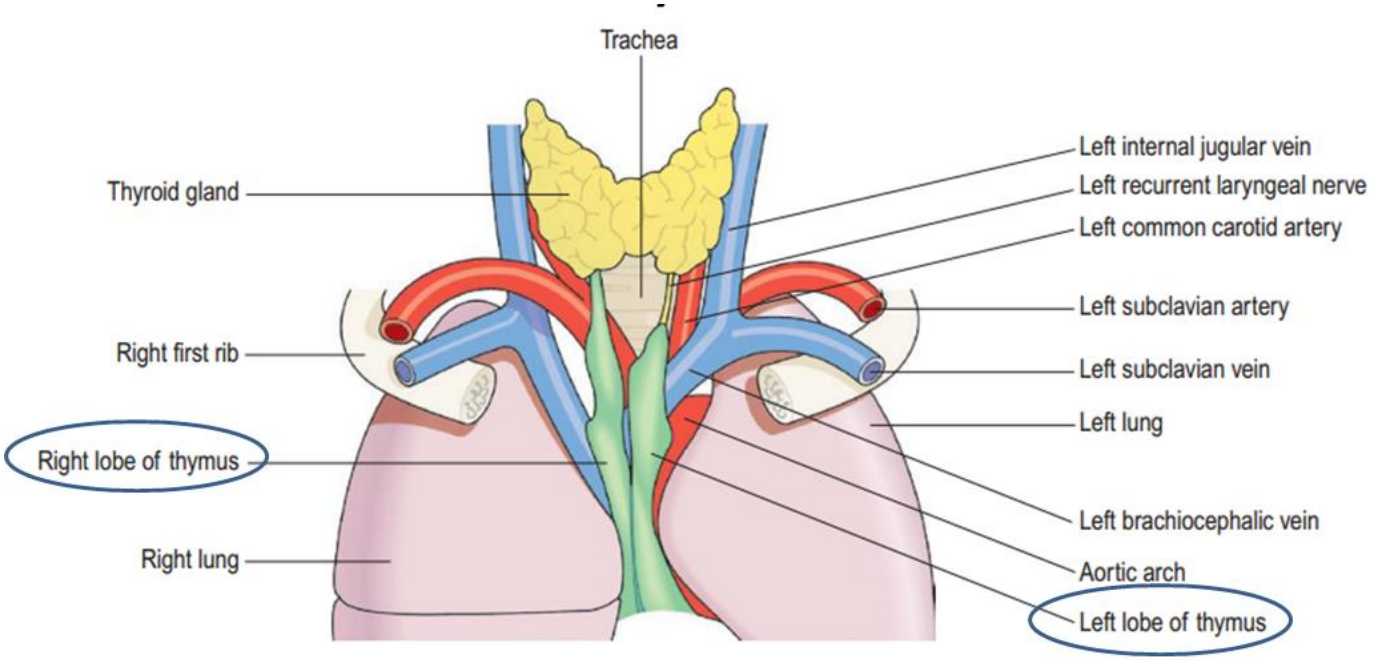

- Slightly oval in shape
- Hilum on lower medial border
  - Splenic vein and artery
- Enclosed in a fibroelastic capsule
- Formed by reticular (supporting) and lymphatic tissue
- Cellular material (Lymphocytes and macrophages) - Pulp

# Spleen -Functions

- **Phagocytosis**
  - Old RBCs
  - Infected leukocytes
  - Diseased platelets
  - Microbes
- **Storage of blood**
- **Immune response**
  - Contains T- and B-lymphocytes.
- **Erythropoiesis**
  - Fetal blood cell production

# Thymus

- Upper part of mediastinum
- About 10 to 15 g at birth and grows until puberty, when it begins to atrophy
- Maturation of lymphocytes
- Bilobed
- Capsulated



# Organs associated with thymus

- Anteriorly – sternum and upper four costal cartilages
- Posteriorly – aortic arch and its branches, brachiocephalic veins, trachea
- Laterally – lungs
- Superiorly – structures in the root of the neck
- Inferiorly – heart

# Structure of thymus

- Right and left lobes that are joined together by fibrous tissue.
- 1. Each lobule is about 2 mm in diameter. It has an outer cortex and an inner medulla
- 2. Both the cortex and medulla contain cells of two distinct lineages. The medulla of adjoining lobule is continuous.
- 3. The thymus has a rich blood supply. It does not receive any lymph vessels, but gives off efferent vessels.

# Functions of Thymus

A) Role in Lymphopoiesis

Stem cells from bone marrow that reach the superficial part of the cortex divide repeatedly to form smaller lymphocytes.

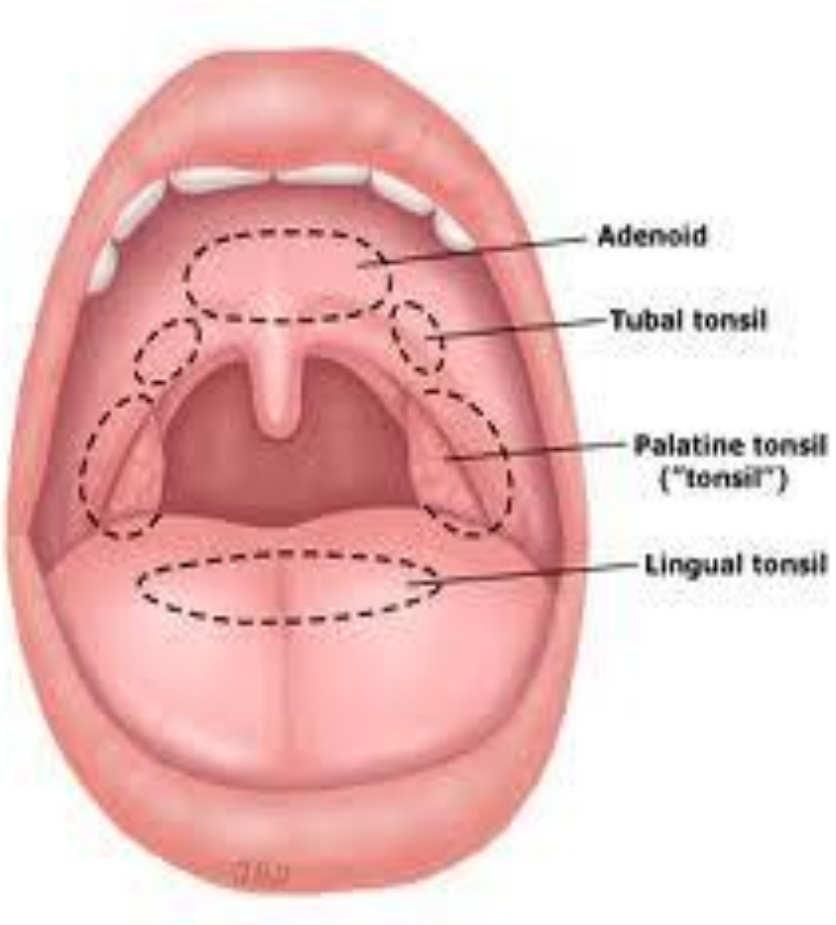
B) Thymus as a Primary Lymphoid Organ

c) Thymic Hormones

Thymulin, Thymopoietin, Thymosin

# Mucosa-associated lymphoid tissue

- Collection of lymphoid tissue
- Throughout git, respiratory tract and genitourinary tract
- Not capsulated
- Contain lymphocytes
- Tonsils and
- Peyer's patches



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Thank you