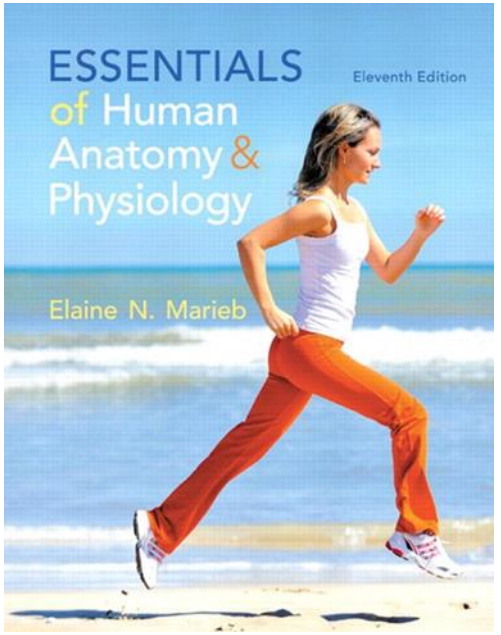
Human Anatomy and Physiology

CLS 224



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Blood
(chapter 10)

1. Composition and function of blood

- Components of blood
- Physical characteristics and volume
- Plasma
- Formed elements– (Erythrocytes*Leukocytes*Platelets)
- Hematopoiesis
- Blood groups and transfusion

2. Hemostasis

Blood Components:

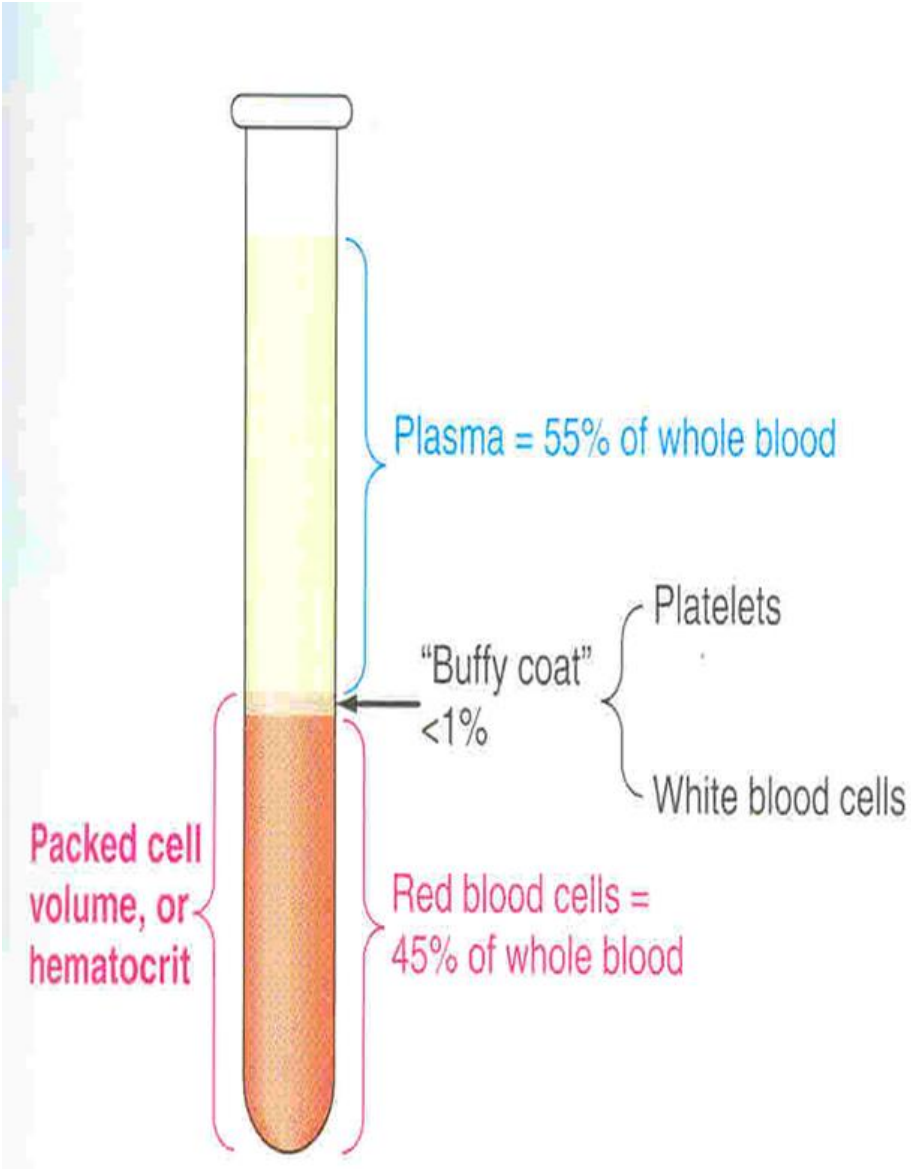
- It is a complex connective tissue in which blood cells are suspended in plasma.
- It is the only fluid tissue.
- It has both solid and liquid compartments.

55% plasma

1% buffy coat

45% Erythrocytes


Baxter
Fenwal
FRESH FROZEN PLASMA


Plasma = 55% of whole blood
Platelets
"Buffy coat"
<1%
White blood cells
Packed cell volume, or hematocrit
Red blood cells = 45% of whole blood

Physical characteristics and volume:

- viscous, thick, opaque fluid.
- Slightly alkaline pH 7.35–7.45
- Its temp. is 38C
- Volume in Healthy males 5-6 liters.

Plasma:

- The fluid portion of blood.
- A solution (90% of it is water.) containing ions, inorganic & organic molecules.

1)Transports substances around the body;

nutrients, salts, respiratory gases, hormones, Abs, Plasma proteins, waste products of cell metabolism.

-Plasma proteins has a variety of functions.

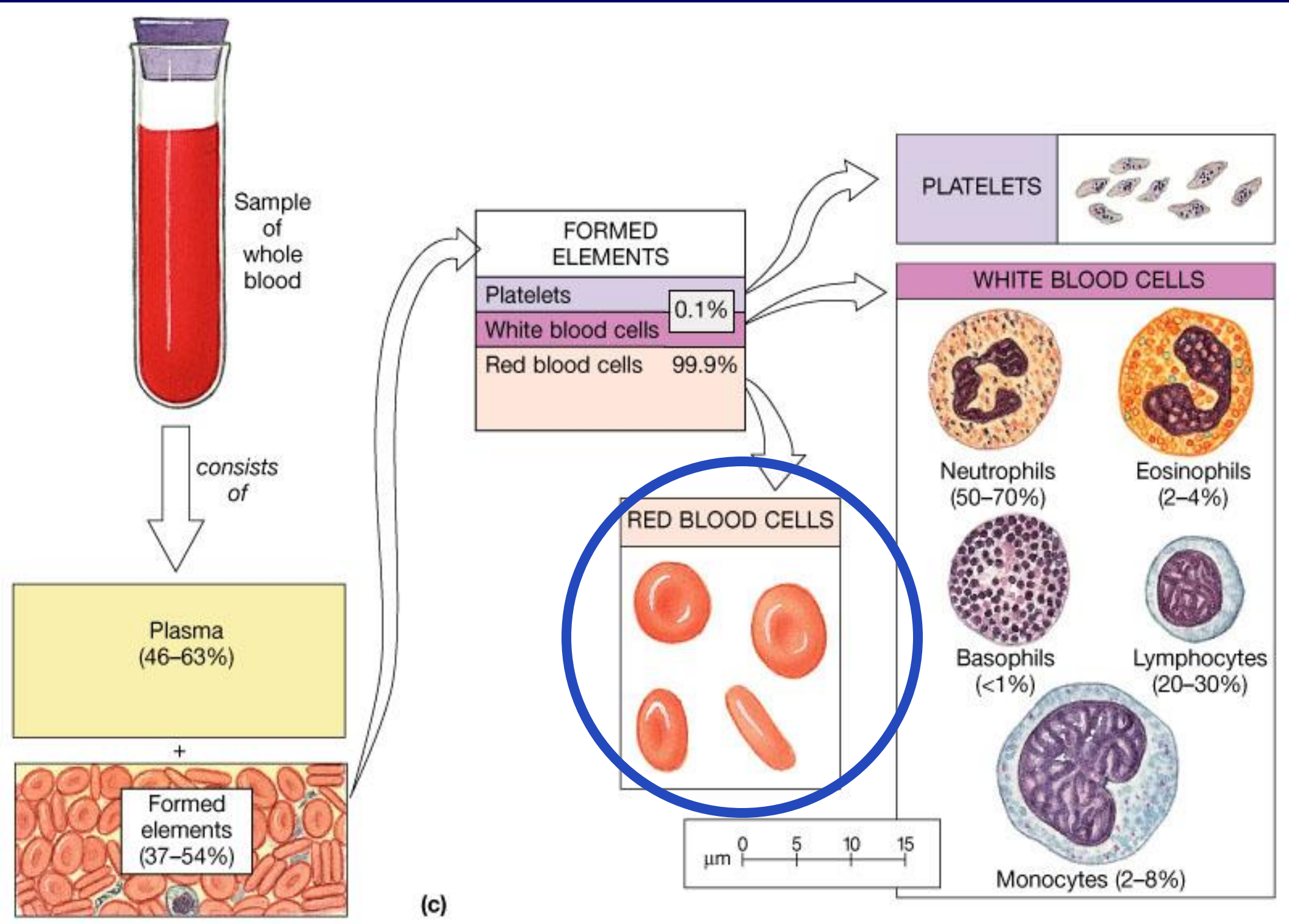
e.g. Albumin maintain the osmotic pressure of plasma

Fibrinogen is essential for blood clotting.

Globulin participates in immune system.

-Most plasma proteins are made by the liver. They aren't taken up by cells to be used as nutrients.

2) Plasma distributes body heat throughout the body.



Erythrocytes (RBCs):

- Structure-
  - *Anucleated*
  - mature RBCs circulating in the blood are filled with hemoglobin.
  - Haemoglobin (Hb), an iron-bearing protein, that binds to oxygen. Made up of four polypeptide chains.

  - Erythrocytes are small, flexible cells shaped like biconcave discs—flattened discs with depressed centers on both sides .
  - A single red blood cell contains about 250 million hemoglobin molecules, each capable of binding 4 molecules of oxygen, so each of these tiny cells can carry about 1 billion molecules of oxygen.
  - Normal blood contains 12–18 grams (g) of hemoglobin per 100 milliliters (ml) of blood. The hemoglobin content is slightly higher in men.

Erythrocytes (RBCs):

Function– ?

Perfect example on how structure fits function.

What determines how well the erythrocytes are performing their role of _5 million /mm3 (outnumber WBC 1000:1)

Is there a way to know the percentage of cells in the blood?

THE HAEMATOCRIT "PACKED CELL VOLUME (PCV)"

What is Haematocrit (Hct)?

- Definition:
  - Is the proportion of blood volume that is occupied by red blood cells.

OR

  - Percentage of red blood cells in whole blood.

- Normal value:
  - Male = 40-52%.
  - Female = 36-48%.

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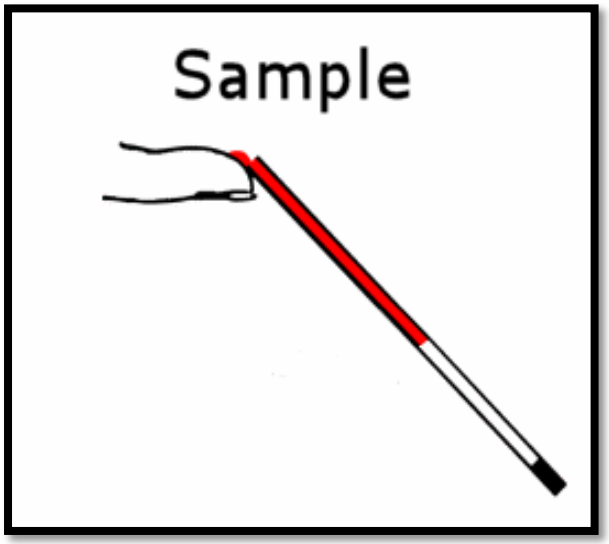
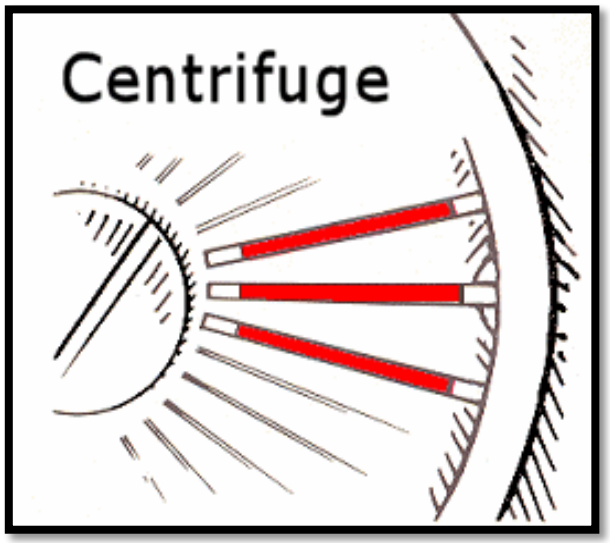


Take a blood sample

Centrifuge



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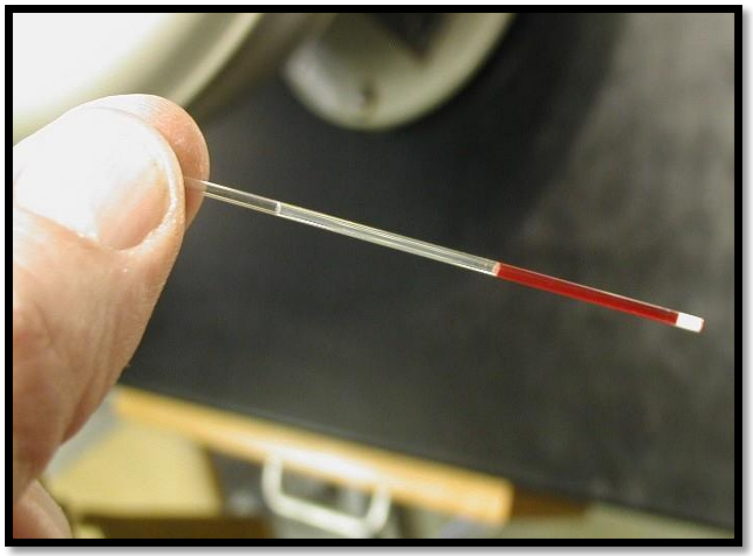
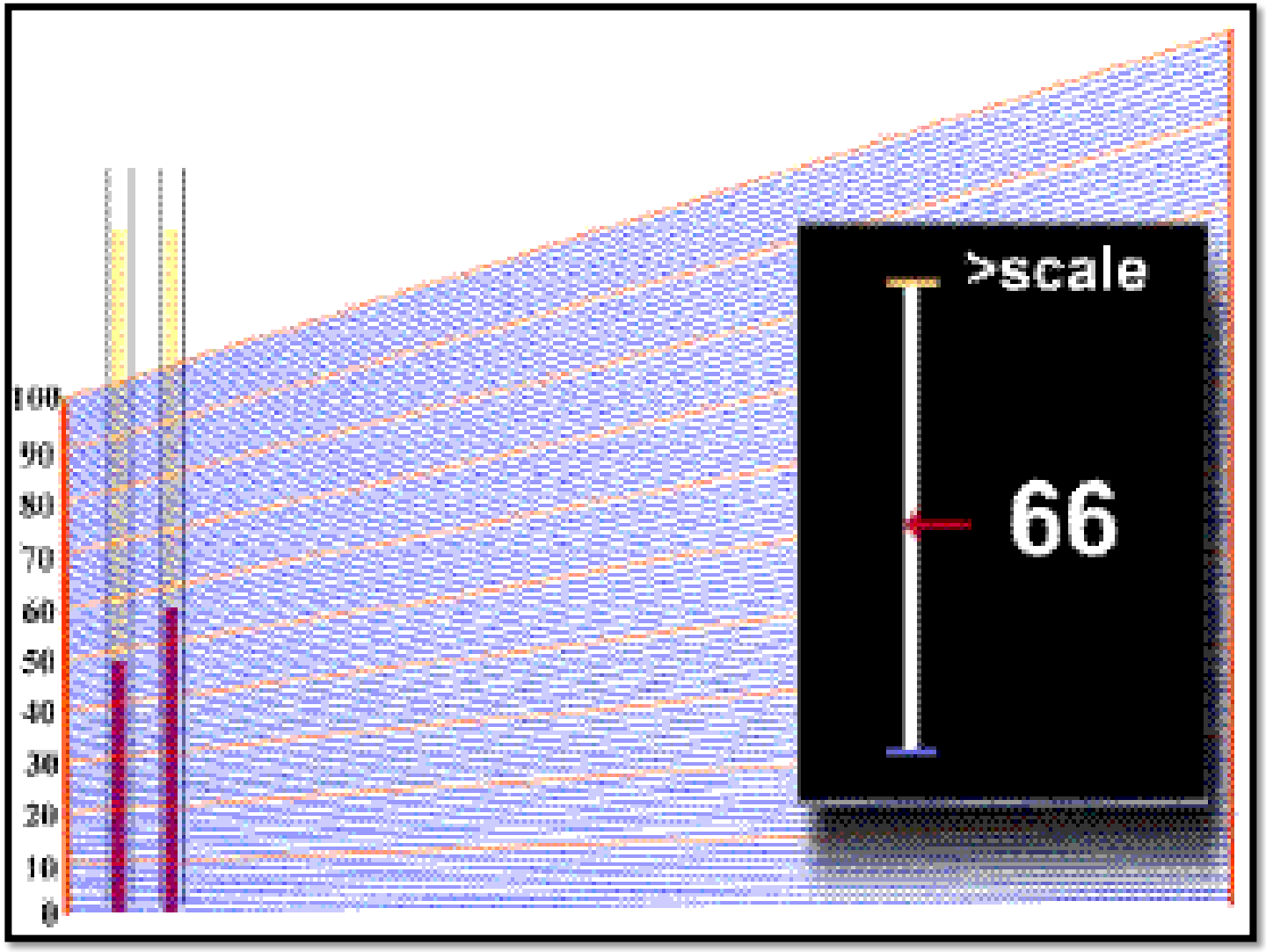


Read

Reading the result



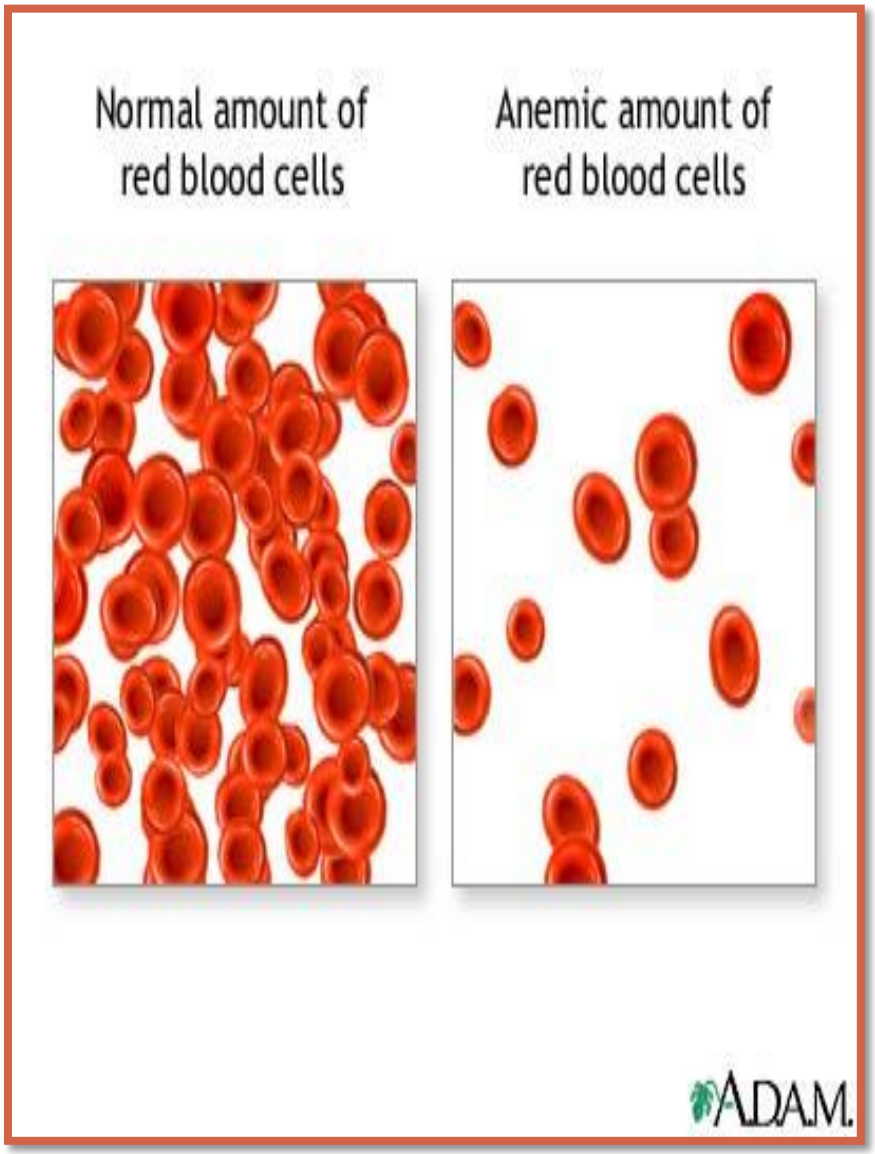
Homeostatic Imbalance of RBCs

Anemia

- Anemia = low hemoglobin level.

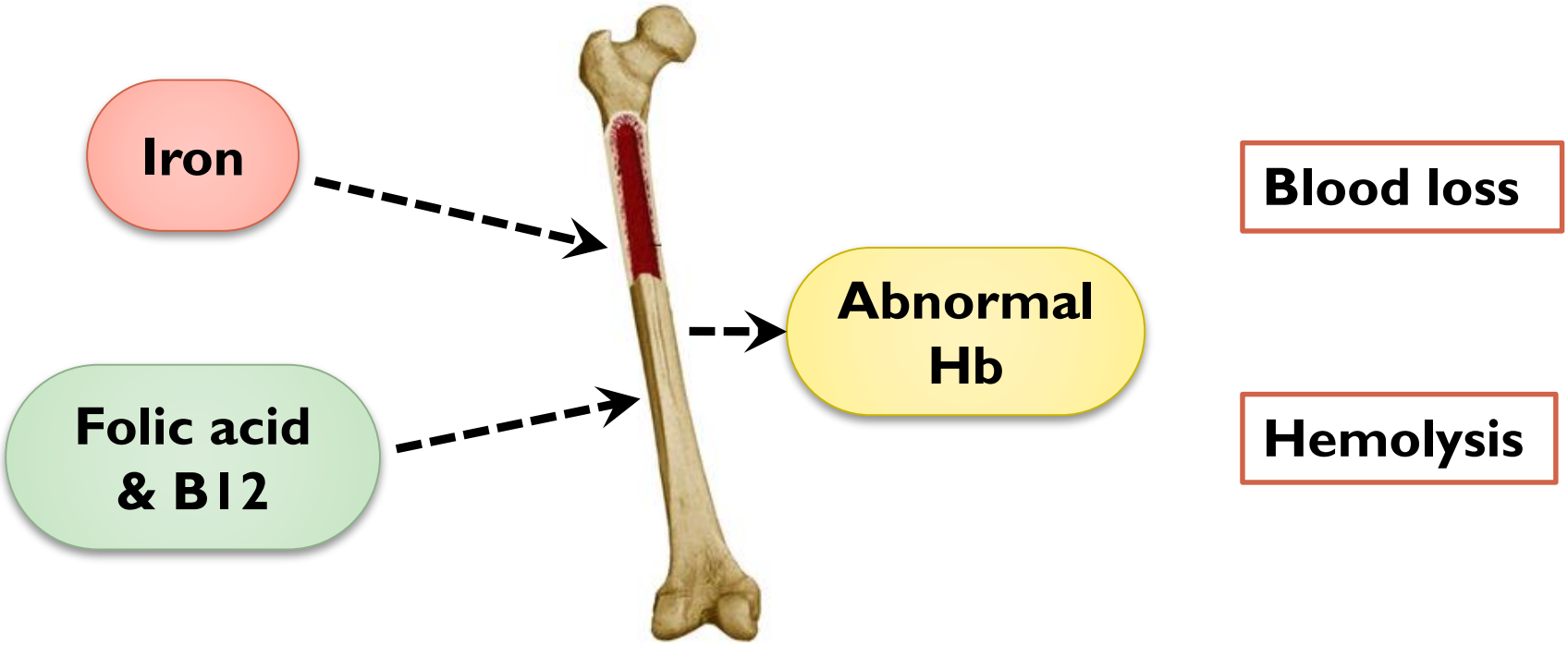
- ↓ Hb level can be caused by;
  1. Too few RBCs.
  2. Too little Hb in the cells.

- Normal hemoglobin level;
  - Males = 13.5-17.5 g/dl.
  - Females = 11.5-15.5 g/dl.



Causes of Anemia

Raw material **Factory** **Circulation**

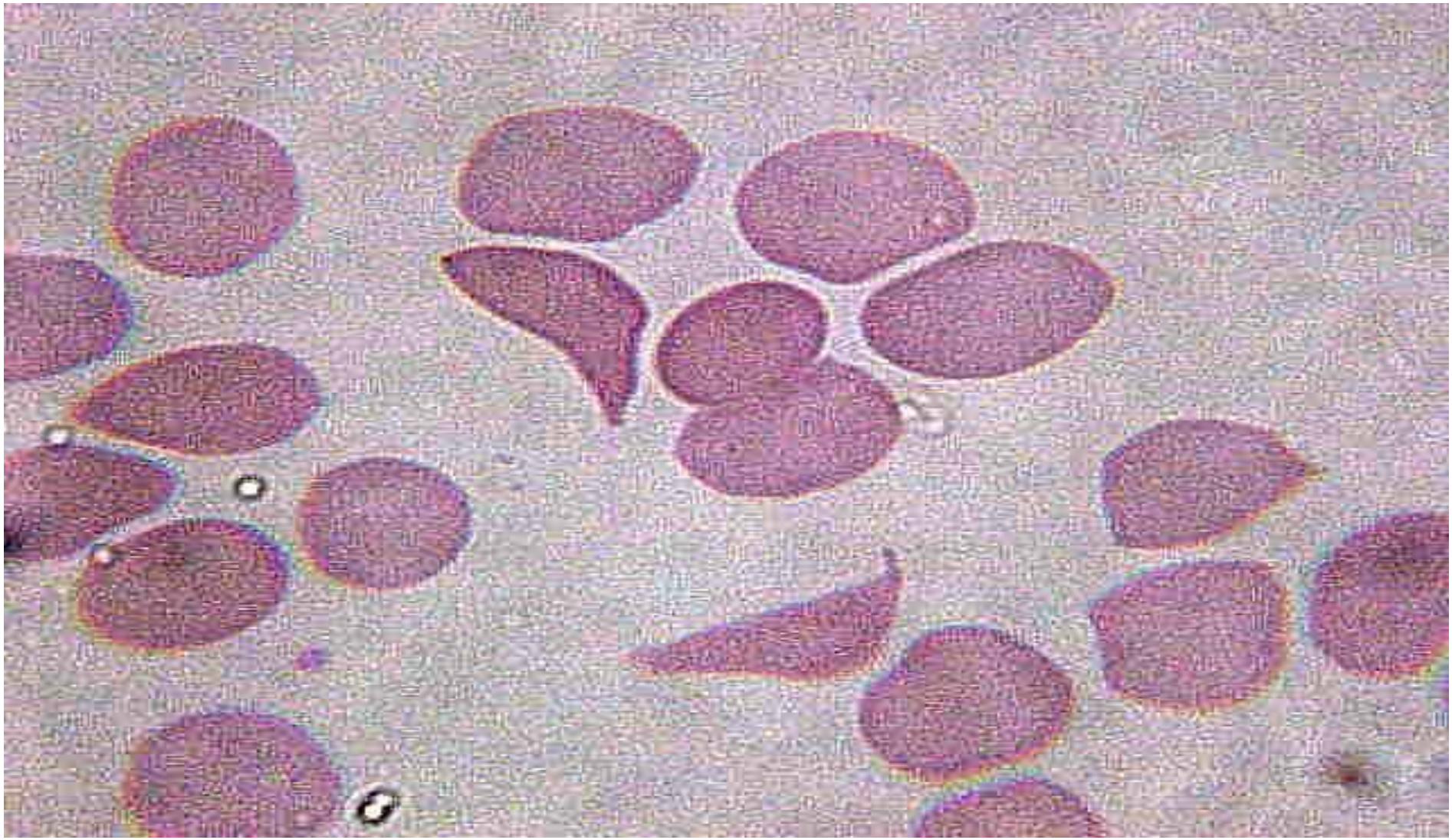


- Iron deficiency anemia.
- Folic acid deficiency.
- Vitamin B12 deficiency (Pernicious anemia).

- Aplastic anemia.
- Sickle cell anemia.

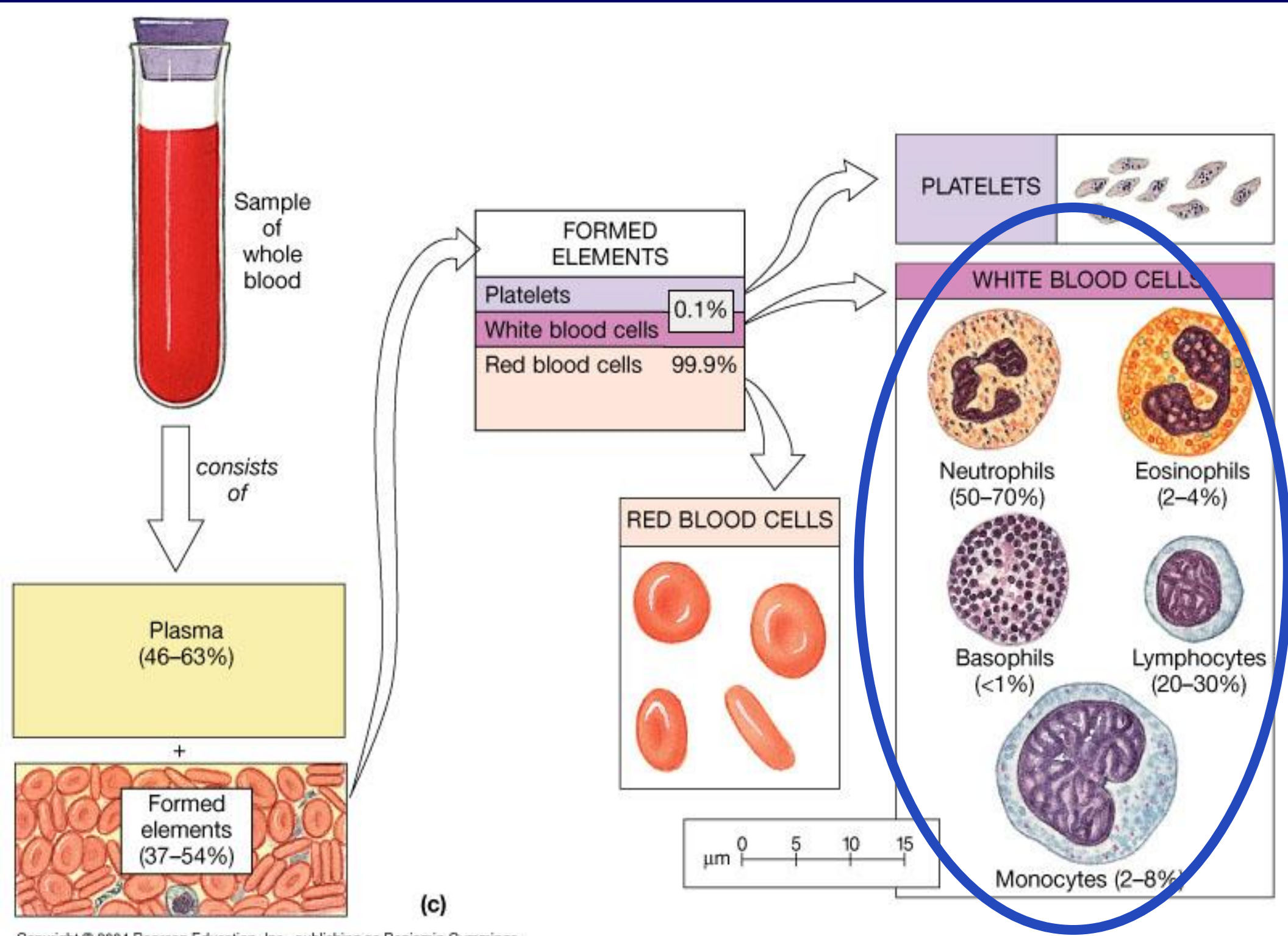
Sickle Cell Anemia

- Genetic disease
- Red blood cells become sickle shape
- Cant carry as much oxygen
- In sickle cell anemia , change in one of the amino acids in two of the four polypeptide chains will result in abnormal hemoglobin that becomes spiky and sharp when the oxygen content of the blood is low.
- The erythrocytes becomes crescent-shaped and rupture easily.
- These events interfere with oxygen delivery (leaving victims gasping for air) and cause extreme pain.



Polycythemia

- Polycythemia = ↑ RBCs.
- **Causes:**
  - Physiologic (high altitude).
  - Pathologic (polycythemia vera).
- The major problem that results from excessive numbers of RBCs is increased blood viscosity, which causes impaired circulation.



Leukocytes (WBCs):

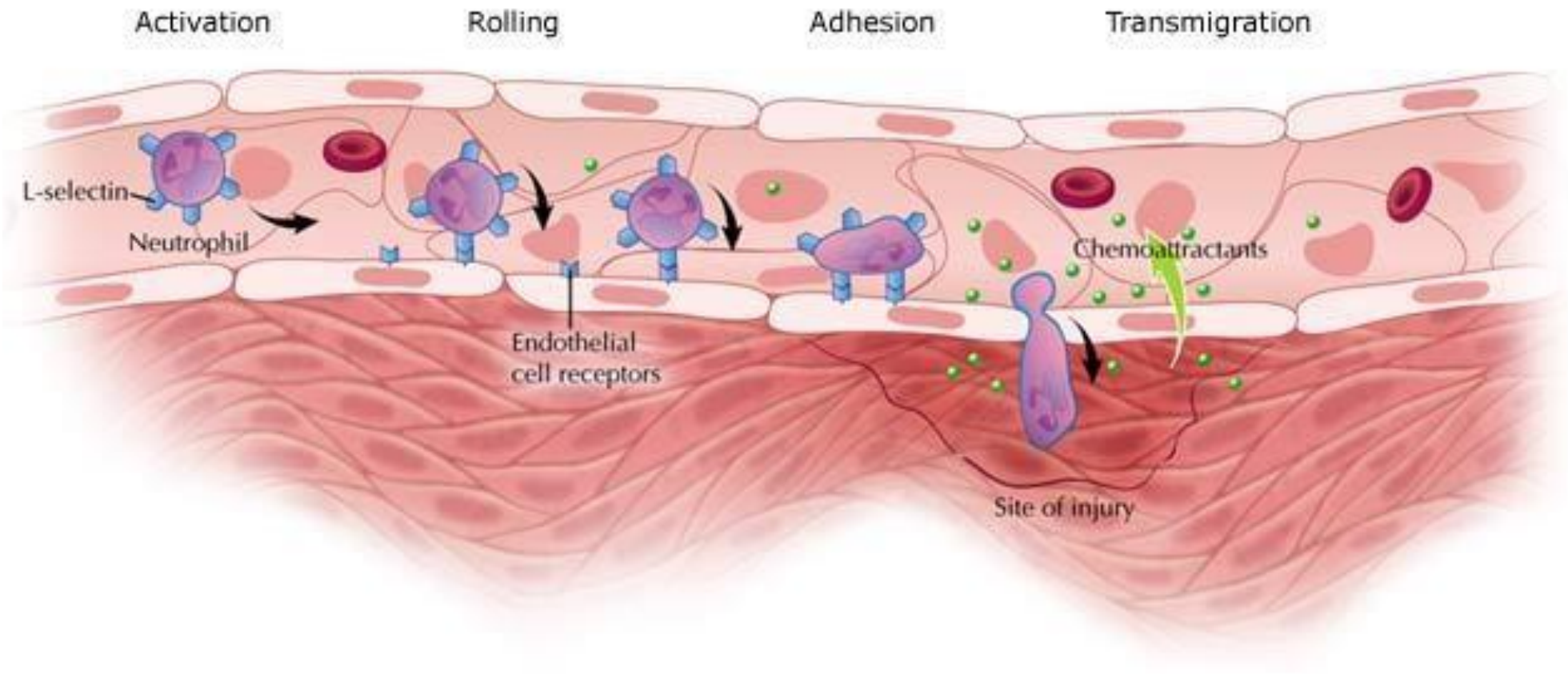
- Structure– The only complete cells in blood
- Function– Form a protective movable army that Defends the body against disease or damage caused by bacteria, viruses, parasites, and tumor cells.

- Unlike RBC, WBC can slip into and out of the BV, process called diapedesis. They can locate areas of tissue damage or infection by responding to certain chemicals that damaged tissue produce (positive chemotaxis).

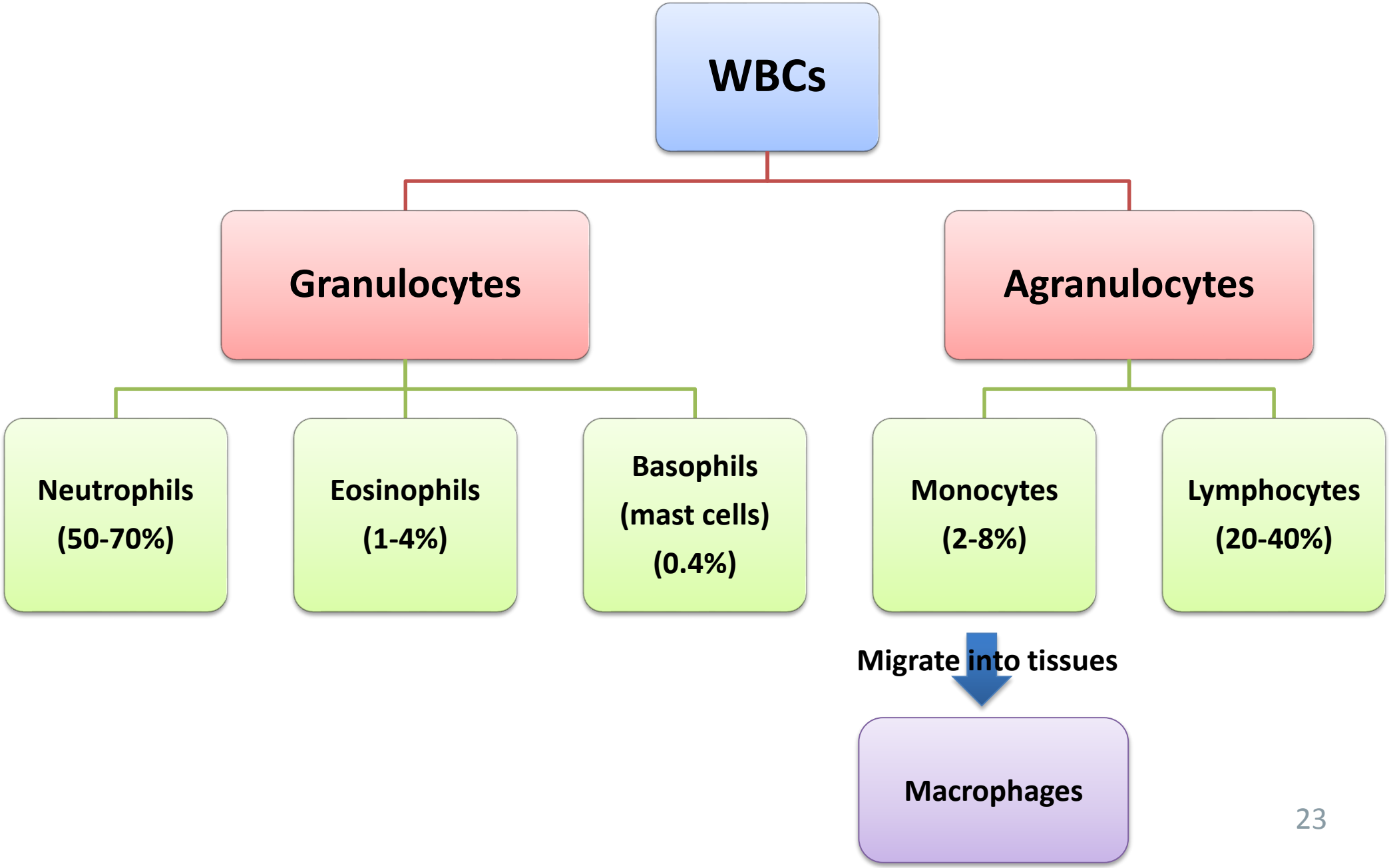
- WBC move by ameboid motion

- Number:

  4,000-11,000/mm3


Activation
Rolling
Adhesion
Transmigration
L-selectin
Neutrophil
Endothelial
cell receptors
Chemoattractants
Site of injury

Types of WBCs



Never let monkeys eat bananas

(neutrophils, lymphocytes, monocytes, eosinophils, basophils).

How to Differentiate?

Granulocytes

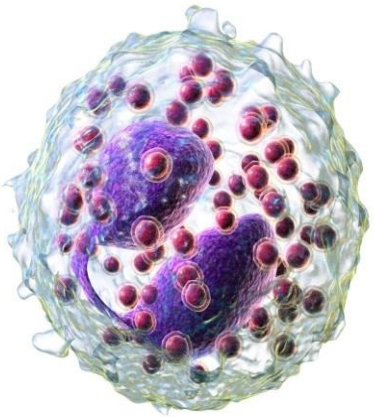
Granular cytoplasm.

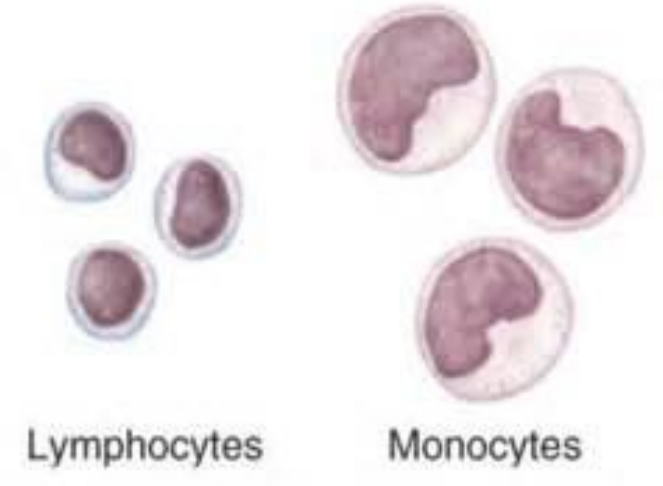
Lobed nucleus.

Agranulocytes

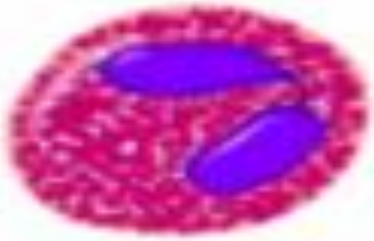
Non-granular cytoplasm.

Non-lobed nucleus.

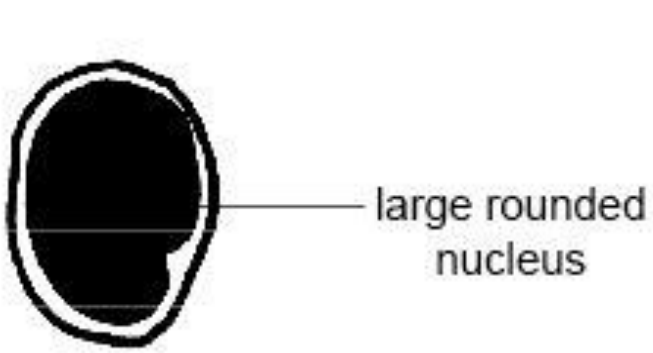




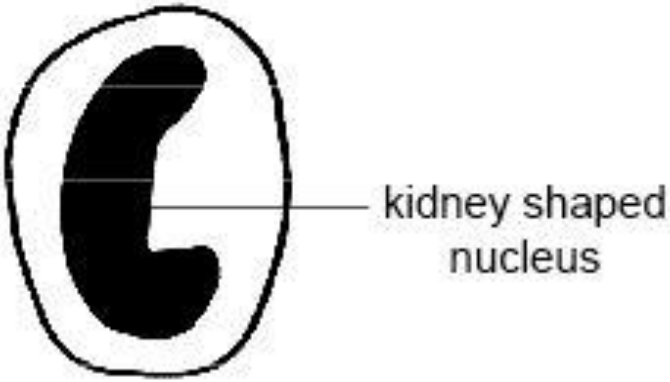
How to Differentiate Between Granulocytes?

Neutrophile	Eosinophile	Basophile
		
• Multilobed nucleus (2-7) lobes. • Pale cytoplasm.	▪ 2-3 lobed nucleus. ▪ Coarse granules which stain with acid dyes like eosin (red).	▪An S-shaped nucleus (2-3 lobes). ▪ Coarse cytoplasmic granules that stains with basic dyes (methylene blue).

How to Differentiate Between Agranulocytes?



A lymphocyte



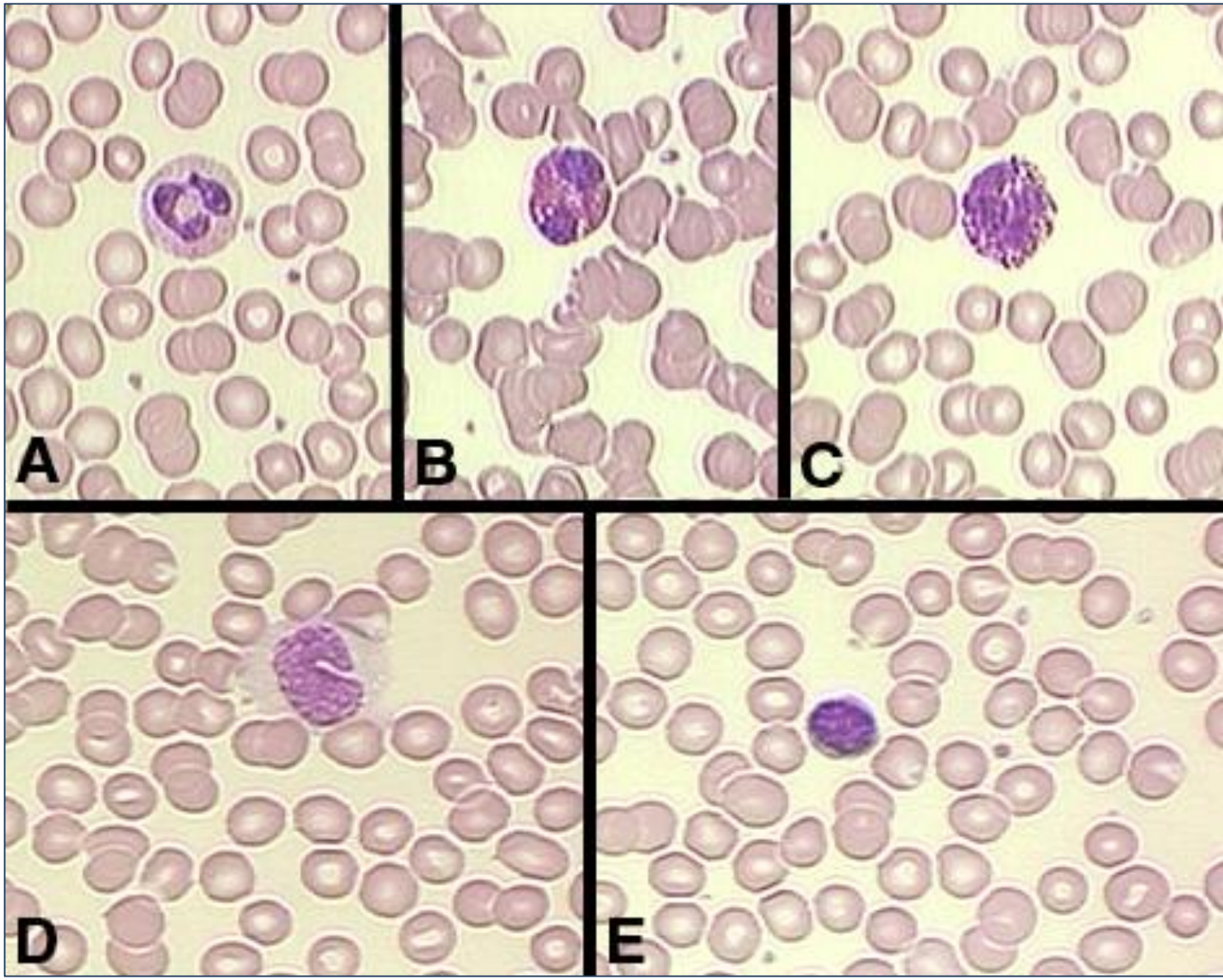
A monocyte

- **Large round nucleus.**
- **Scanty cytoplasm.**

- **Larger than other cells.**
- **Oval, kidney, horse-shoe shaped nucleus.**

On blood film

A. Neutrophil
B. Eosinophil
C. Basophil
D. Monocyte
E. Lymphocyte



WBC	Function
Neutrophils	short-term or acute bacterial and fungal infections.
Eosinophils	Parasitic infections and allergies .
Basophils	inflammatory reactions, prevents blood from clotting and promotes blood flow to tissues..
Lymphocytes	Part of immune system; (B lymphocytes) produces antibodies; (T lymphocytes) Involved in graft rejection, fighting tumors and viruses.
Monocytes (or macrophages in tissues)	chronic infections such as tuberculosis

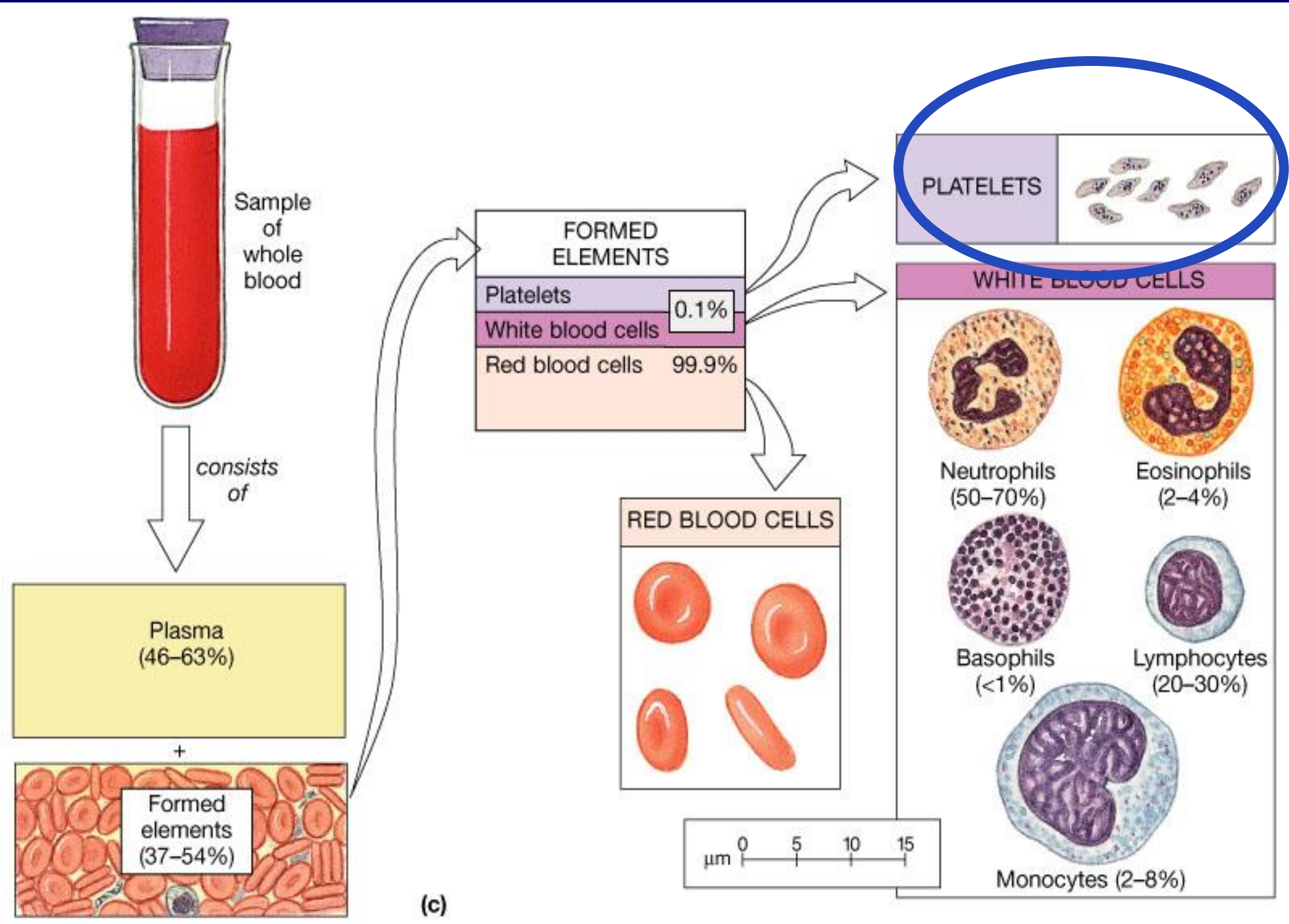
Leukocytosis

- an increase in the number of white cells in the blood, especially during an infection
- generally indicates that a bacterial or viral infection.

- Eosinophilia? Neutrophilia? Lymphocytosis?

Leukopenia

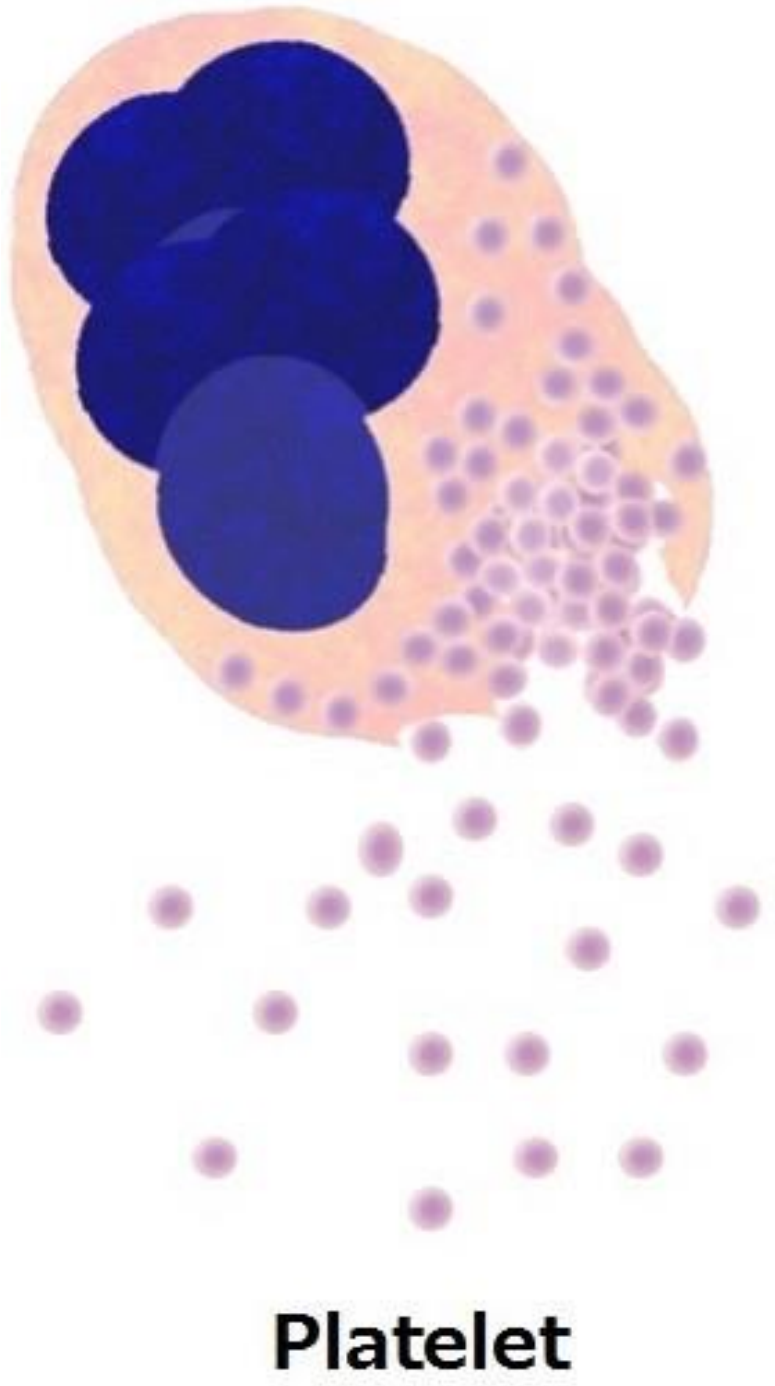
- Is an abnormally low WBC count.
- It is commonly caused by certain drugs, such as corticosteroids and anticancer agents.



Platelets:

- Not a cell
- Fragments Derived from ruptured multinucleated megakaryocytes.

- function–Needed for the clotting process that occurs in plasma when BVs are ruptured or broken.
- Live 2-4 days
- Number–300,000/mm3



Hematopoiesis

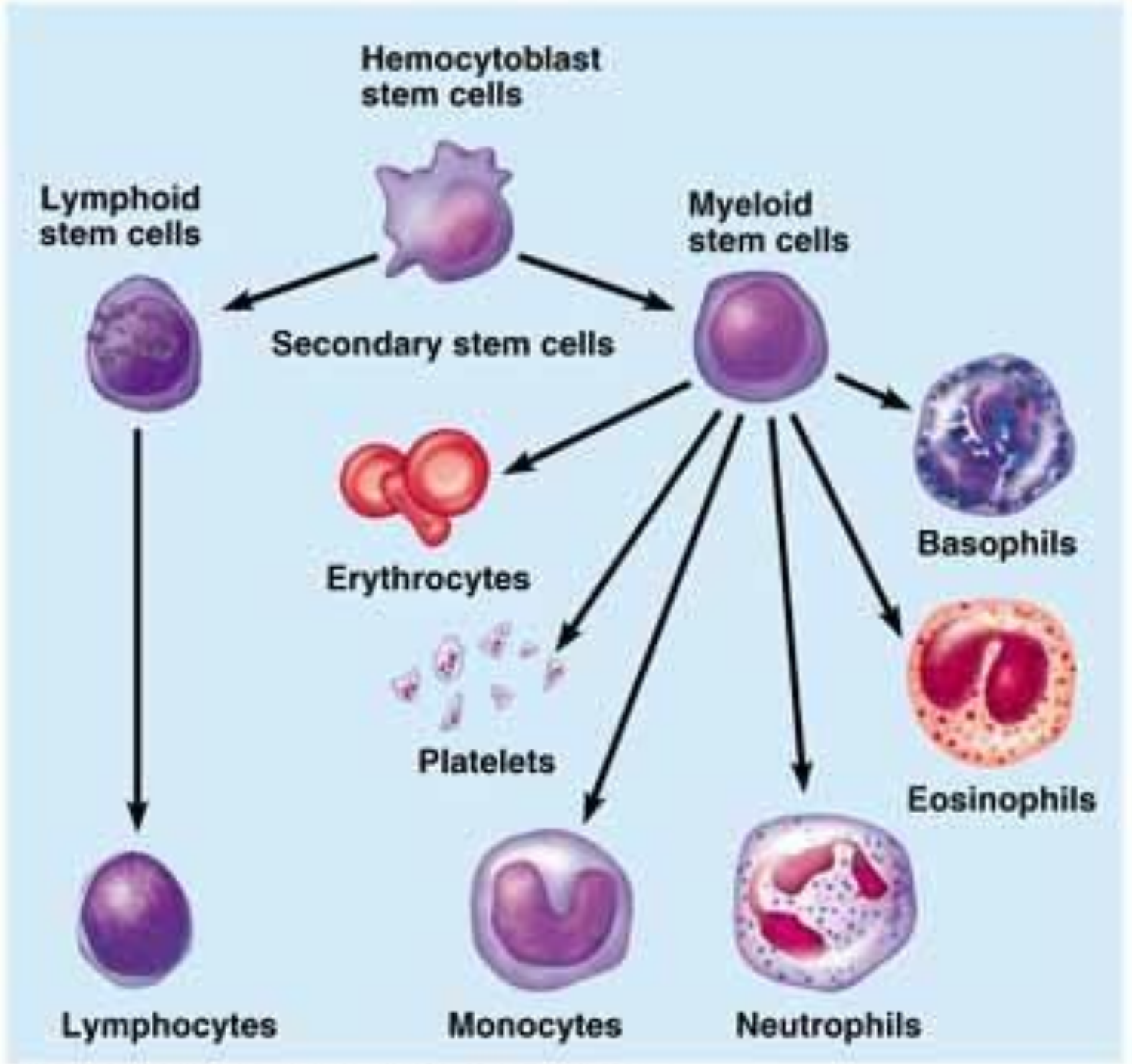
- Blood cell formation
- Occurs in red bone marrow (flat bones: skull, ribs, pelvis and sternum/ proximal epiphyses: humerus and femur/ vertebrae).
- All blood cells are derived from a common stem cell (hemocytoblast).
- Hemocytoblast differentiate into;

1) Lymphoid stem cell:

produces lymphocytes.

2) Myloid stem cell:

produces other formed elements.



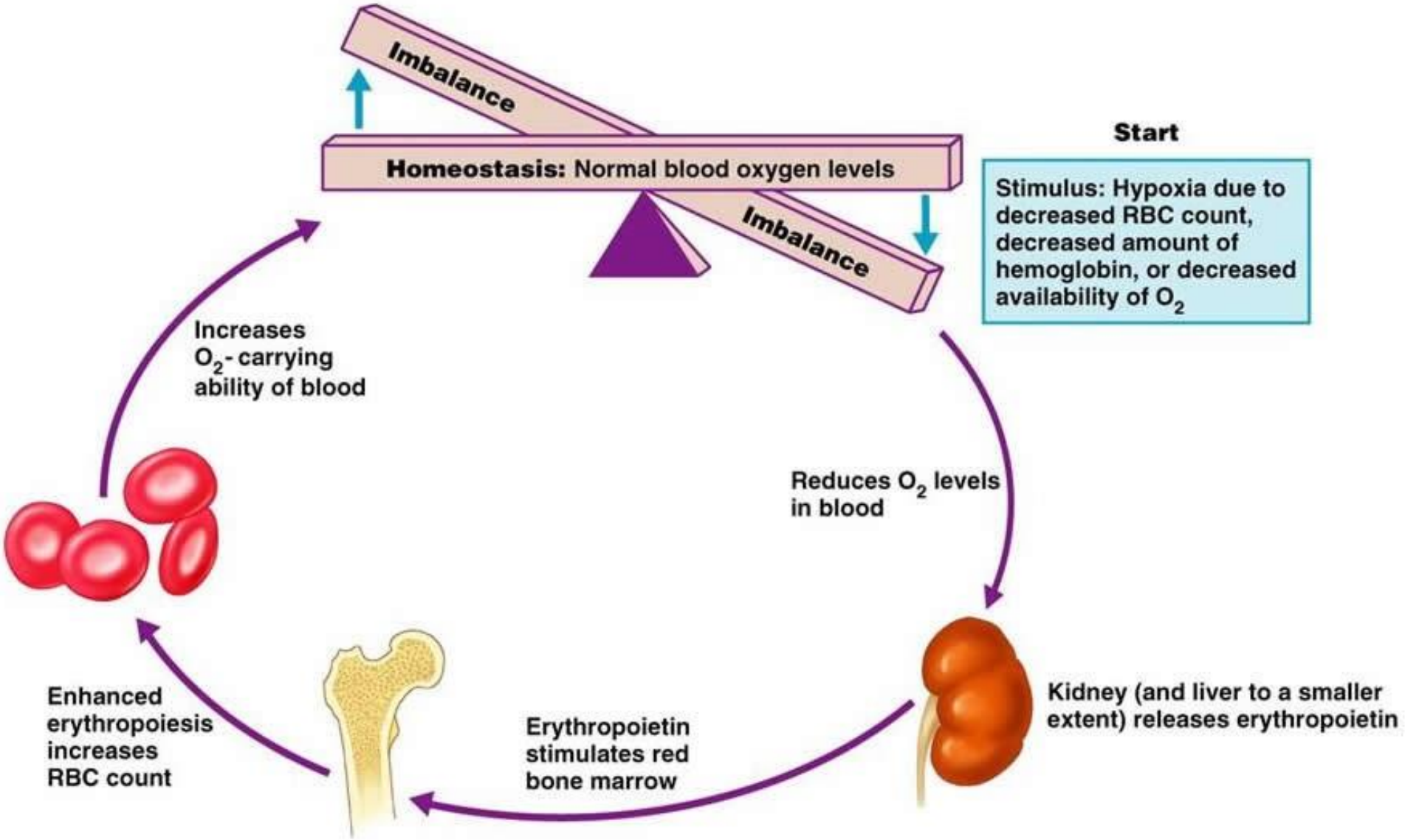
Fate of Erythrocyte

- Unable to divide, grow, or synthesize proteins. (?)
- Wear out in 100 to 120 days.
- When worn out, they are eliminated by phagocytes in the spleen and liver.
- Lost cells are replaced by division of hemocytoblast.

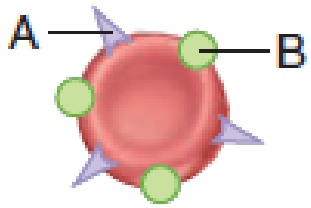
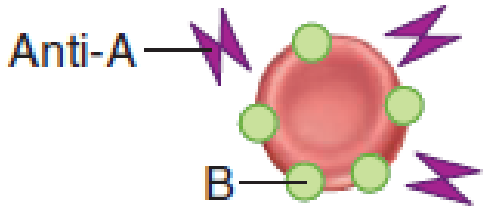
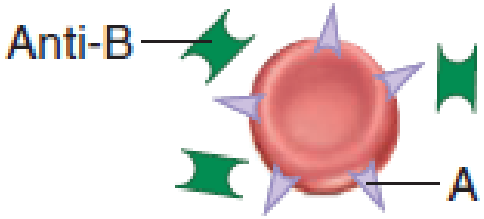
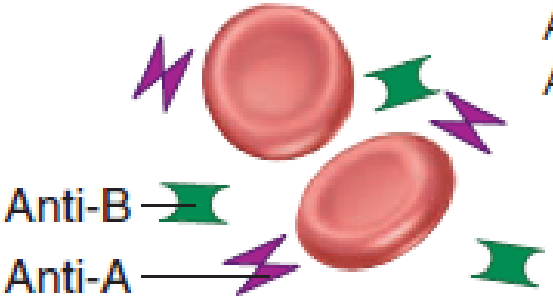
Control of Erythrocyte production

- Rate of production is controlled by a hormone called (erythropoietin).
- Kidneys produce erythropoietin as a response to reduced oxygen levels in blood for any reason, that will then target the bone marrow .

Hemeostasis (balance)



Blood Groups and Transfusions

Blood group	RBC antigens (agglutinogens)	Illustration	Plasma antibodies (agglutinins)	Blood that can be received
AB	A B		None	A, B, AB, O "Universal recipient"
B	B		Anti-A (a)	B, O
A	A		Anti-B (b)	A, O
O	None		Anti-A (a) Anti-B (b)	O "Universal donor"

2. Hemostasis

Objectives:

- Describe the blood clotting process.

2. Hemostasis

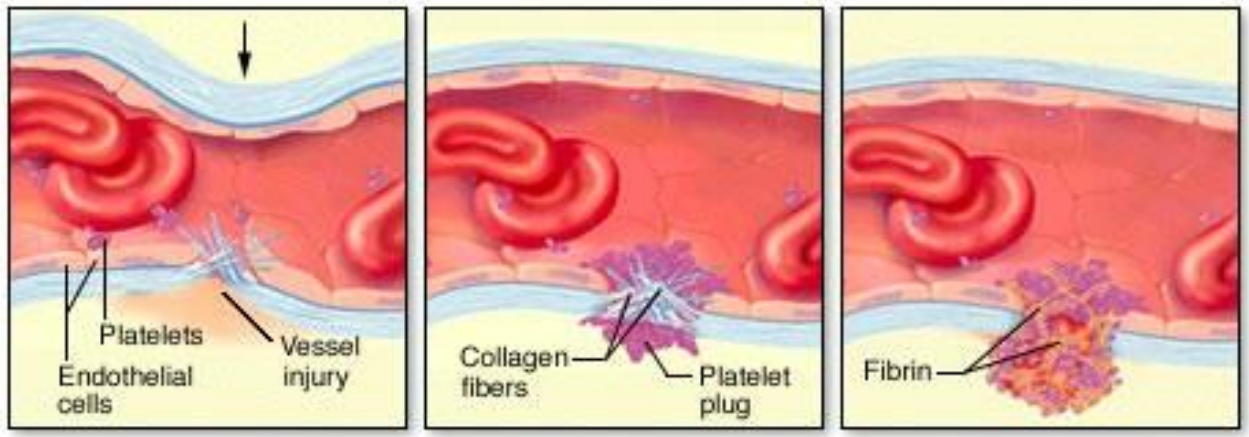
- Stoppage of blood flow when a blood vessel wall breaks.
- Fast and localized reaction.

Hemostasis involves three phases:

1) Vascular spasms

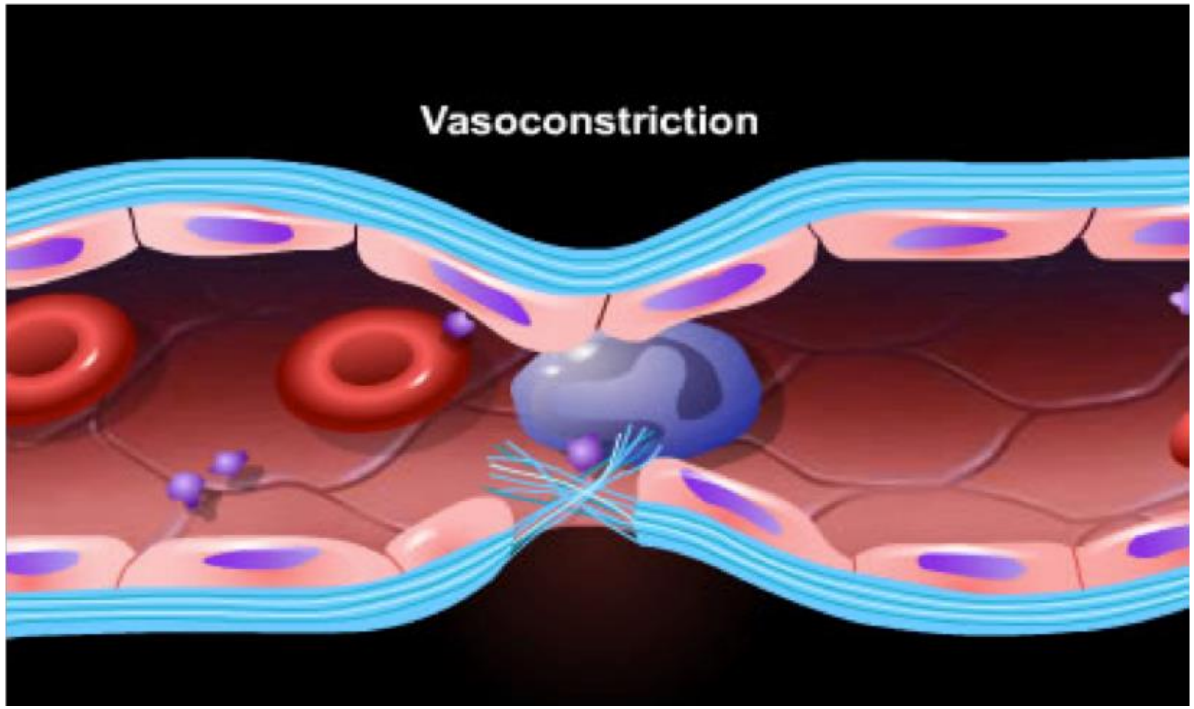
2) Platelet plug formation

3) coagulation (blood clot, fibrin clot)



1) Vascular Spasm

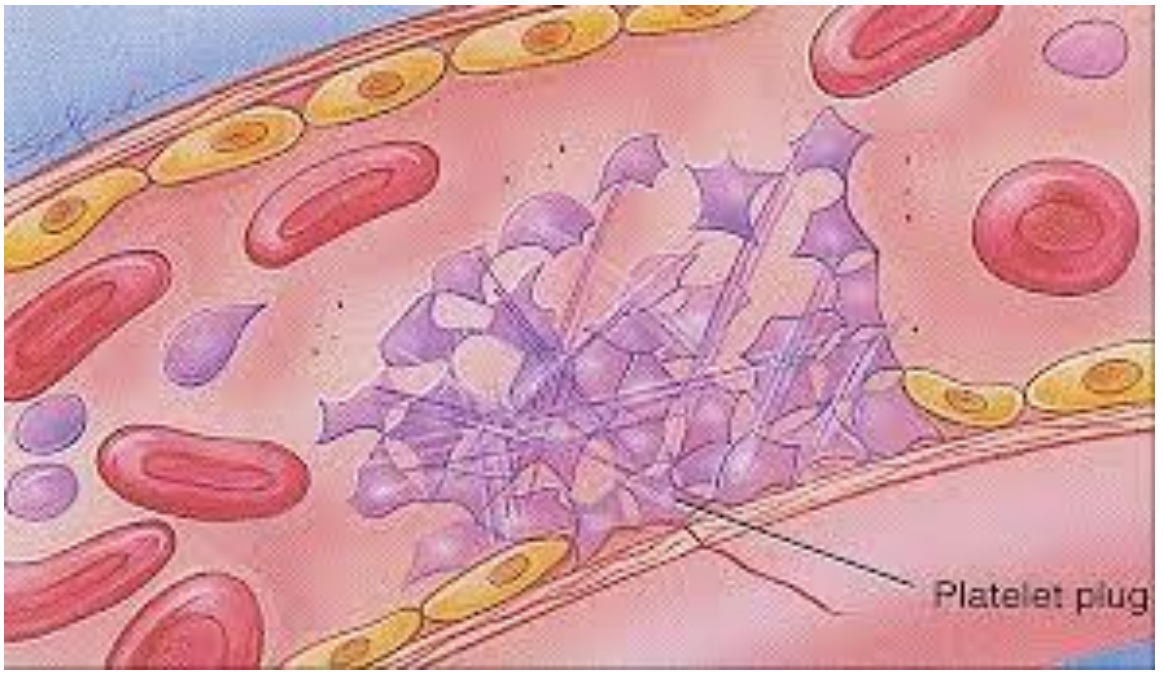
- direct injury to the smooth muscle cells, stimulation of local pain receptors, and release of serotonin by anchored platelets
- Spasms narrow the BV at that point decreasing blood loss until clotting occur.



2) Platelet plug formation

- Collagen fibers are exposed by a break in a BV.
- Platelets become “sticky” and cling to fibers (damaged site).
- Anchored platelets release chemicals to aqract more platelets to the site.

•Platelets pile up to Form a **platelet plug**.



3) Coagulation

- Injured tissue factor (TF).
- PF3 (a phospholipid) coating platelets interacts with TF, vitamin K, blood protein clotting factors, and calcium ions to form an activator that triggers the *clotting cascade.*
- Prothrombin activator converts prothrombin to thrombin (an enzyme).

•Thrombin joins soluble fibrinogen forming insoluble fibrin, which then forms a Mesh that traps the RBCs and forms the basis of the clot.

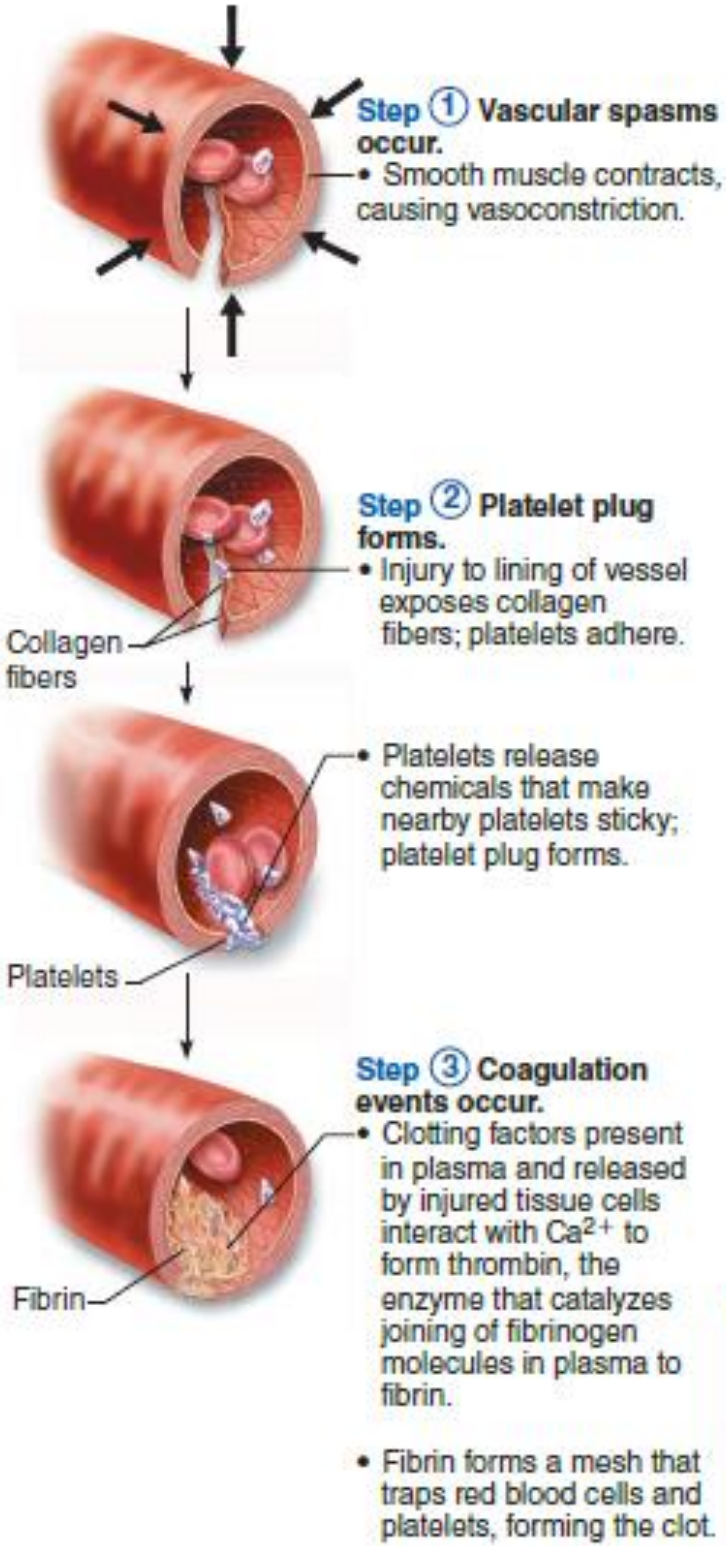
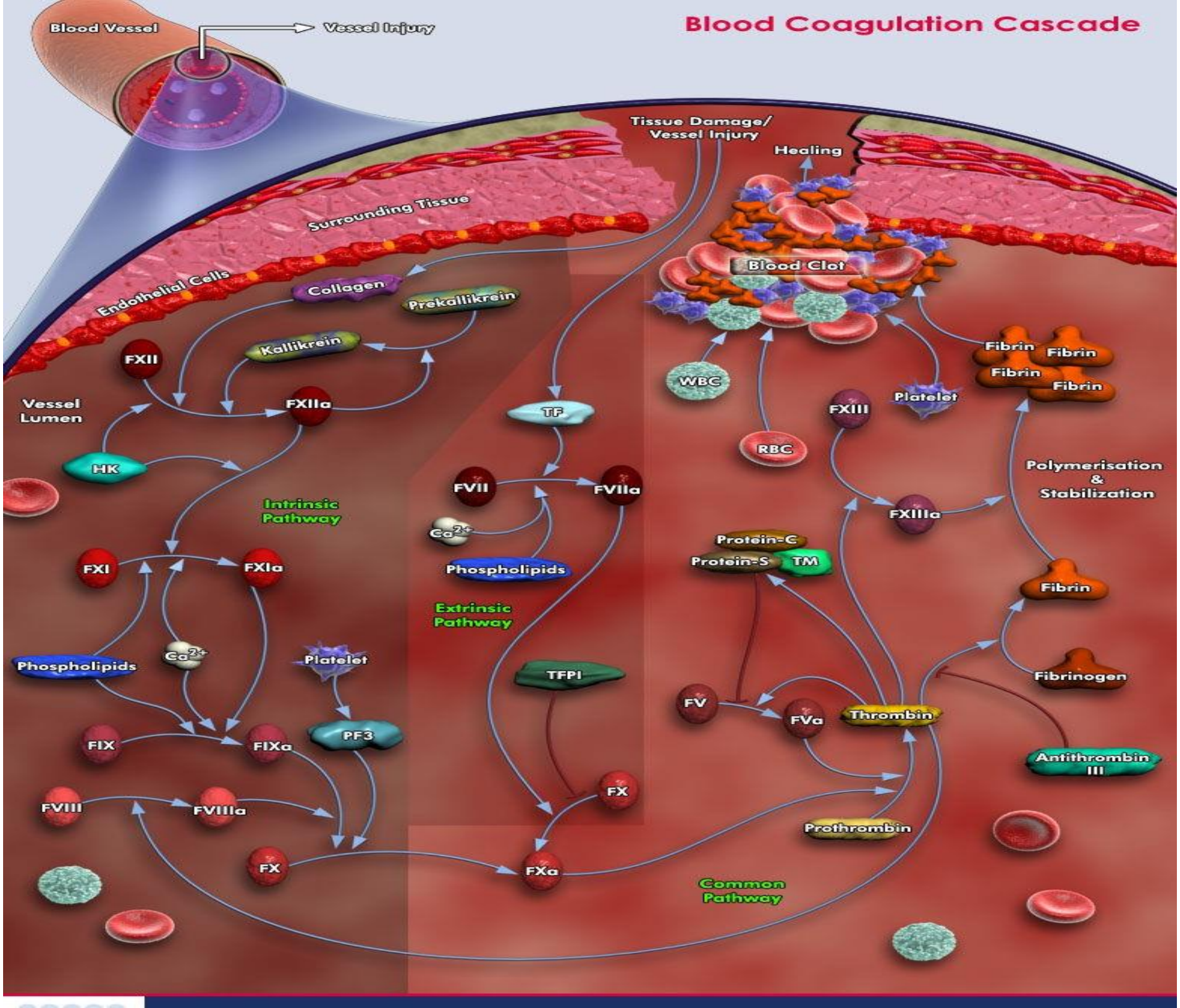


Figure 10.6 Events of hemostasis.

Blood clotting

- Blood usually clots within 3-6 minutes.
- Once the clotting cascade has started, the triggering factors are rapidly inactivated to prevent widespread clotting.
- endothelium regenerates and the clot is broken down.


Blood Coagulation Cascade
Blood Vessel
Vessel Injury
Tissue Damage/
Vessel Injury
Healing
Surrounding Tissue
Endothelial Cells
Blood Clot
Collagen
Prekallikrein
Kallikrein
FXII
FXIIa
Vessel
Lumen
HK
Intrinsic
Pathway
FXI
FXIa
Phospholipids
Ca2+
Platelet
FIX
FIXa
PF3
FVIII
FVIIIa
FX
FXa
TF
FVII
FVIIa
Ca2+
Phospholipids
Extrinsic
Pathway
TFPI
FX
Common
Pathway
Prothrombin
Thrombin
FV
FVa
WBC
RBC
Platelet
FXIII
FXIIIa
Fibrin
Fibrin
Fibrin
Fibrin
Polymerisation
&
Stabilization
Protein-C
Protein-S
TM
Fibrin
Fibrinogen
Antithrombin
III

Undesirable clotting

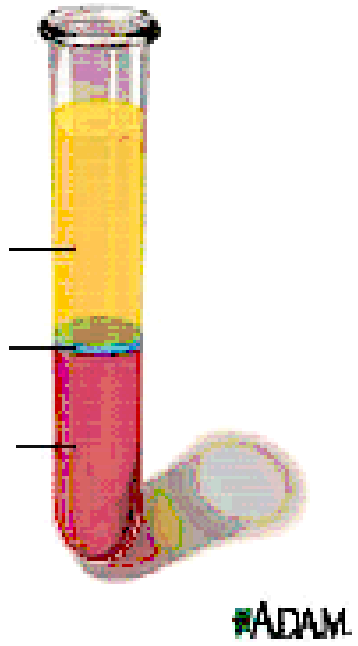
- Thrombus:

A clot in an unbroken BV. Can be deadly in areas like the heart.

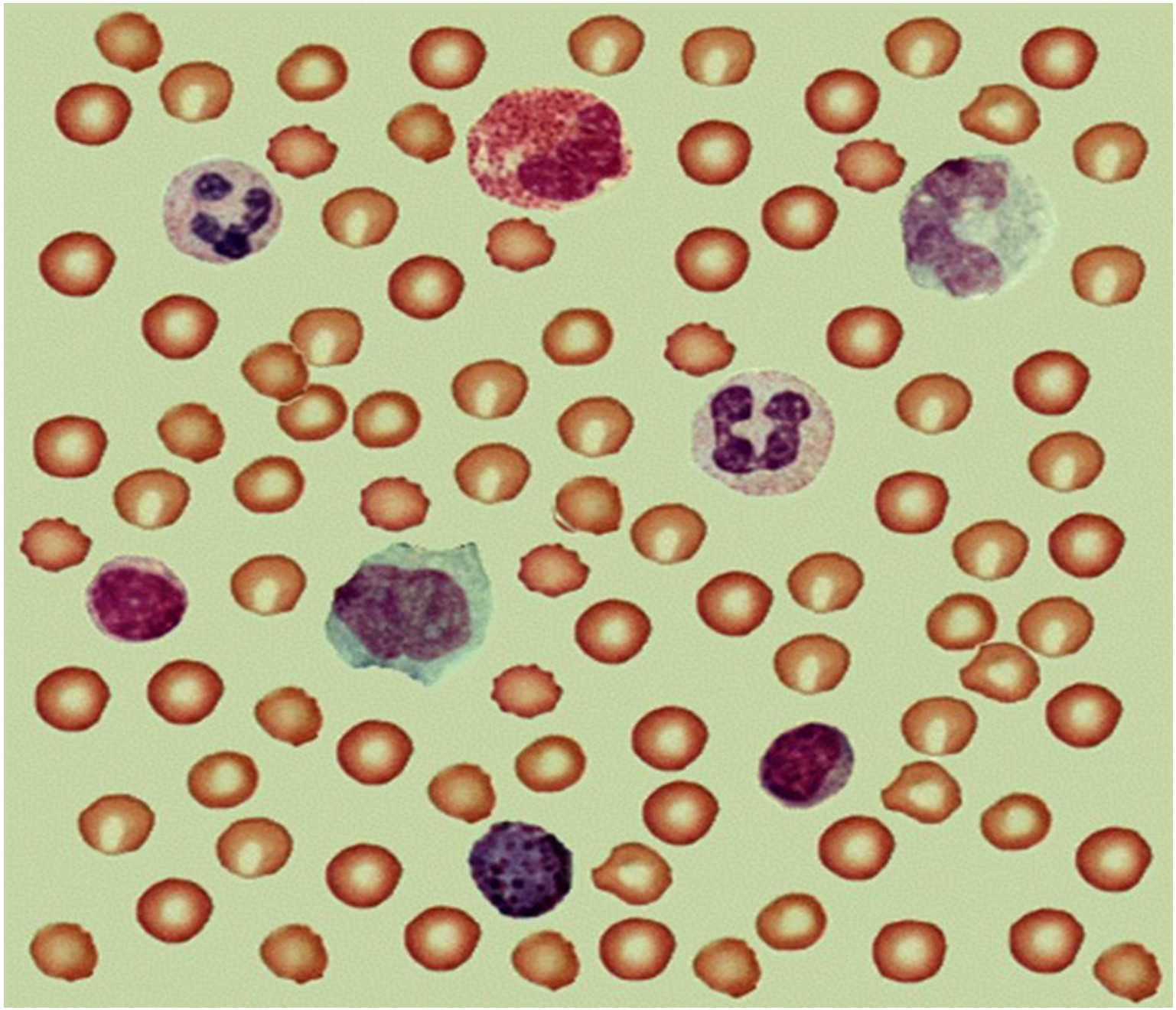
- Embolus:

A thrombus that breaks away and floats freely in the bloodstream. Can later clog vessels in criFcal areas such as the brain

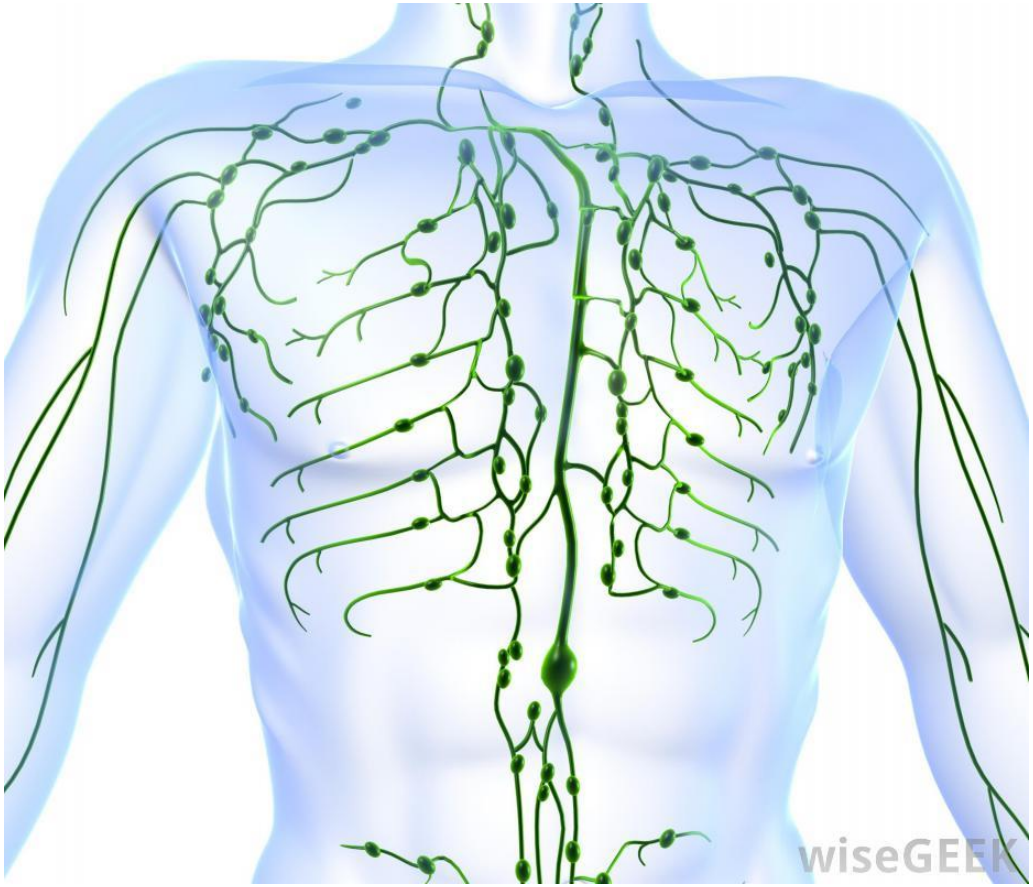
Name the parts of the blood?



Identify cells

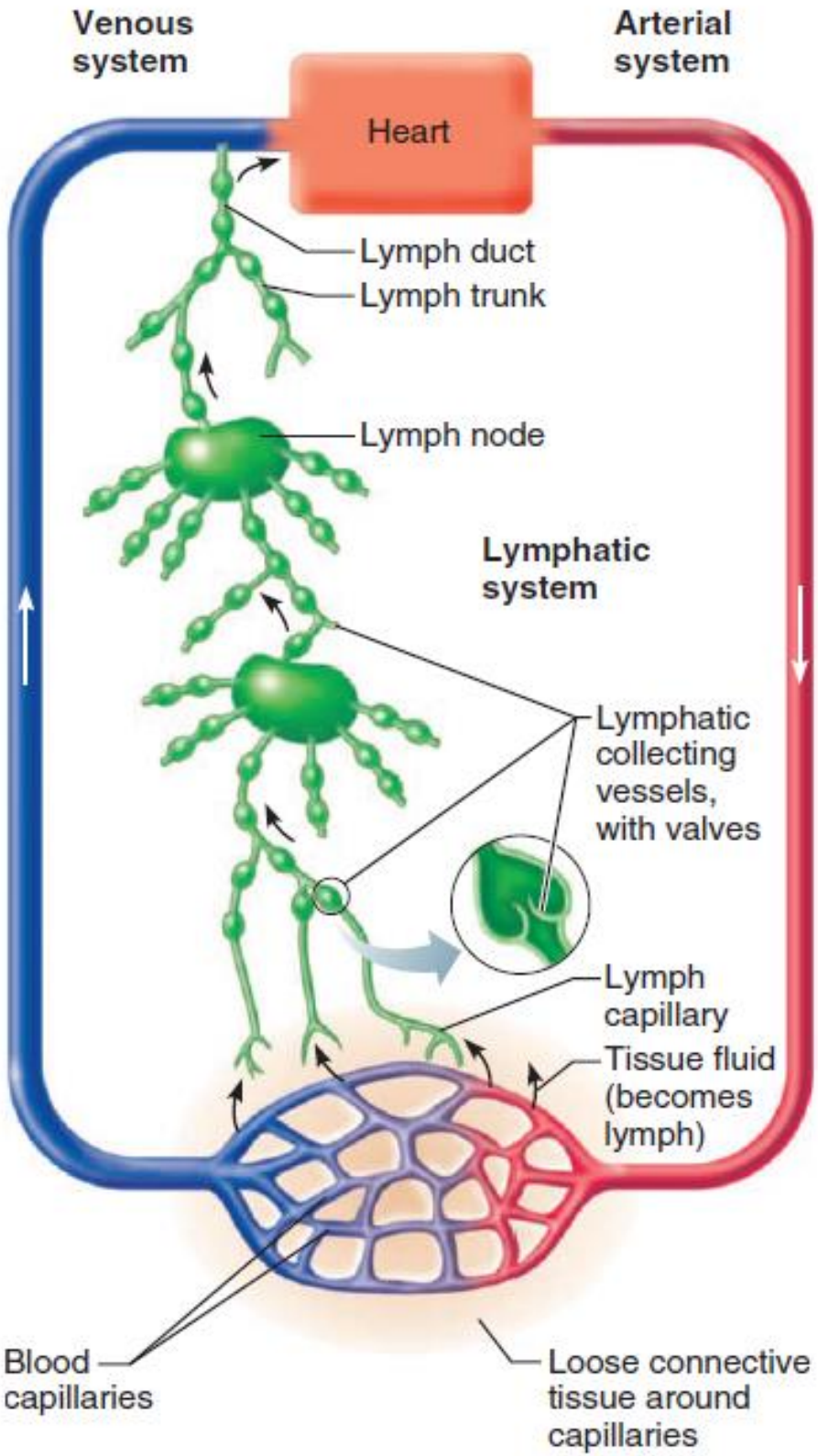


Lymphatic System (chapter 12)



Introduction

- Components
  - **Lymph** is the fluid.
  - Network of lymphatic vessels (**lymphatics**).
  - Lymphoid tissues and organs.
- Functions
  - Return tissue fluid to the bloodstream.
  - Transport fats from the digestive tract to the bloodstream.
  - Surveillance & defense (lymphoid tissues and organs house phagocytic cells and lymphocytes).


Venous system
Arterial system
Heart
Lymph duct
Lymph trunk
Lymph node
Lymphatic system
Lymphatic collecting vessels, with valves
Lymph capillary
Tissue fluid (becomes lymph)
Blood capillaries
Loose connective tissue around capillaries

Lymphatic Vessels

- Originate as lymph capillaries
- Capillaries unite to form larger vessels
  - Resemble veins in structure
  - Connect to lymph nodes at various intervals
- Lymphatics ultimately deliver lymph into 2 main channels
  - Right lymphatic duct
    - Drains right side of head & neck, right arm, right thorax
    - Empties into the right subclavian vein
  - Thoracic duct
    - Drains the rest of the body
    - Empties into the left subclavian vein

Lymphatic Vessels

The function of the lymphatic vessels is to form a drainage system that picks up this excess tissue fluid. This fluid is called lymph (clear water), and vessels returns it to the blood.

Lymphatic Vessels

- lymph flows only toward the heart.
- lymph capillaries sound between the tissue cells and blood capillaries in the loose connective tissues of the body and absorb the leaked fluid.
- the edges of the endothelial cells forming their walls loosely overlap one another, forming flaplike *minivalves* that act as one-way door.
- gape open when the fluid pressure is higher in the interstitial space, allowing fluid to enter the lymphatic capillary.
- when the pressure is higher inside the lymphatic vessels, the endothelial cell flaps are forced together, preventing the lymph from leaking.

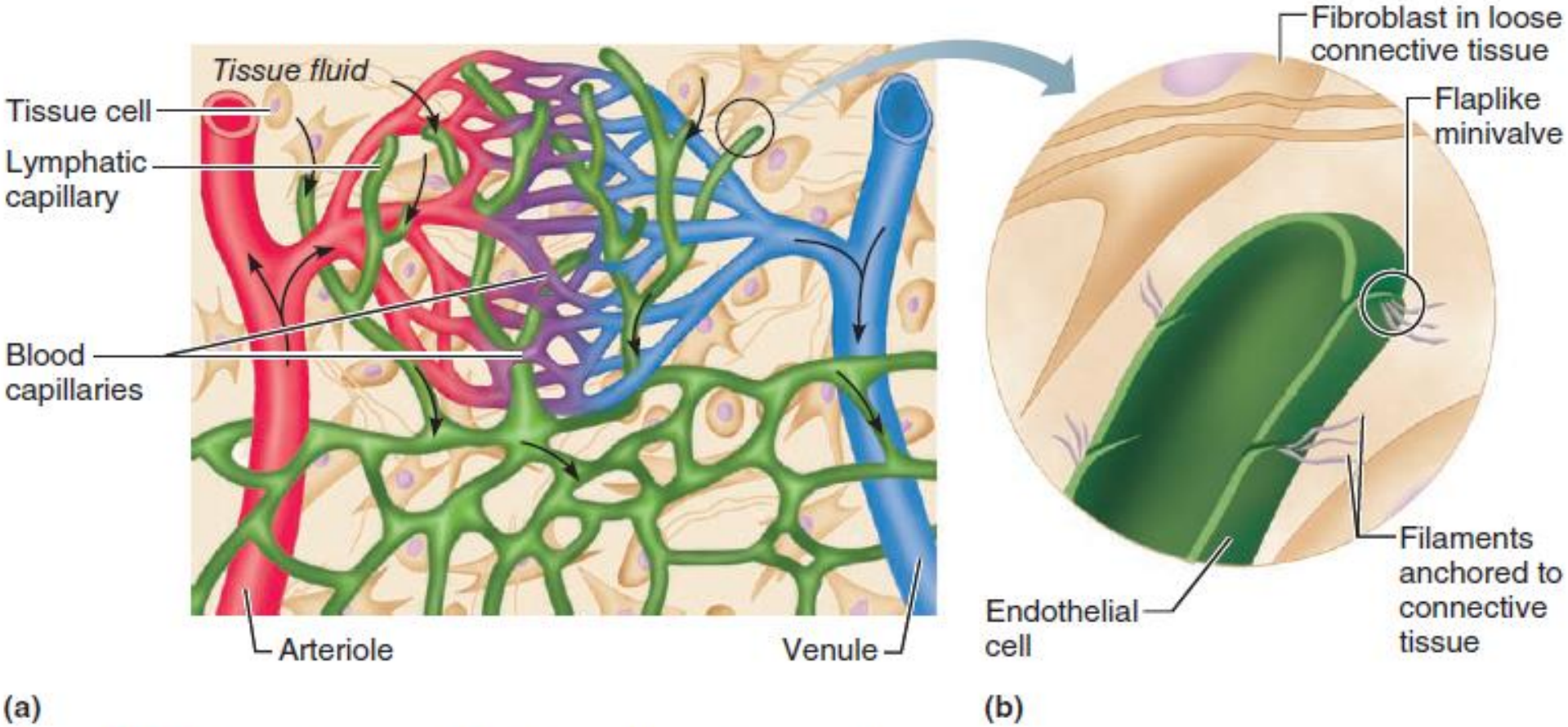


Figure 12.2 Special structural features of lymphatic capillaries.
(a) Structural relationship between blood capillaries and lymph capillaries. Black arrows indicate direction of fluid movement. **(b)** Lymph capillaries begin as blind-ended tubes. The endothelial cells forming their walls overlap one another, forming flaplike minivalves.

Lymph Nodes

- Oval structures located along lymphatics
- Enclosed by a fibrous capsule
- Cortex = outer portion
  - Germinal centers produce lymphocytes
- Medulla = inner portion
  - Medullary cords
- Lymph enters nodes through afferent lymphatics, flows through sinuses, exits through efferent lymhpatic

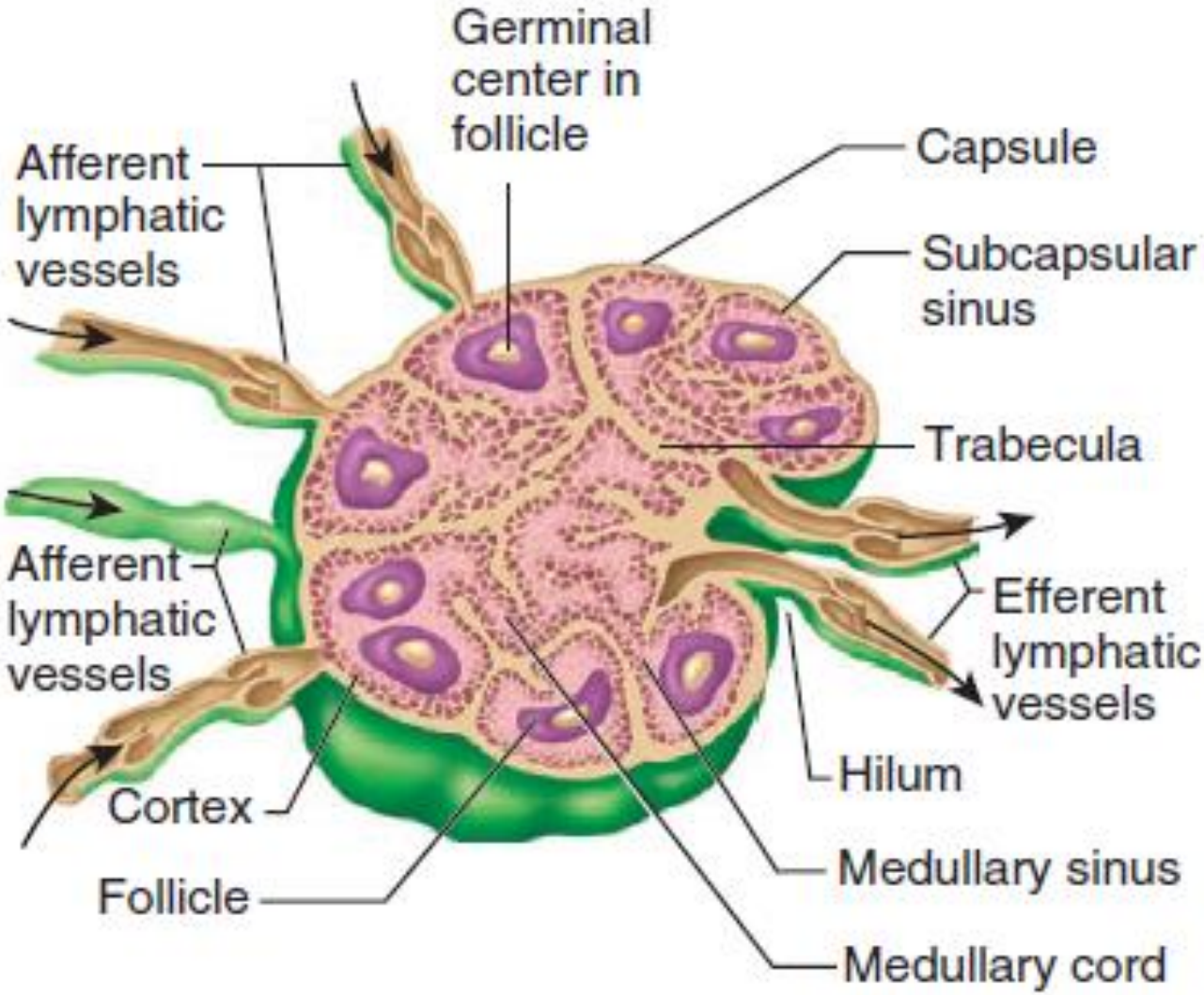
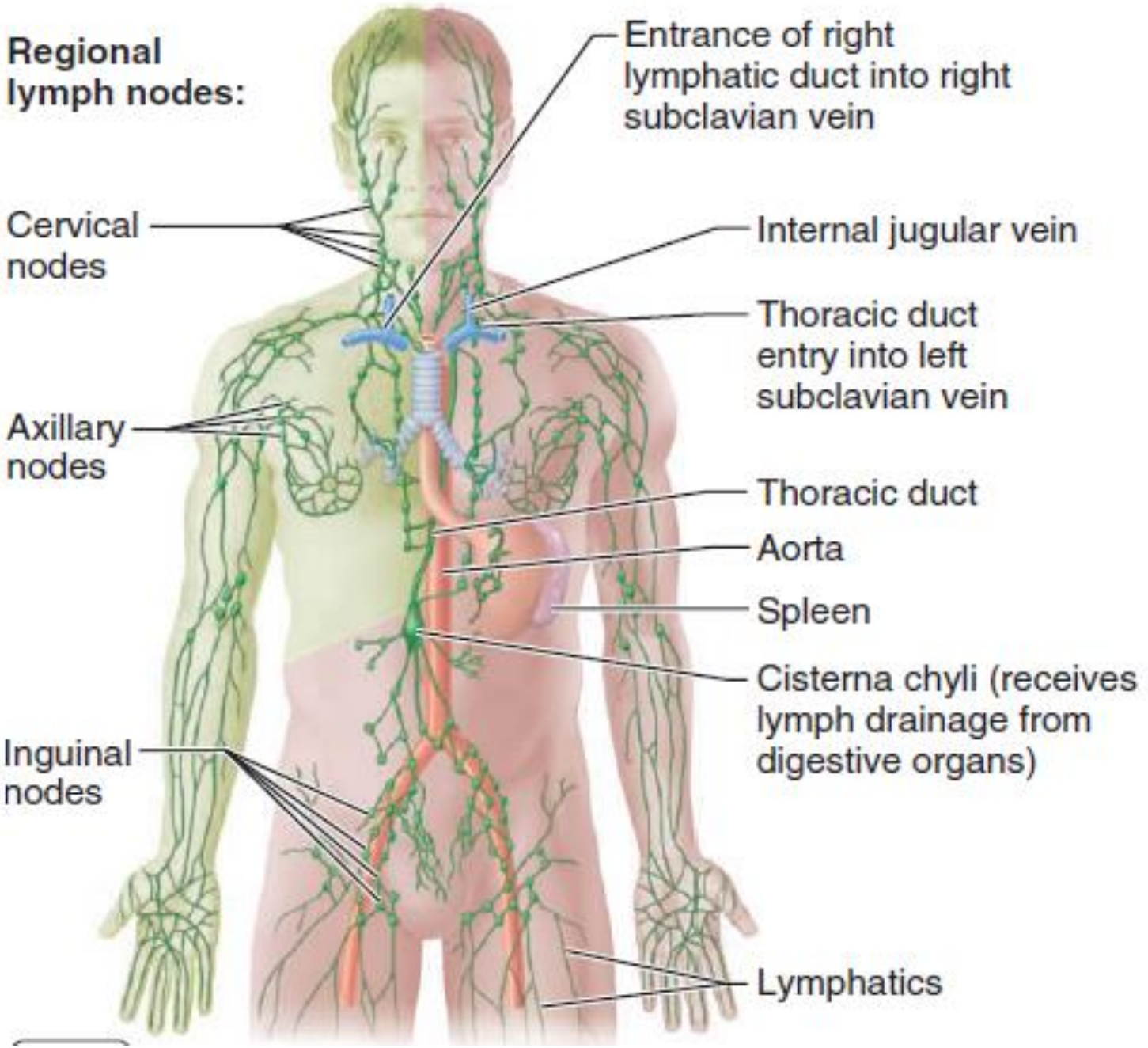


Figure 12.4 Structure of a lymph node.
Longitudinal section of a lymph node and associated lymphatics. Notice that several afferent lymphatics enter the node, whereas fewer efferent lymphatics exit at its hilum.

Lymph Nodes

- lymph nodes help protect the body by removing foreign material from the lymph (macrophages) and by producing lymphocytes that function in the immune response.


Regional lymph nodes:
Entrance of right lymphatic duct into right subclavian vein
Cervical nodes
Internal jugular vein
Thoracic duct entry into left subclavian vein
Axillary nodes
Thoracic duct
Aorta
Spleen
Cisterna chyli (receives lymph drainage from digestive organs)
Inguinal nodes
Lymphatics

Other Lymphoid Organs

- spleen, thymus, tonsils, Peyer's patches and appendix.
- The common feature of all these organs is a predominance of reticular connective tissue and lymphocytes.
- Although all lymphoid organs have roles in protecting the body, only the lymph nodes filter lymph.

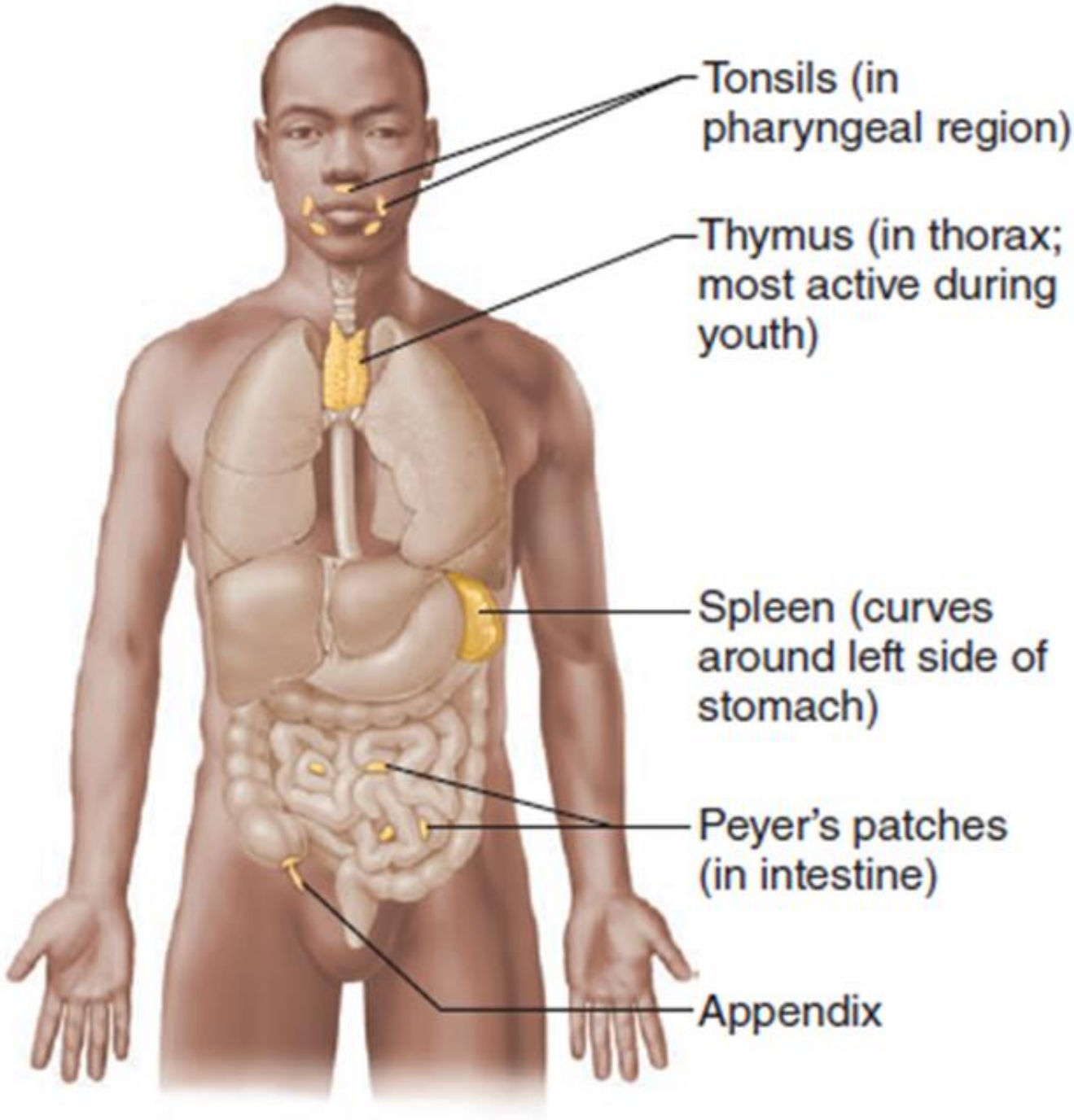
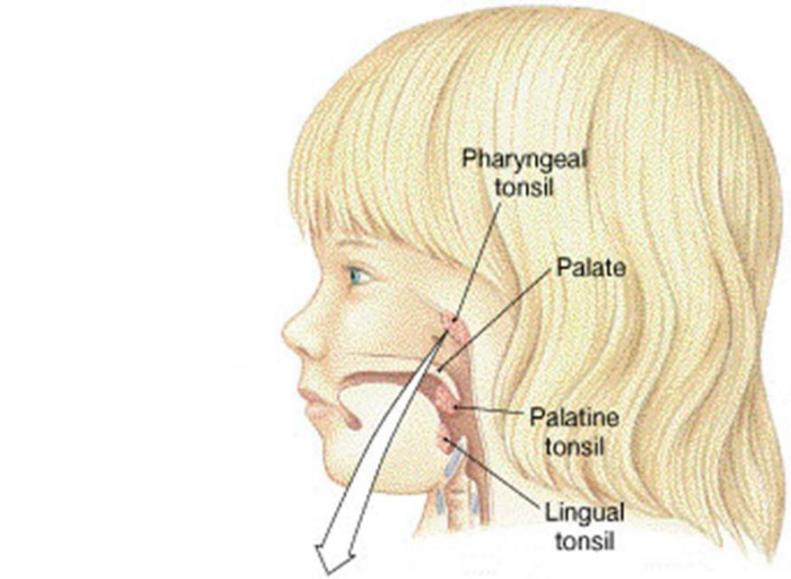
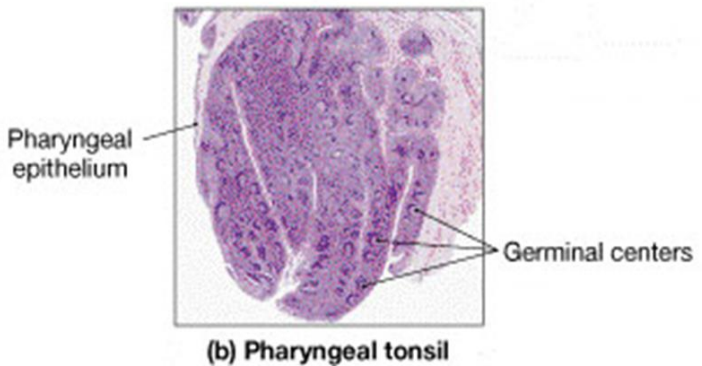


Figure 12.5 Lymphoid organs. Locations of the tonsils, spleen, thymus, Peyer's patches, and appendix.

Tonsils

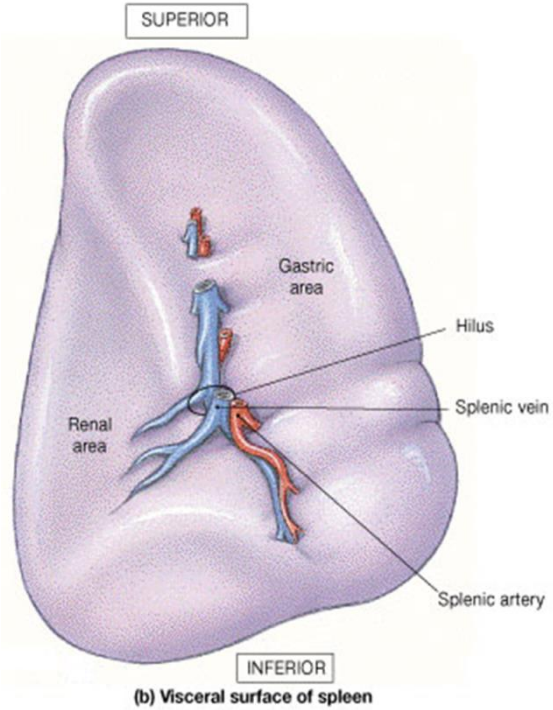
- Multiple groups of large lymphatic nodules
- Location – mucous membrane of the oral and pharyngeal cavities





Spleen

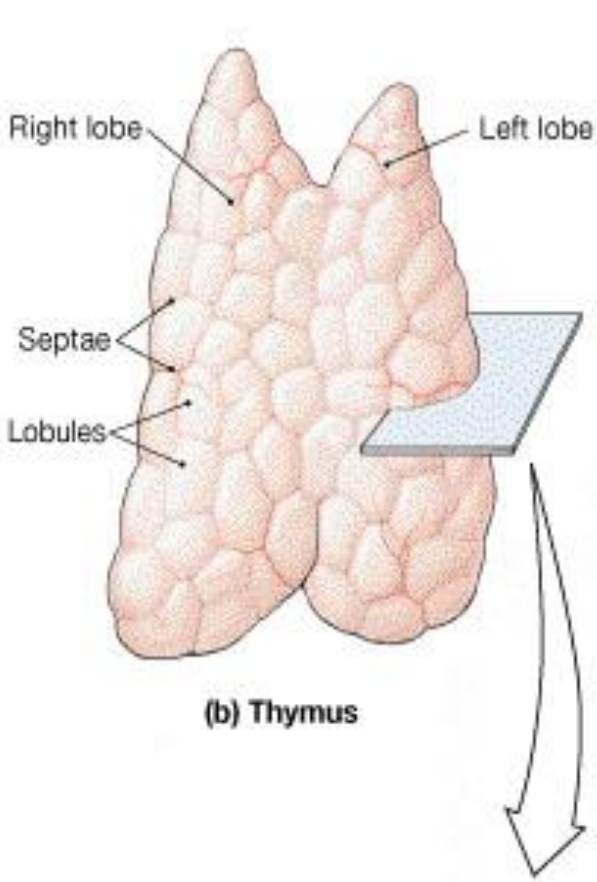
- Largest lymphatic organ
- Located between the stomach & diaphragm
- Functions
  - Filters blood
  - Stores blood



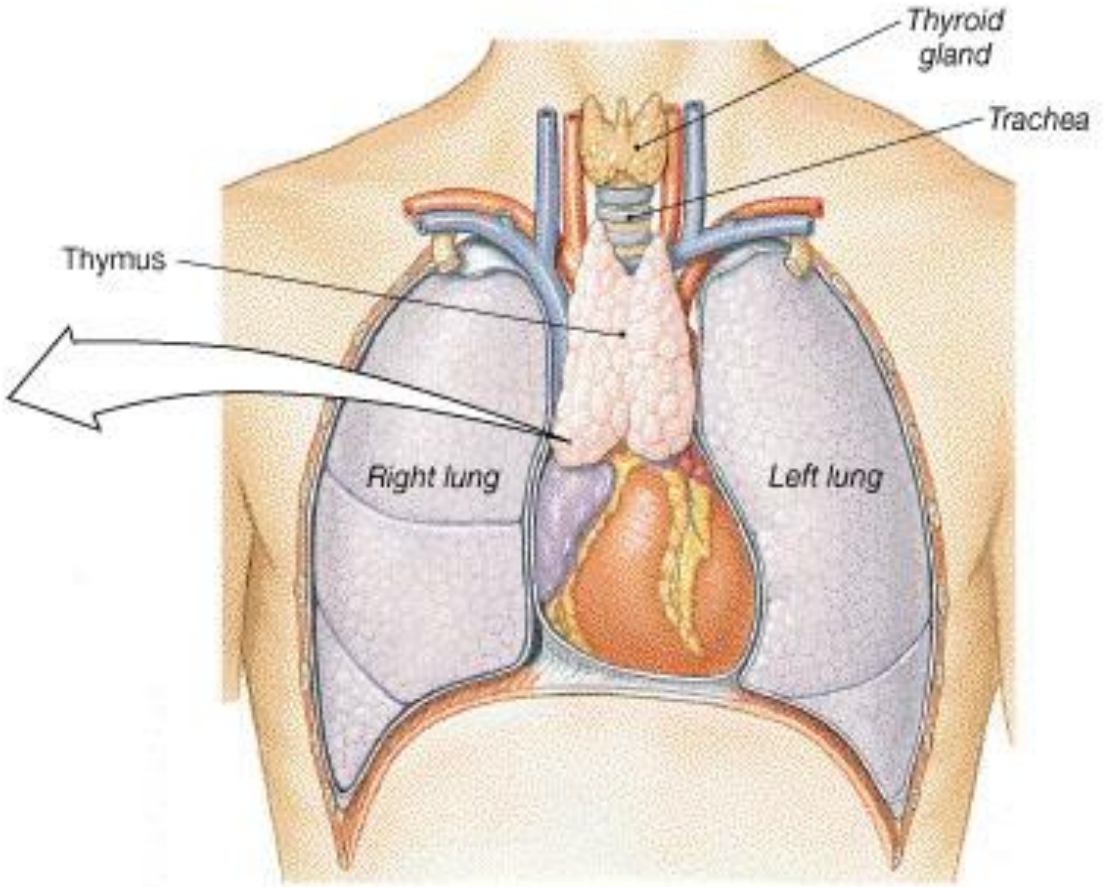
(b) Visceral surface of spleen

Thymus Gland

- Location – behind the sternum in the mediastinum
- The capsule divides it into 2 lobes
- Development
  - Infant – prominent
  - Puberty – maximum size
  - Maturity – decreases in size
- Function
  - Differentiation and maturation of T cells



(b) Thymus



(a) Location of thymus within thoracic cavity

Peyer’s patches & appendix

- found in the wall of the distal part of the small intestine.
- The macrophages of Peyer’s patches and the appendix are in an ideal position to capture and destroy bacteria (always present in tremendous numbers in the intestine), thereby preventing them from penetrating the intestinal wall.

Function of the Lymphatic System

- Defense against harmful organisms and chemicals
- 2 types of defense
  - Nonspecific
  - Specific
- Specific defense = immunity
  - Humoral immunity involves B cells that become plasma cells which produce antibodies that bind with specific antigens.
  - Cell-mediated immunity involves T cells that directly destroy foreign cells

BODY DEFENSES

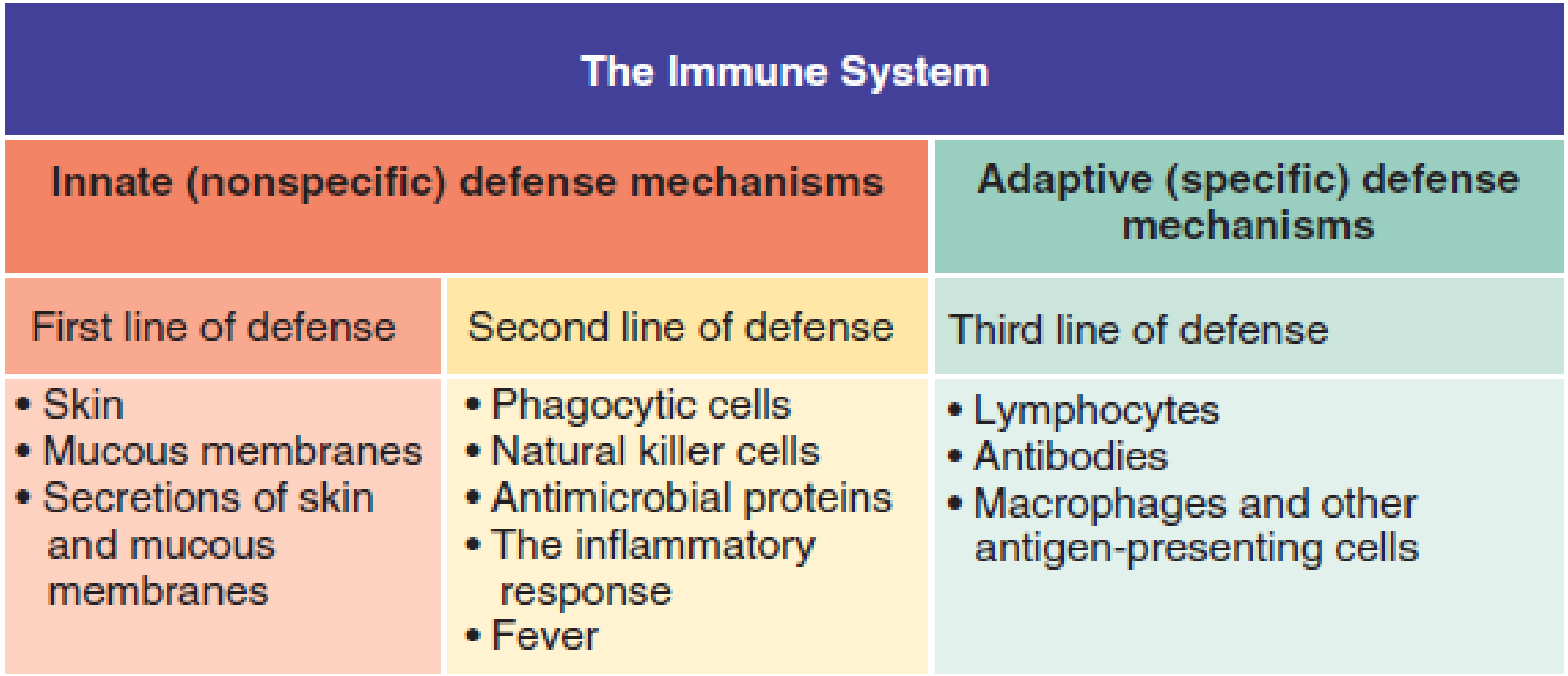


Figure 12.6 An overview of the body's defenses.