Blood Cells

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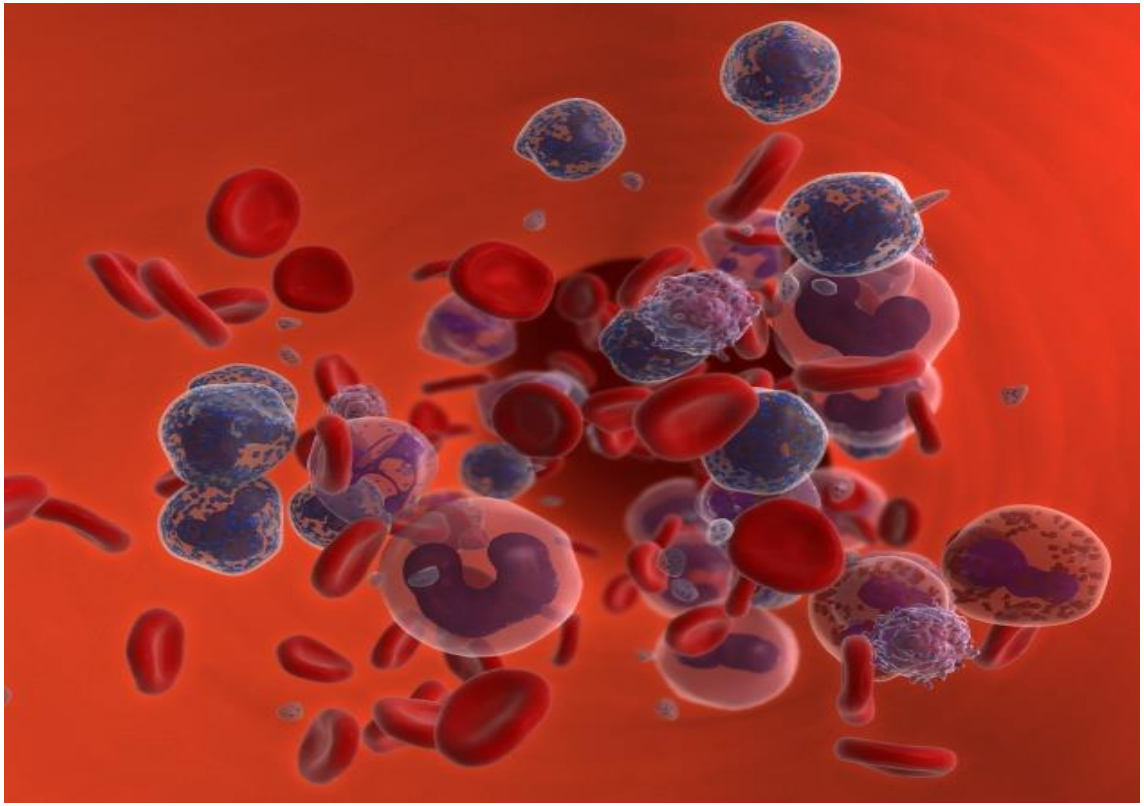
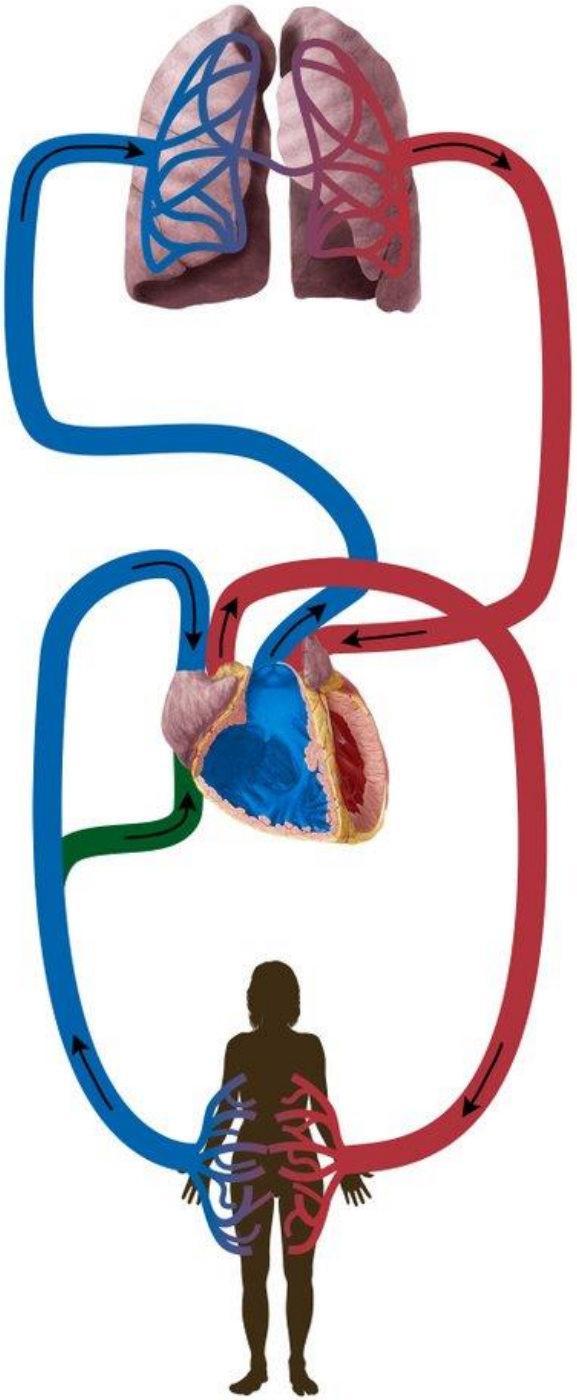
Blood

- Specialized form of **connective tissue**
- Components:
  - Blood cells (several types)
  - Plasma (extracellular matrix)





Functions of Blood

- Transports nutrients and respiratory gases
- Transports waste products to organs and tissues where they can be recycled or released
- Transports hormones
- Transports immune cells throughout the body
- Helps regulate body temperature
- Maintains of acid-base and osmotic balance

✓ pH of 7.4
✓ Color is dependent on amount of Oxygen
More oxygen = brighter the red
Less oxygen = duller the red

Blood is propelled mainly by rhythmic contractions of the heart

About **5-6 Liters** of blood in an average adult moves unidirectionally within the closed circulatory system

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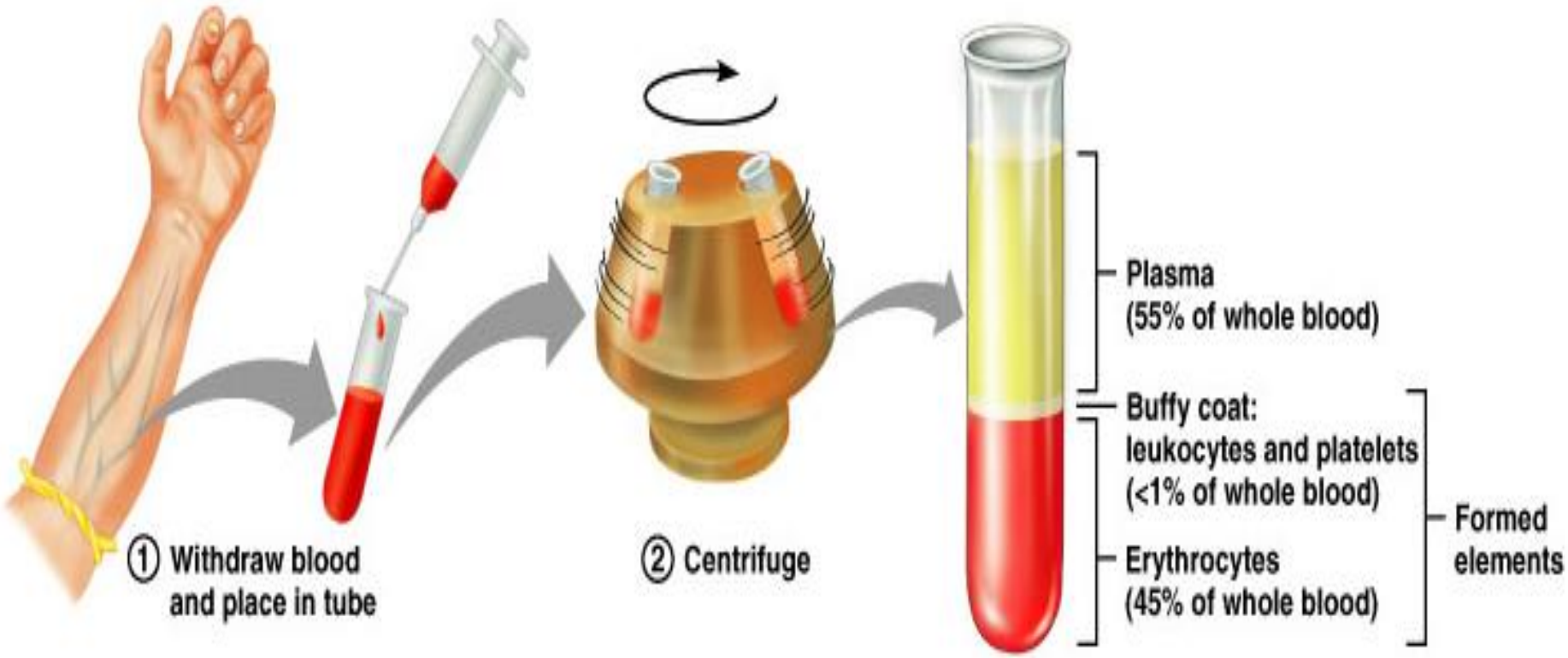


Collected blood in which clotting is prevented by the addition of anticoagulants (eg, heparin , citrate or EDTA) can be separated by centrifugation into layers that reflect its heterogeneity

Physical Characteristics

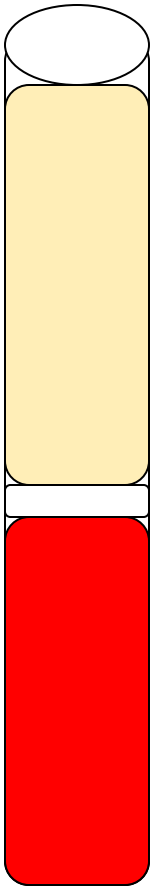
HEMATOCRIT: Ratio of the volume of RBCs to the volume of whole blood

Example: a hematocrit value of 40% means that there are 40 ml of RBCs in 100 ml of whole blood

Normal hematocrit:
Males=40-53%
Females= 36-48%

Fluid

- **Living 45%**
  - Cells (**formed elements**)
    - RBC **Erythrocytes** (carry oxygen)
    - BUFFY COAT
      - WBC **Leukocytes** (immune)
      - Platelets **Thrombocytes** (clotting)
- **Non living (Matrix) 55%**
  - Plasma (pale yellow fluid)
    - 90% water
    - 10 % (electrolytes, nutrients, proteins (albumin), waste (CO_2, ammonia, urea), gases, hormones)

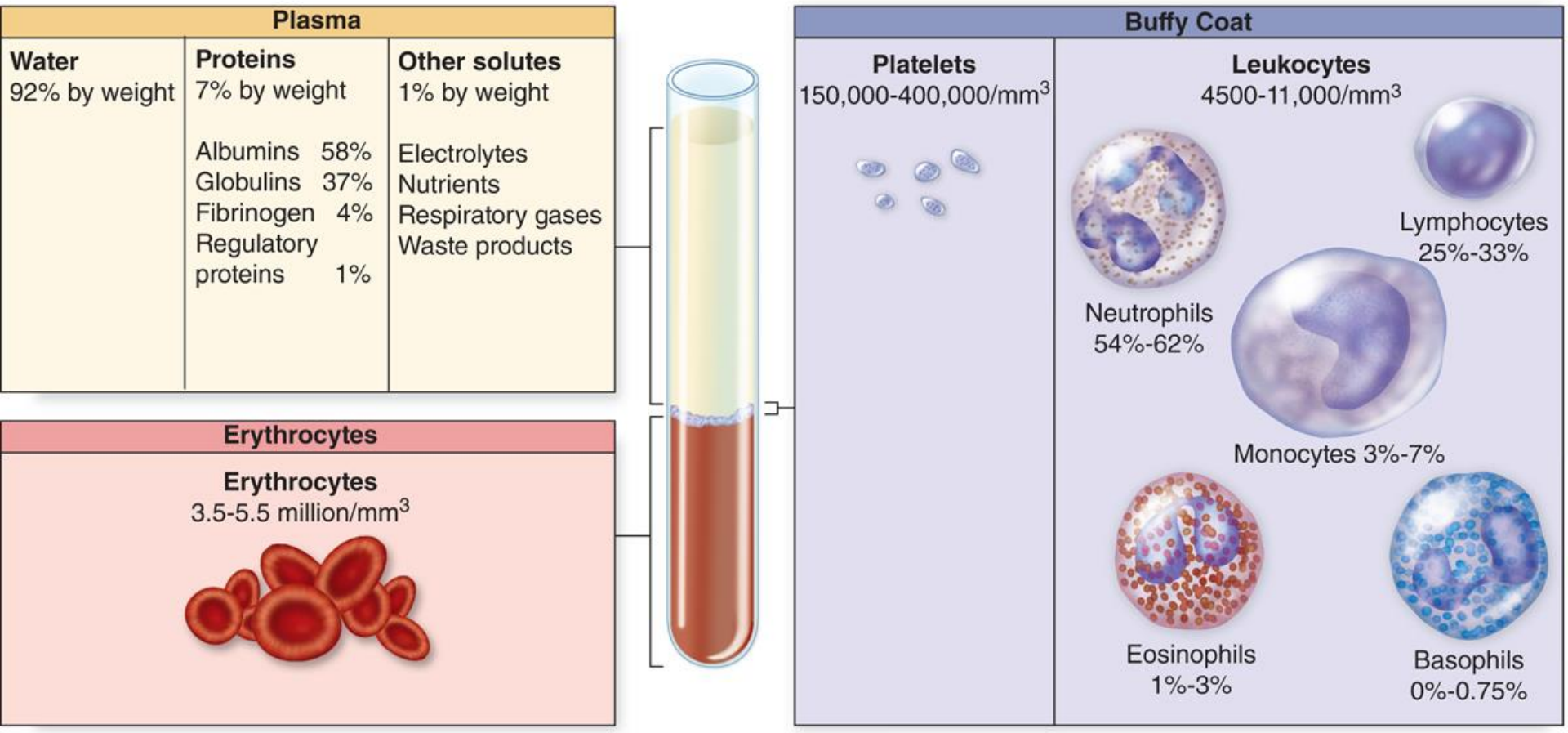


Top layer= plasma

Middle layer= buffy coat

Bottom layer=RBCs
(Packed Cell Volume)

Values are those used by the US National Board of Medical Examiners



Serum = everything in plasma, minus the clotting factors

Albumin:

✓ The most abundant plasma protein

✓Is made in the liver

✓Helps maintain the osmotic pressure in capillaries

✓Transports steroid hormones and fatty acids

Fibrinogen:

✓ The largest plasma protein

✓ Is made in the liver

✓Important for clot formation

Fresh plasma

The importance of proteins inside the plasma is to prevent fluid loss and to create osmotic pressure (to keep the blood inside the blood vessels)

Plasma cell

Globulins (α, β and or γ globulins):

α and β globulins

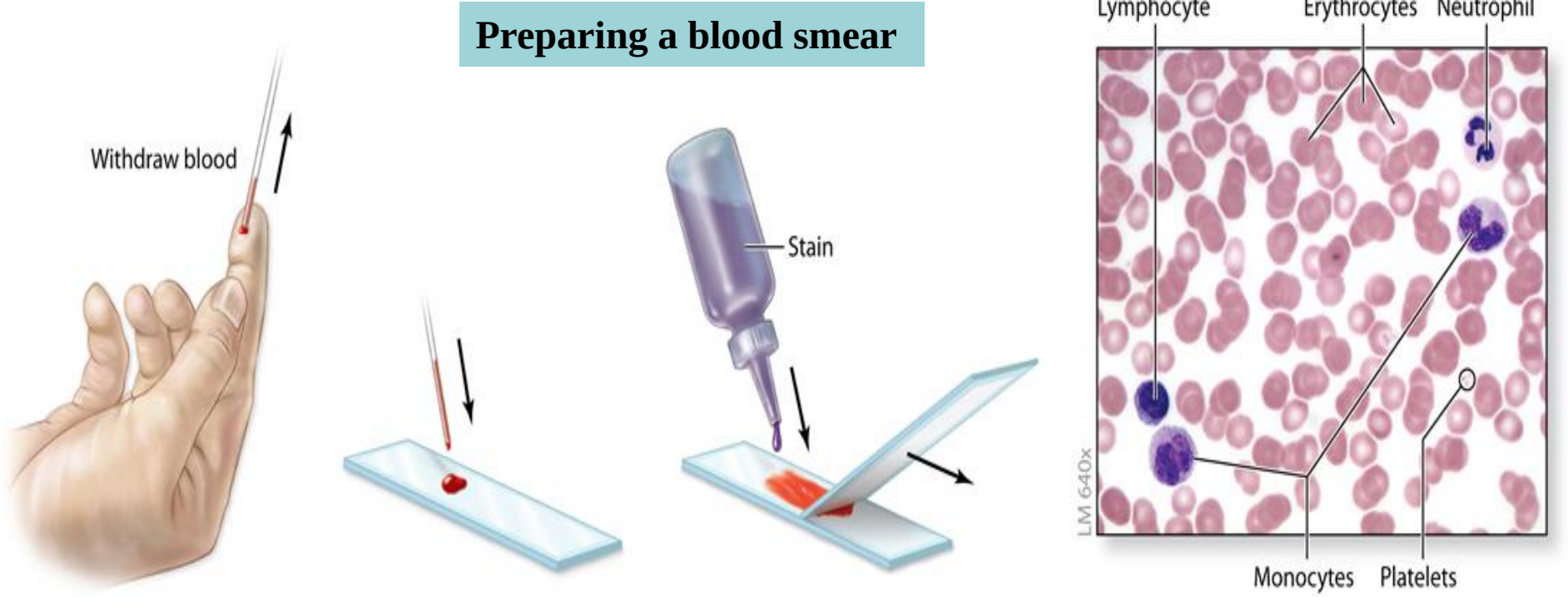
✓Are made mainly by liver

✓Transport fat soluble vitamins, lipids and iron

γ-globulins (Immunoglobulins (antibodies):

secreted by plasma cells

Preparing a blood smear



(1) Prick finger and collect a small amount of blood using a micropipette.

(2) Place a drop of blood on a slide.

(3a) Using a second slide, pull the drop of blood across the first slide's surface, leaving a thin layer of blood on the slide.

(3b) After the blood dries, apply a stain briefly and rinse. Place a coverslip on top.

(4) When viewed under the microscope, blood smear reveals the components of the formed elements.

Polychromatic stains:
Giemsa
Wright
Leishman

Blood cells can be studied histologically in smears prepared by spreading a drop of blood in a thin layer on a microscope slide

The Staining of Blood Cells

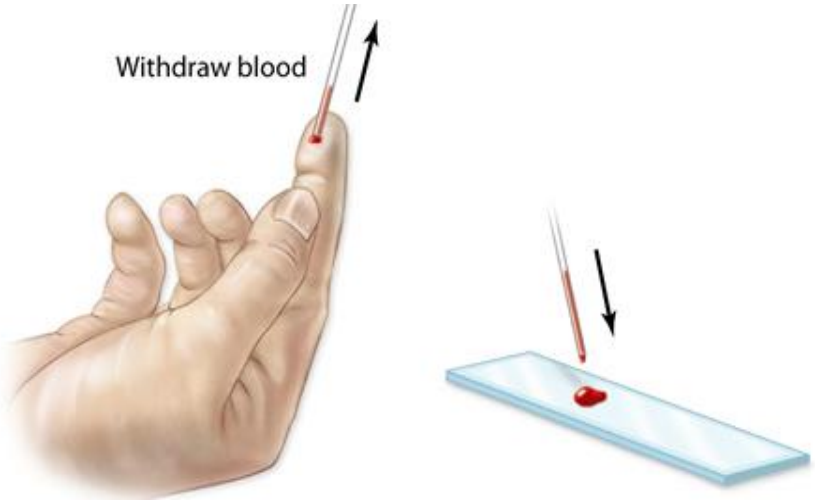
Blood film/ smear: a drop of blood is spread on a glass slide and left dry in air
Staining: with neutral stain e.g **Leishman's stain**

Leishman's stain: formed of a mixture of:

- **Eosin**, an acidic dye that stains pink to red
- **Methylene blue**, a basic dye that stains blue to purple

Dissolved in methyl alcohol (fixative)

Azure dye!!



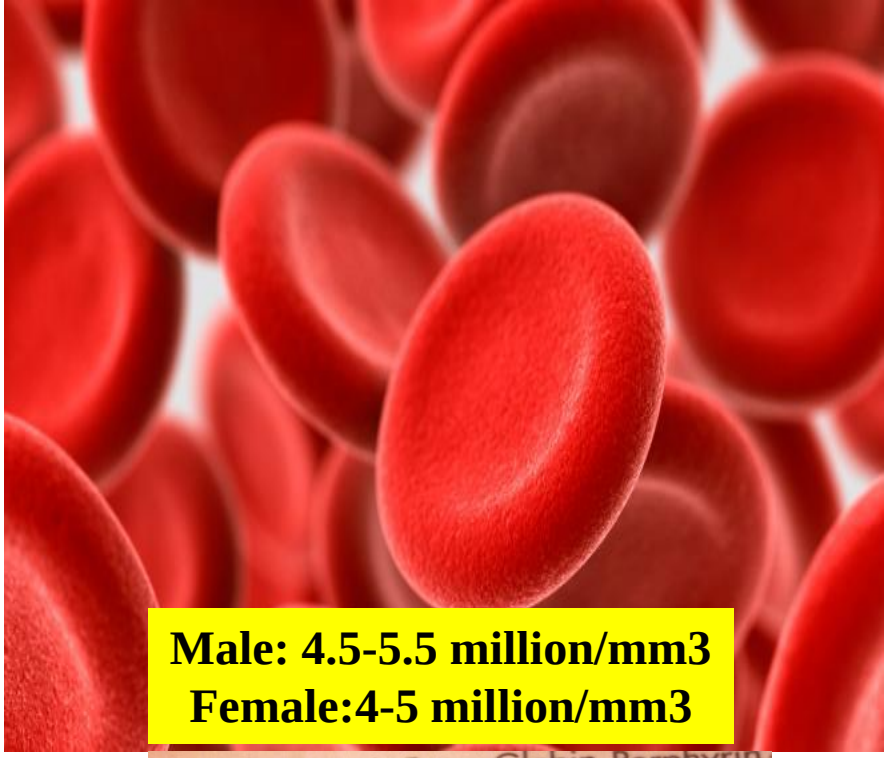
Blood film/smear

Erythrocytes (RBCs)

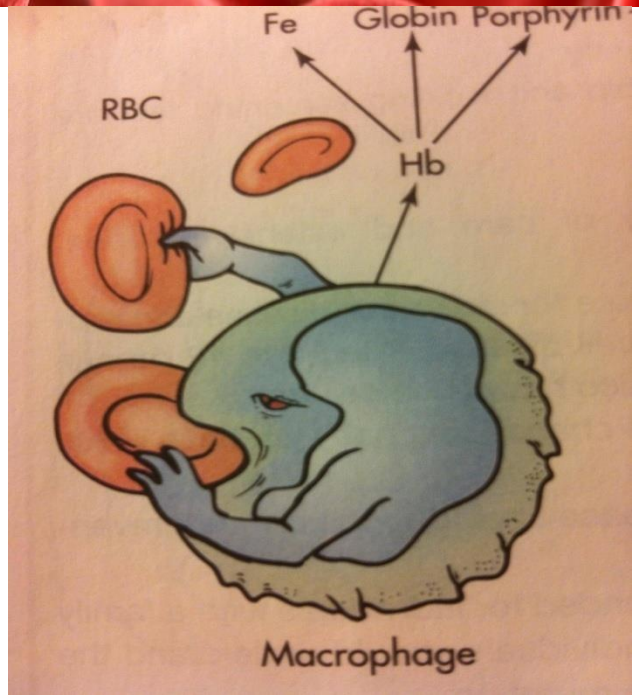
- Small, biconcave discs
- Transport oxygen and CO_2, cytoplasm is full of hemoglobin molecules
- Have no nuclei or organelles
- Pick up O_2 at lung capillaries and release it at body tissue capillaries

During their maturation process, the erythrocytes extrude their nuclei, and the mature RBCs enter the bloodstream, without their nuclei

- **Fate:** Survive for ~100-120 days in the circulation. Worn out RBCs are removed by macrophages of the spleen, bone marrow and liver.



Male: 4.5-5.5 million/mm3
Female:4-5 million/mm3



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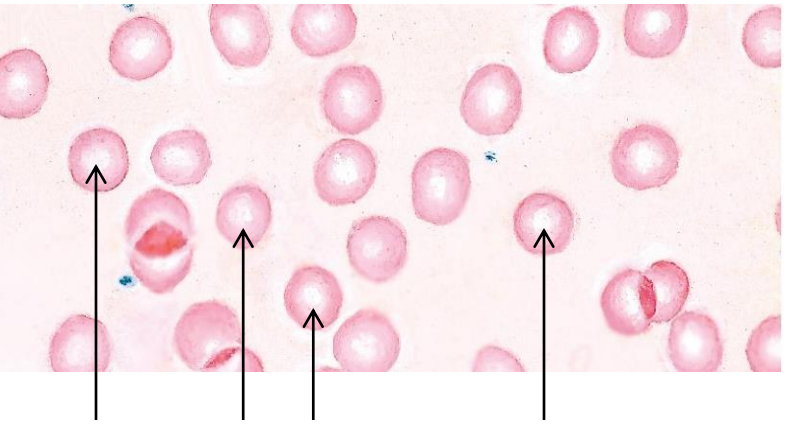
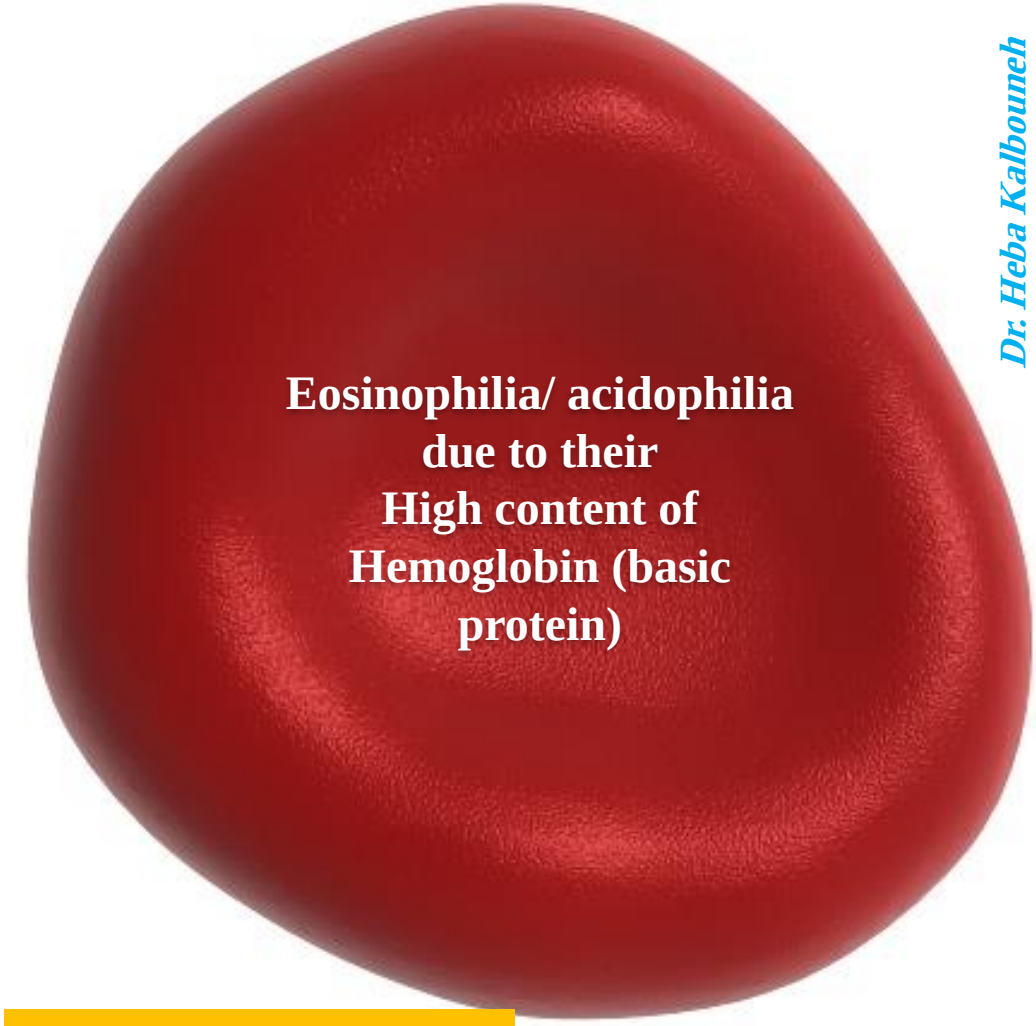
Biconcave shape provides 20-30% greater surface area than a sphere relative to cell volume, facilitating gas exchange

The biconcave shape along with the fluidity of the plasma membrane (50% proteins) permits erythrocytes to bend and adapt to the small diameters and irregular turns of capillaries

Erythrocyte consists of an **outer plasma membrane** enclosing hemoglobin and a **limited number of enzymes** necessary for maintenance of plasma membrane integrity and gas transport functions



The pale staining of the central region is a result of its biconcave disc shape ⟹ **Normochromic RBCs**

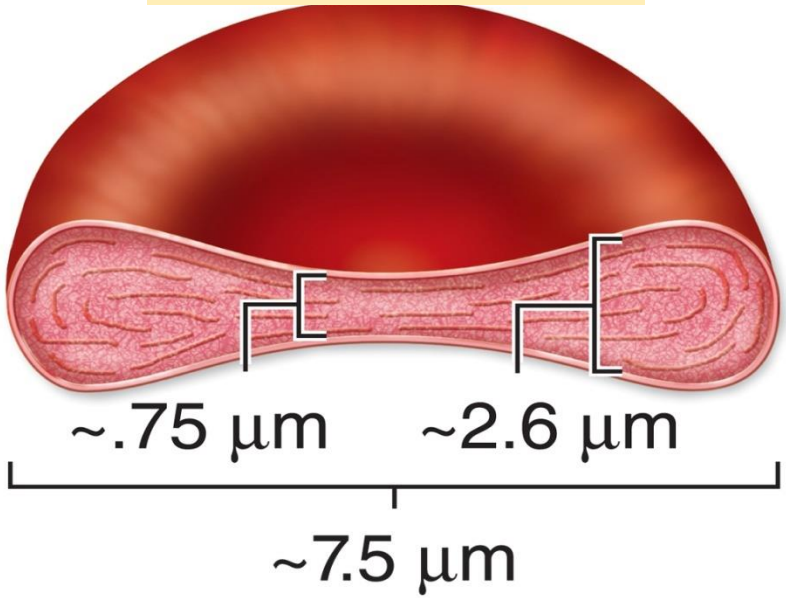


Immediately beneath the plasma membrane is a **meshwork of proteins** (Spectrin and Ankyrin) forming a cytoskeleton

This submembranous meshwork stabilizes the membrane, maintains the cell shape, and provides the cell elasticity required for passage through capillaries

Top view

Sectional view



Size

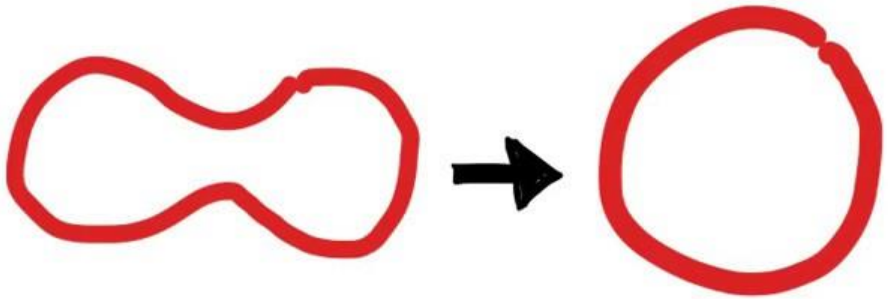
6-9 um in diameter (7.5 um)

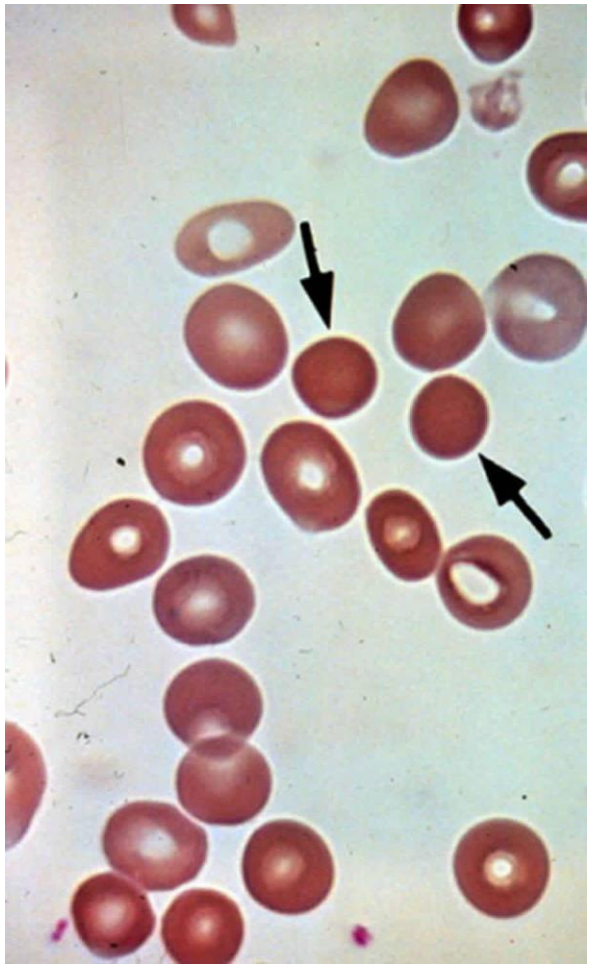
Thickness

2.6-µm thick at the rim, but only 0.75-µm thick in the center

!!!!! Erythrocytes can be used as a size reference for other cell types

Hereditary Spherocytosis





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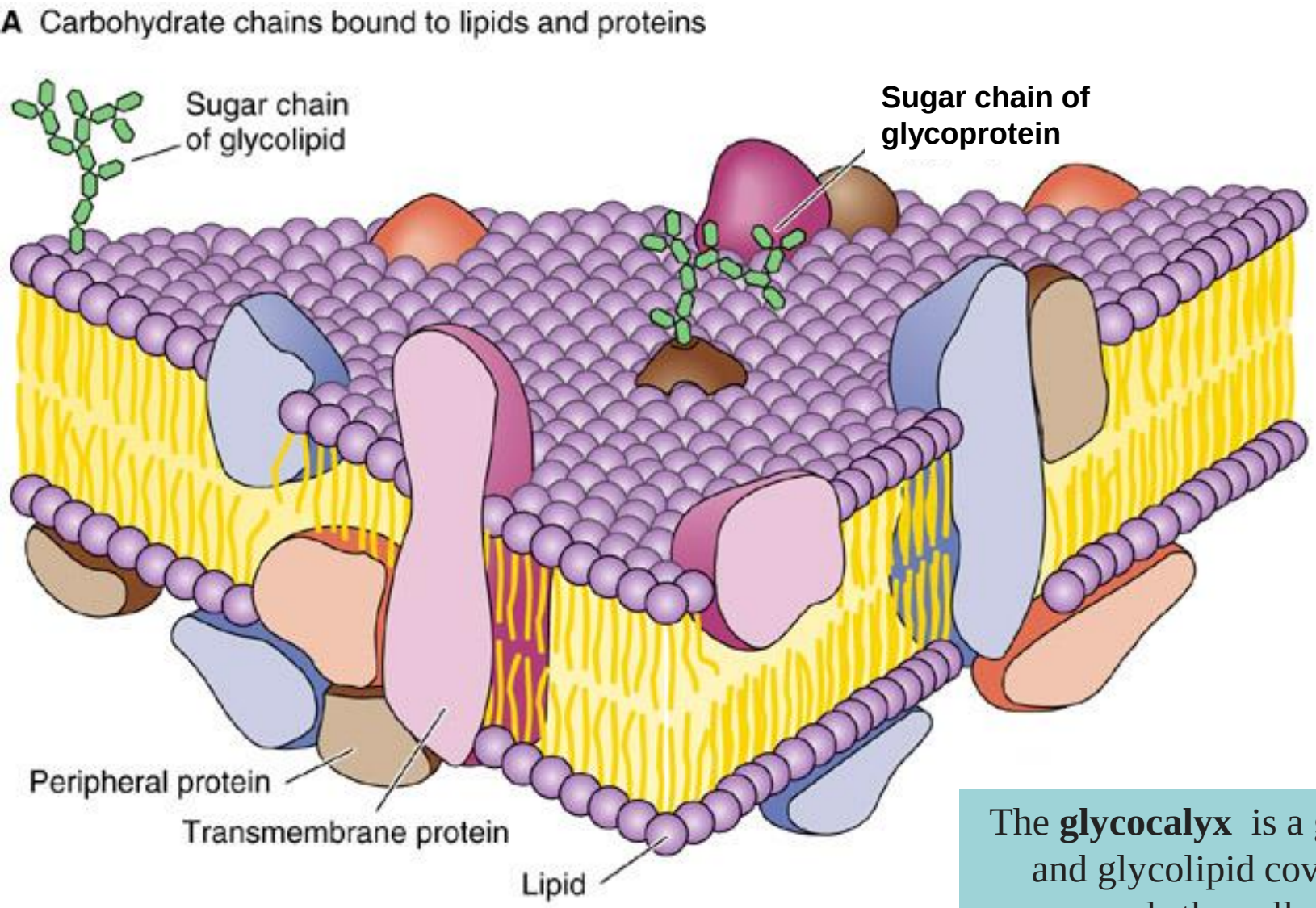
Caused by mutations in genes relating to membrane proteins (mostly Spectrin and Ankyrin) that allow for the erythrocytes to maintain their biconcave shape

Cell Membrane



The **glycocalyx** is a glycoprotein and glycolipid covering that surrounds the cell membranes

LM:

Blood film stained with Leishman:

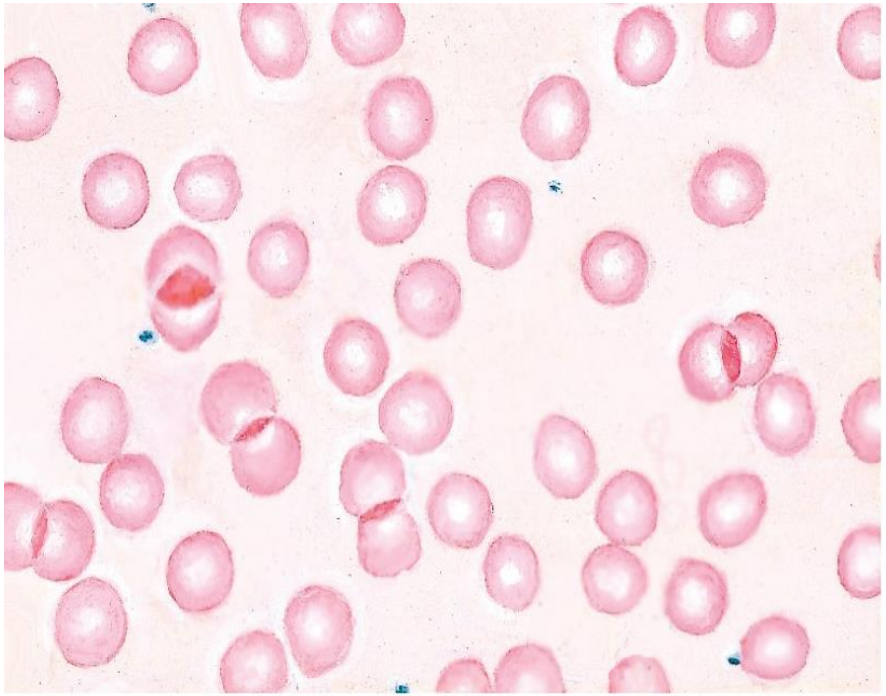
Rounded

Non nucleated

Acidophilic (with pale central area)

A zone of **central pallor** is about 1/3 the size of the RBC

LM



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EM:

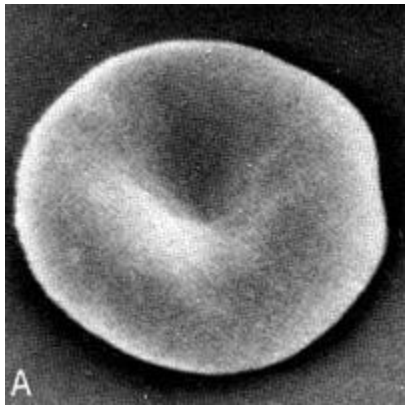
✓Have no nucleus or organelles

✓Filled with hemoglobin

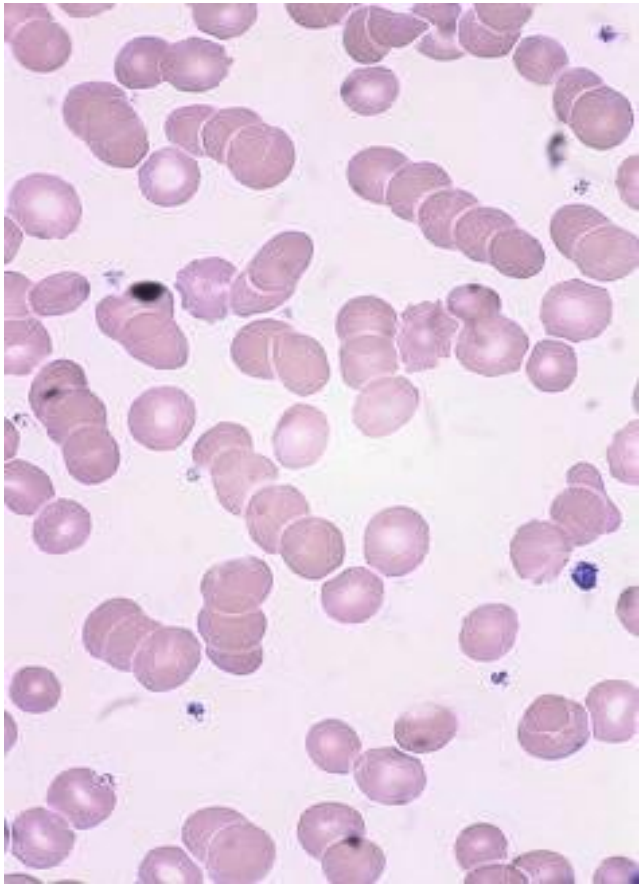
Electron dense and homogenous

TEM

SEM



Rouleaux appearance occurs to some extent in all films



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Rouleaux formation:

✓RBCs may adhere to one another loosely in stacks called Rouleaux (pile of coins)

✓In slow (not in normal) circulation

Due to surface tension caused by their biconcave surface (reversible)

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Abnormalities of Erythrocytes

Change from the normal **size**, **shape** or **staining properties** of erythrocytes are **important indicator of disease**. However, some of these abnormalities may be found in healthy individuals

Abnormal sizes:
Microcytes (<6um)
Macrocytes (>9um)
Anisocytosis (different sizes)

Abnormal shapes:
Due to changes either in the cell membrane or Hb content

Abnormal staining:
Hypochromia: Denotes a decrease in the intensity of staining
Indicates a decreased amount of hemoglobin
Frequently accompanies microcytosis

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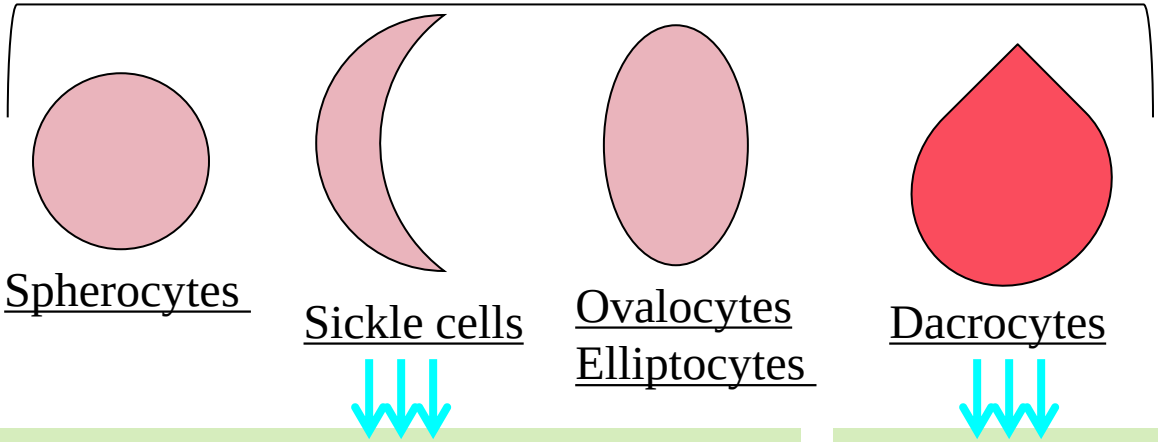
Hypochromic microcytic anemia

Poikilocytes
(Poikilocytosis)



Spherocytes

Sickle cells

Ovalocytes
Elliptocytes

Dacrocytes

⇩

One of the most sever changes in shape occurs during SICKLING of RBCs in sickle cell anemia where erythrocytes take on the form of crescents

Teardrop shaped cells

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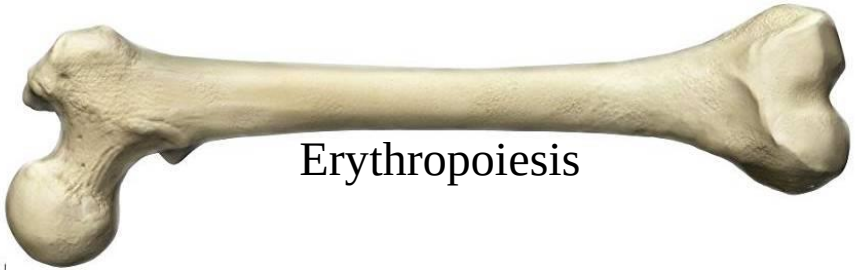
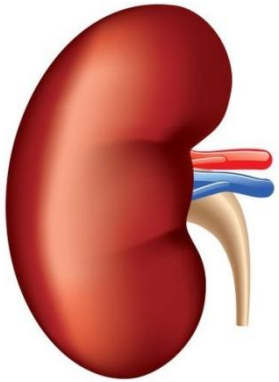
⇩

Sickle cell anaemia results from abnormal hemoglobin



Erythropoiesis



Production of erythrocytes in the bone marrow, is stimulated by erythropoietin

Erythropoietin is produced by the kidneys

When RBC count drops, such as during blood loss, the resulting oxygen-deficiency state, **hypoxemia**, is detected by the kidneys.

The kidneys respond by increasing their erythropoietin secretion, which leads to increased red blood cell production

Anemia: a decrease in the total number of RBCs (and/or hemoglobin)

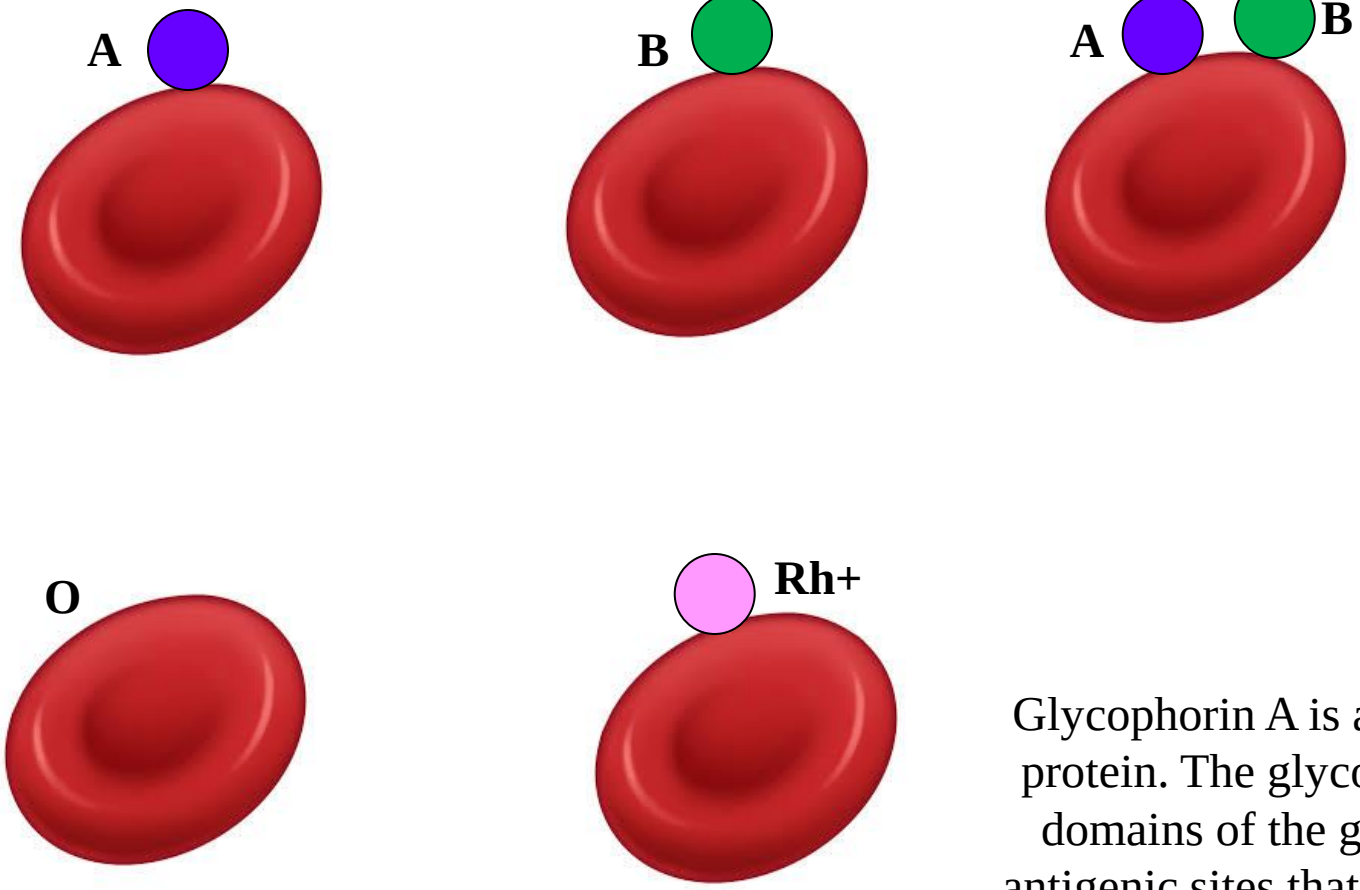
Polycythemia: an increase in the total number of RBCs

Consequently

People living at high altitudes usually have higher RBC count as a response to lower oxygen levels.

Athletes whose demand for oxygen is more elevated, also have higher RBC counts.

RBC plasma membranes have glycoprotein antigens on their external surfaces



Glycophorin A is an integral membrane protein. The glycosylated extracellular domains of the glycophorins include antigenic sites that form the basis for the ABO blood typing system

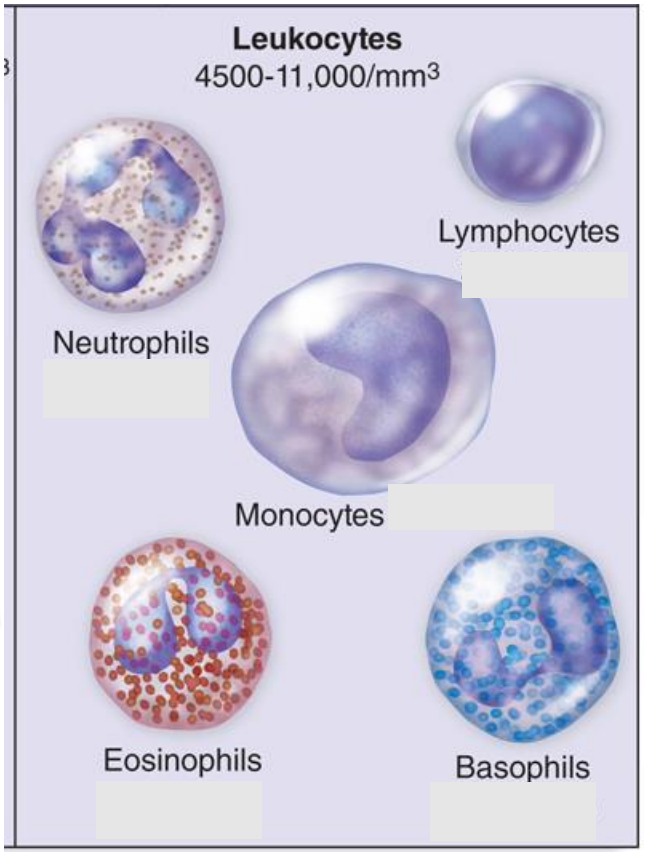
	RBCs (Erythrocytes)	WBCs (Leukocytes)
Types	1 type	5 types
	Not true cells	True cells
Number	Male: 4.5-5.5 million/mm3 female:4-5 million/mm3	4500-11000/mm3
Diameter	6-9um (7.5um)	6-20um
Life span	120 days	Few days-years
Origin and maturation	Bone marrow	Bone marrow and lymphoid tissue
Shape	Biconcave discs	Spherical
Function	Gas exchange	Defense
Motility	Non motile	Motile
	Function exclusively within vascular system	Function mainly OUTSIDE blood vessels in the tissues

Leukocytes

- Originate in the bone marrow and released continuously into the blood
- Travel in bloodstream but function mainly **outside** blood vessels (in loose CT)
- Leukocytes form a mobile army that helps protect the body from damage by bacteria, viruses, parasites, toxins and tumor cells

- 5 types organized into 2 groups
  - **Granulocytes**
    - Neutrophils
    - Eosinophils
    - Basophils
  - **Agranulocytes**
    - Lymphocytes
    - Monocytes

Leukocytes, or WBCs, are nucleated and subdivided into granulocytes and agranulocytes, depending on the presence or absence of **specific** granules in their cytoplasm.



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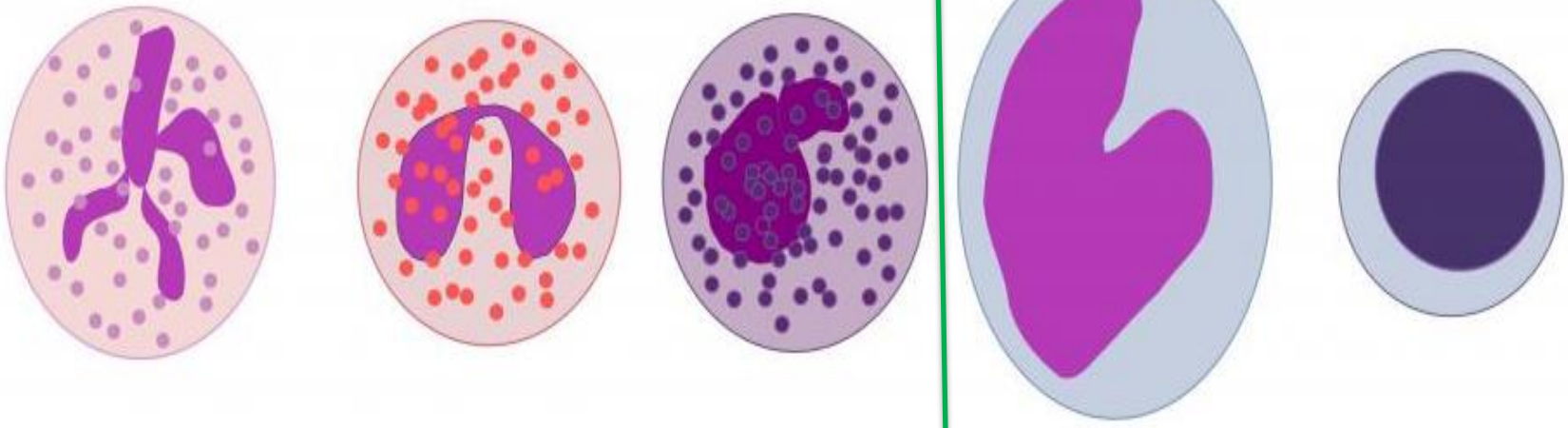
Leukocytes (White Blood Cells)

Granulocytes

Agranulocytes



Neutrophil

Eosinophil

Basophil

Monocyte

Lymphocyte

Cytoplasmic granules

Specific granules
Secondary granules

Non-specific granules
Azurophilic granules
Lysosomes
Primary granules

Granulocytes

- Cytoplasmic granules (containing enzymes or chemicals) → makes cytoplasm look grainy
- Single multi-lobed nucleus (segmented)
- All are phagocytic; they engulf and consume foreign cells and material
- 3 main types:

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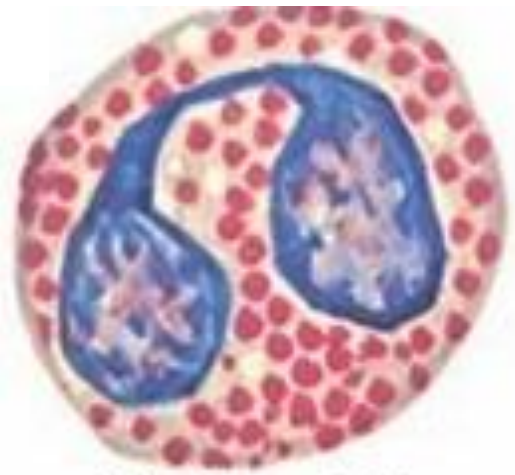
Large granules, Red

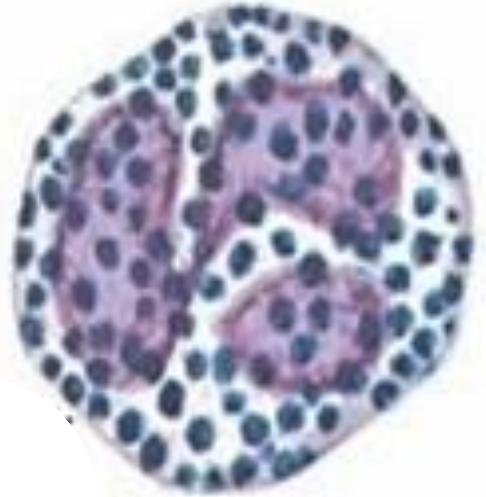


Eosinophil

Small granules, pale pink/ salmon pink

Neutrophil

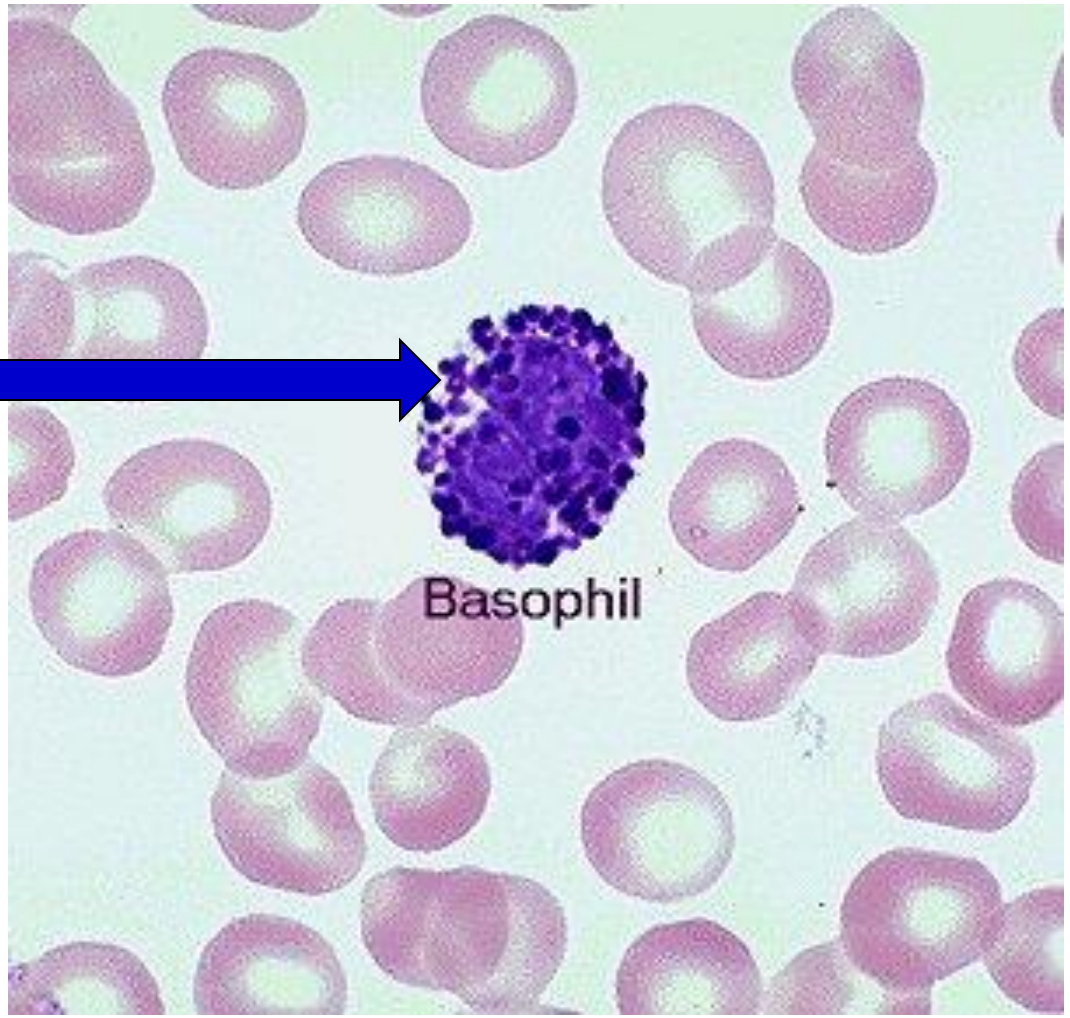
Large granules, blue



Basophil

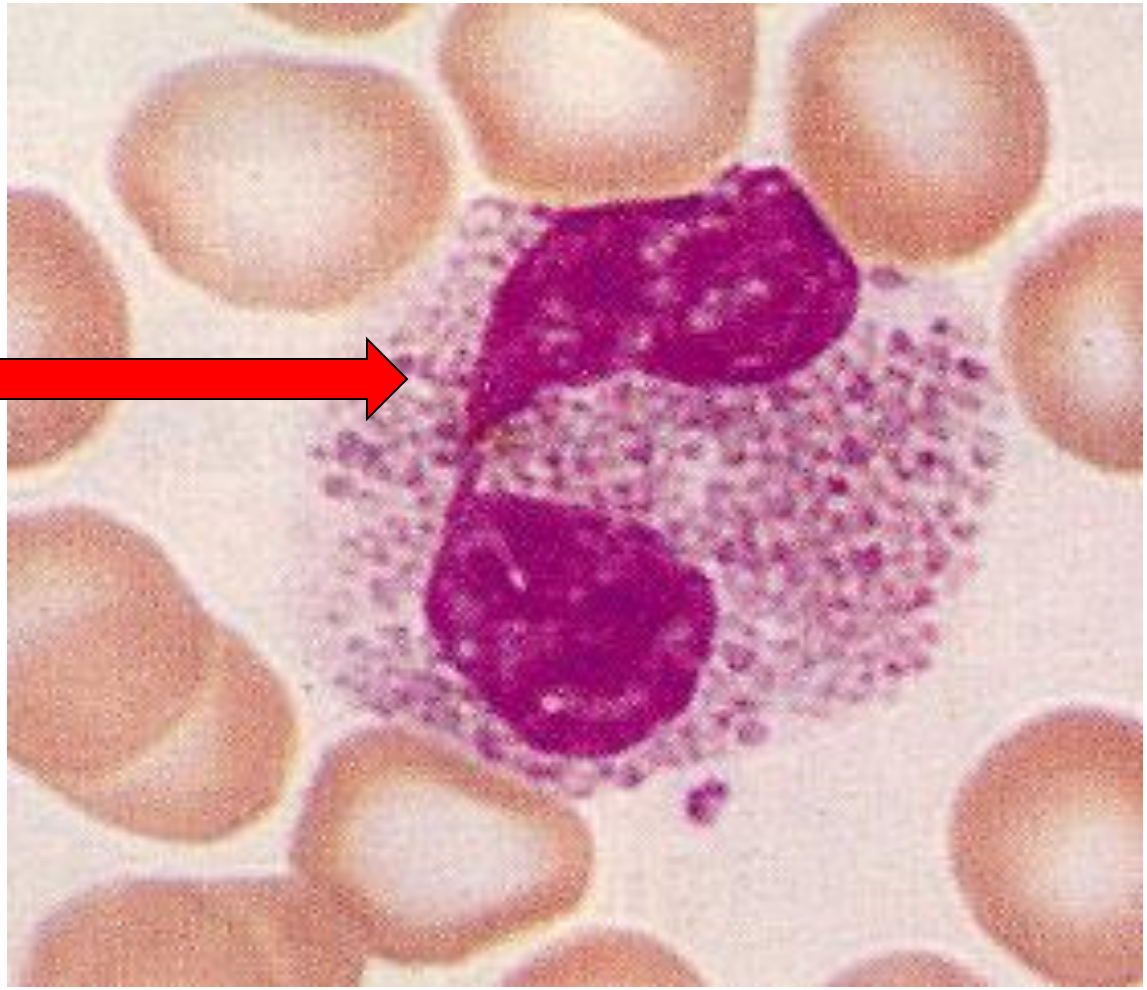
Basophil

These specific granules stain with basic stains



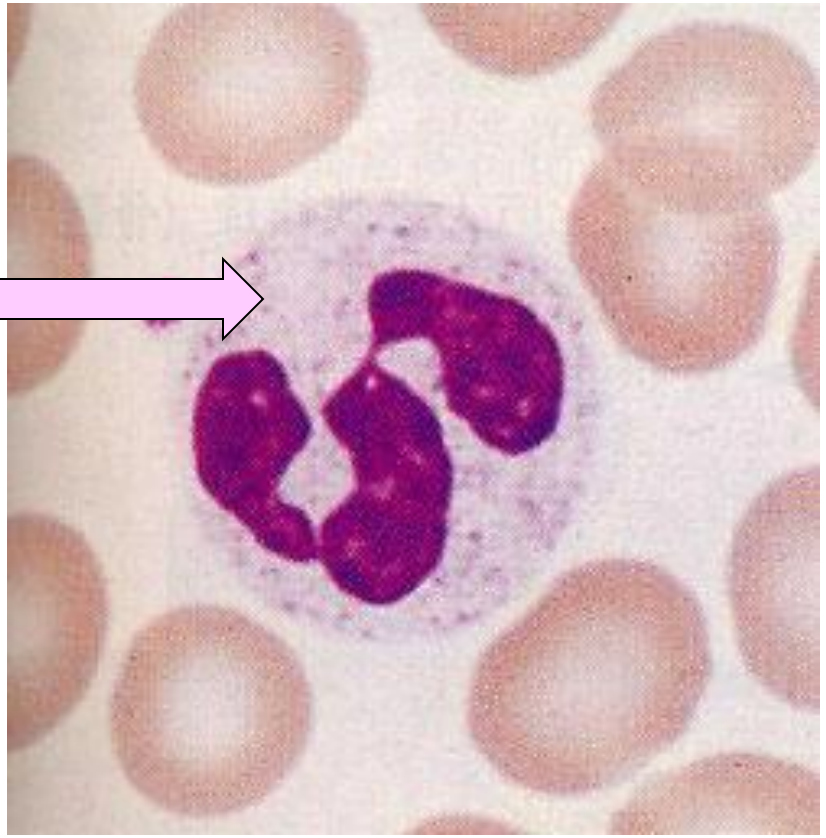
EOSINOPHIL

These specific granules stain red with acidic stains such as eosin



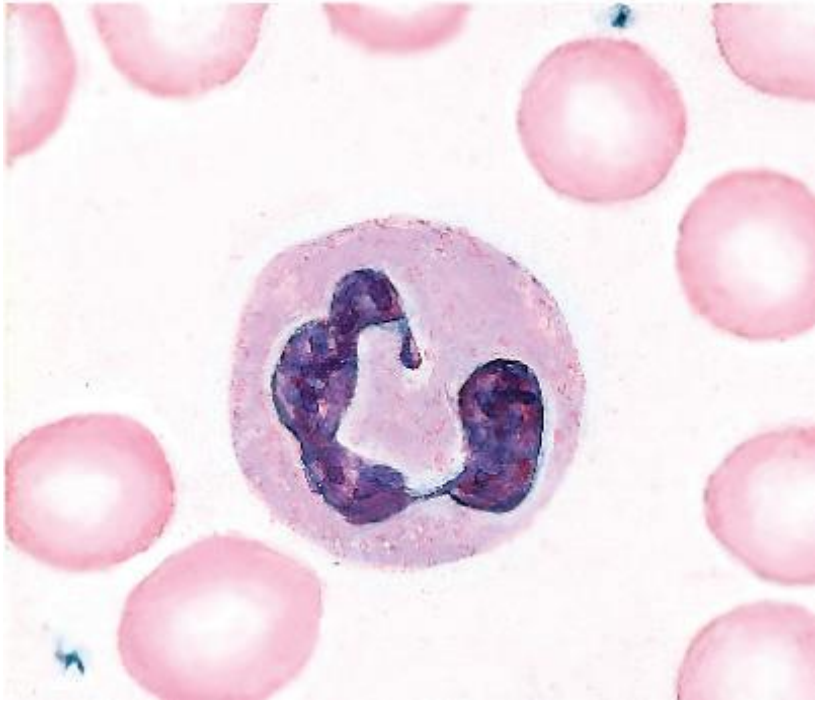
Neutrophil

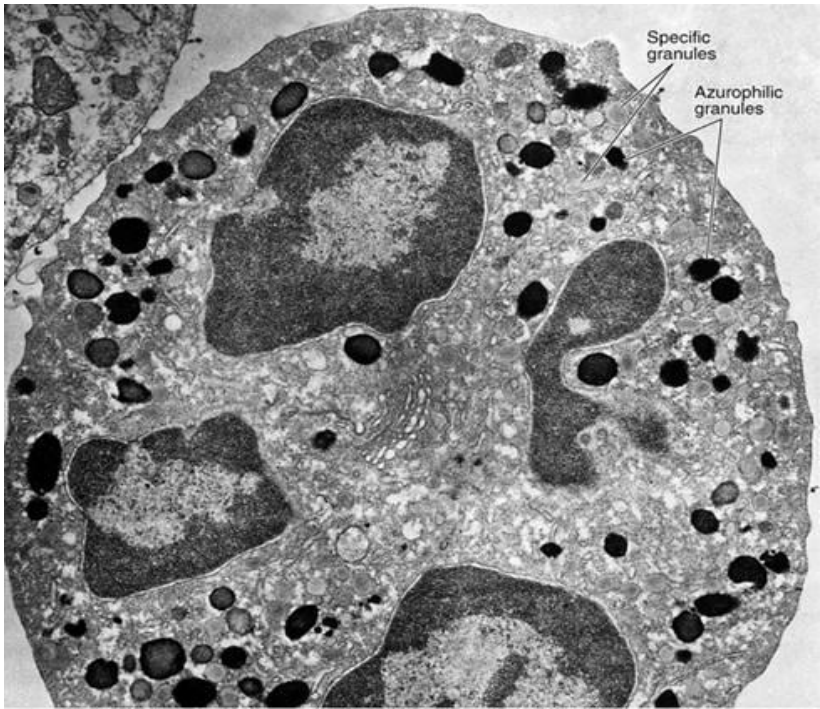
These granules are neutrophilic, meaning they show no special affinity for either acidic or basic stains but are stained mildly by both



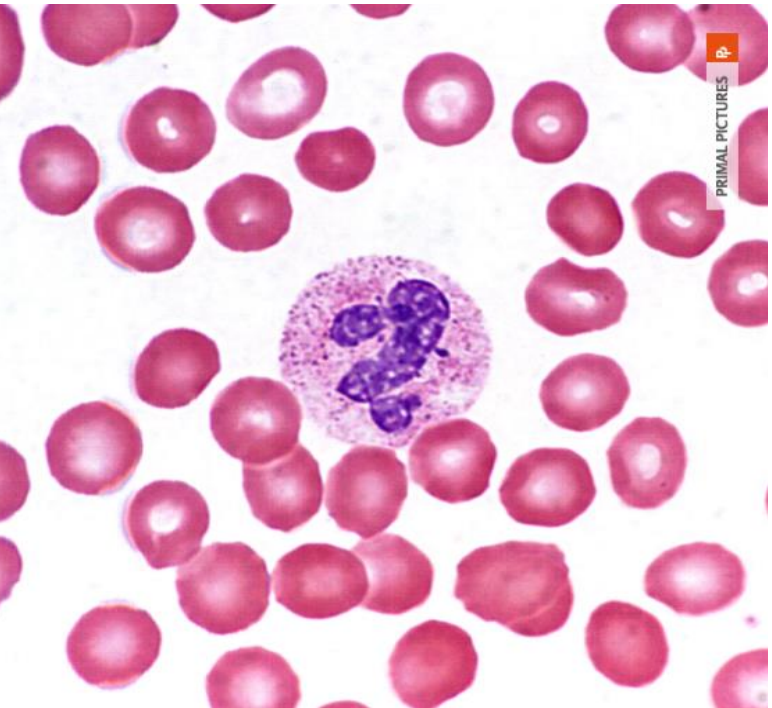
Neutrophils

- The most common leukocyte
- 2-5 lobes in nucleus connected by “threads” of nuclear material (**polymorphs**)
- Light pink cytoplasm
- Called neutrophils because cytoplasm takes up red (acidic) and blue (basic) stains equally
- Specialized for responding to Bacterial invasions- Acute infections- Acute pyrogenic infections
- Neutrophils are short-lived cells with a half-life of 6-8 hours in blood and a life span of 1-4 days in connective tissues before dying by apoptosis.





In females, the inactive X chromosome **(Barr body)** may appear as a drumstick-like appendage on one of the lobes of the nucleus *(about 3% of neutrophils in peripheral blood)*



Neutrophils are the first WBCs that leave the blood in large numbers to reach the site of inflammation **Why???**

Cells of acute infection

1- The most abundant
2-The most motile
3- Neutrophil chemotactic factors are the first released

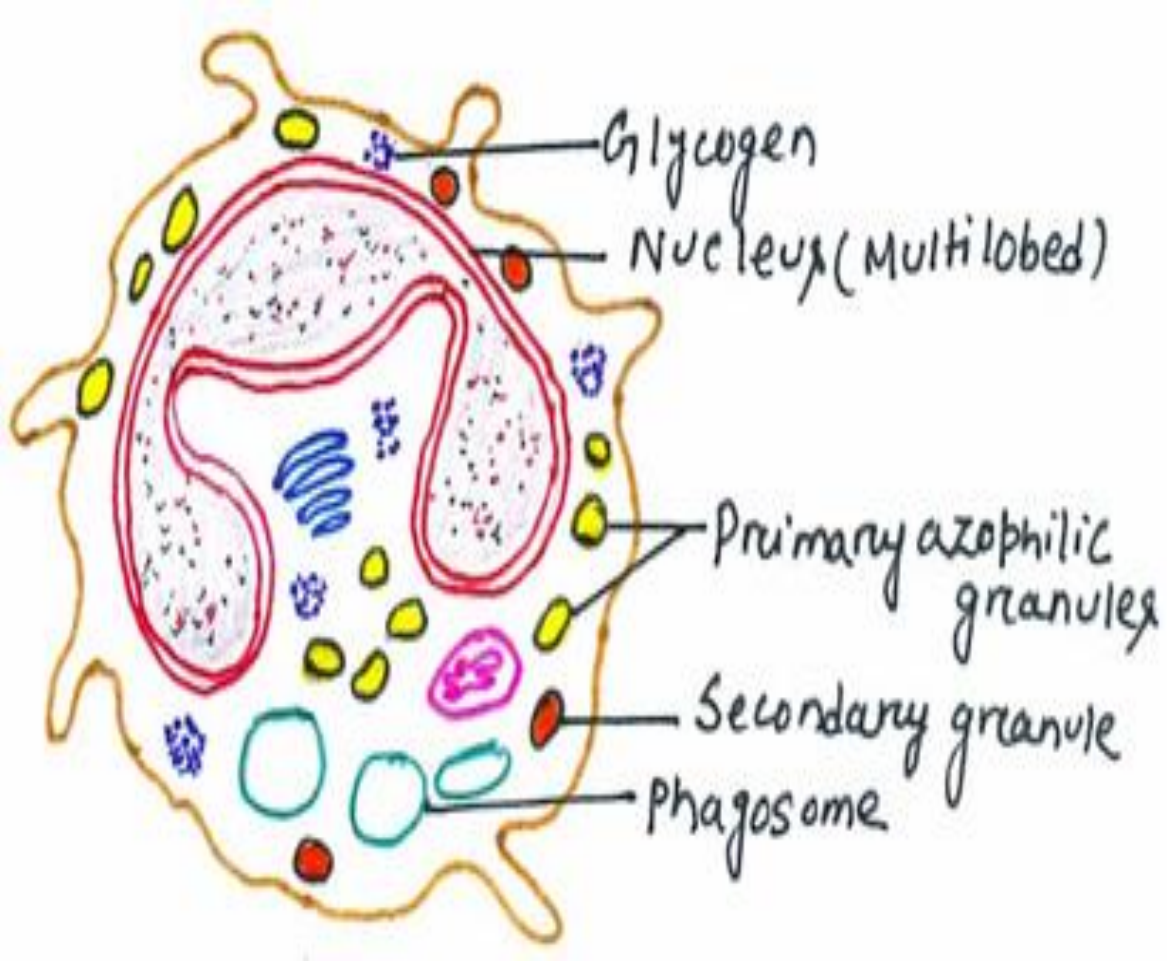
- **Specific granules (secondary)**
  - **Lysozyme**
  - **Phagocytin** (bactericidal)
  - **Lactoferrin** (bacteriostatic)
  - **Collagenase**

- **Azurophilic granules (primary)**
  - **Myeloperoxidase**
  - **Acid hydrolase**
  - **Defensins**

Form H_2O_2, HOCL: powerful cytotoxin

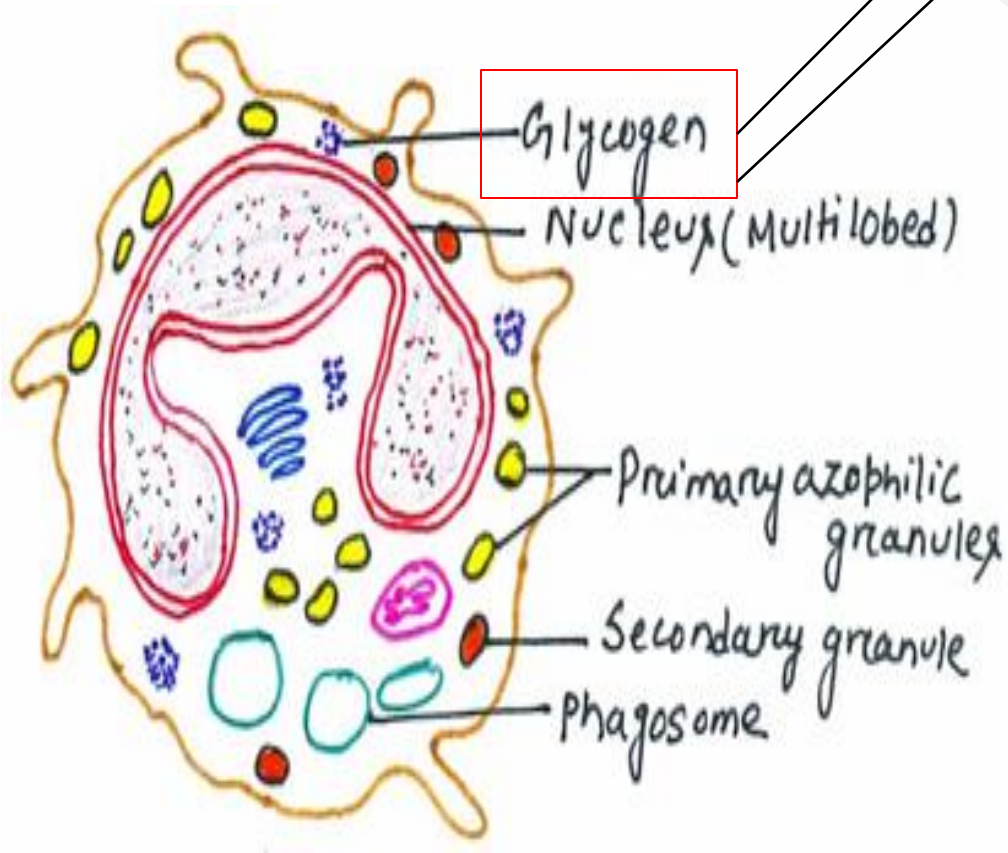
Different names for neutrophils:
Polymorphs
Pus cells
Myelocytes
Microphages
Cells of acute inflammation

Pus is pyrogenic



Dead neutrophils, bacteria, lysed ECM, and tissue-fluid form a viscous, usually yellow collection of fluid called **pus**.

Few organelles

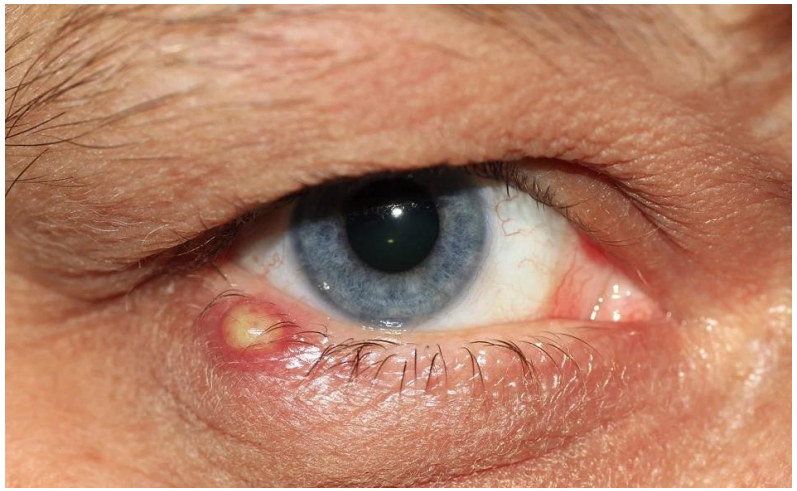


The ability of neutrophils to survive in an anaerobic environment is highly advantageous, because they can kill bacteria and help clean up debris in poorly oxygenated regions, for example, damaged or necrotic tissue lacking normal microvasculature.

Neutrophilia
Neutropenia

Pus is a viscous, usually yellow collection of fluid.

Pyogenic is referring to bacterial infections that make pus
while **pyrogenic** is producing heat



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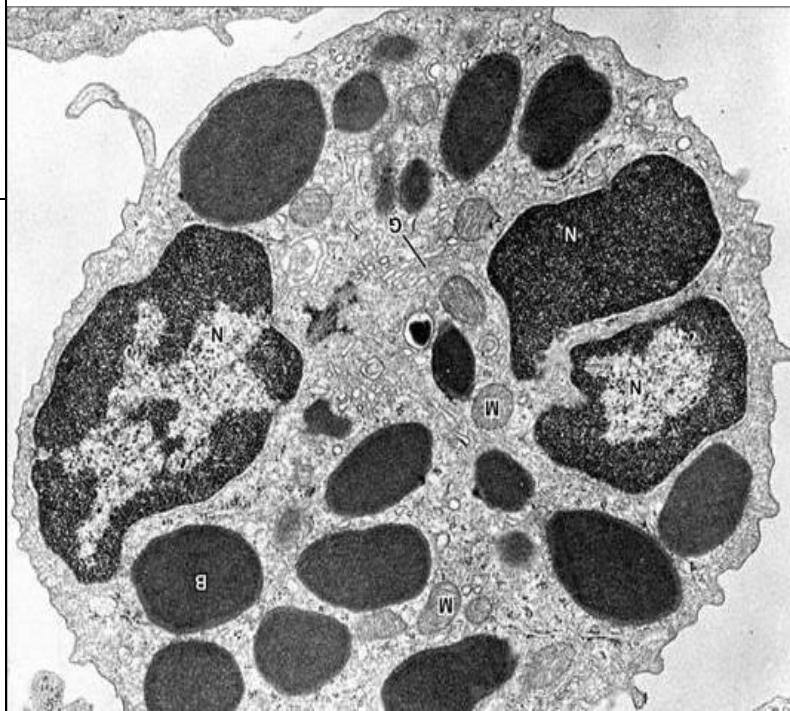
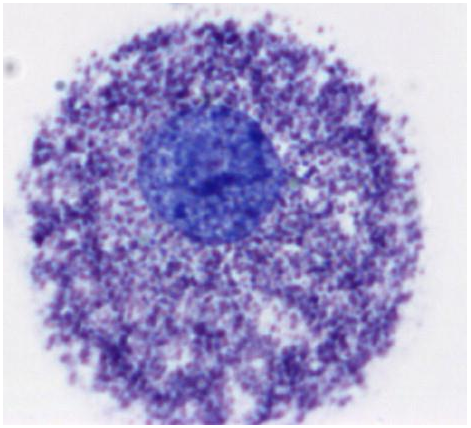
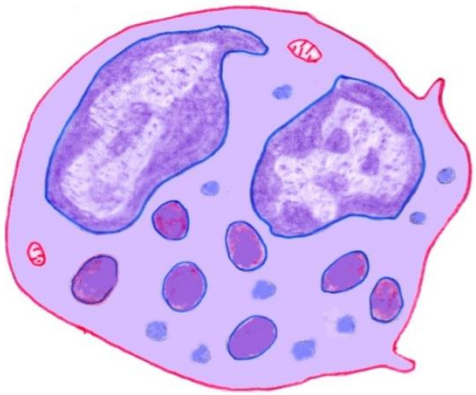
Basophils

- Rarest leukocyte – might not see these under the microscopes
- Usually have bi-lobed, S-shaped nuclei obscured by the large basophilic granules
- Has large granules that stain dark purple/ blue in basic dyes (*basophil* = basic loving)
- Granules contain histamine, heparin and eosinophilic chemotactic factor that mediate inflammation in allergic reactions and parasitic infections





Mast cell



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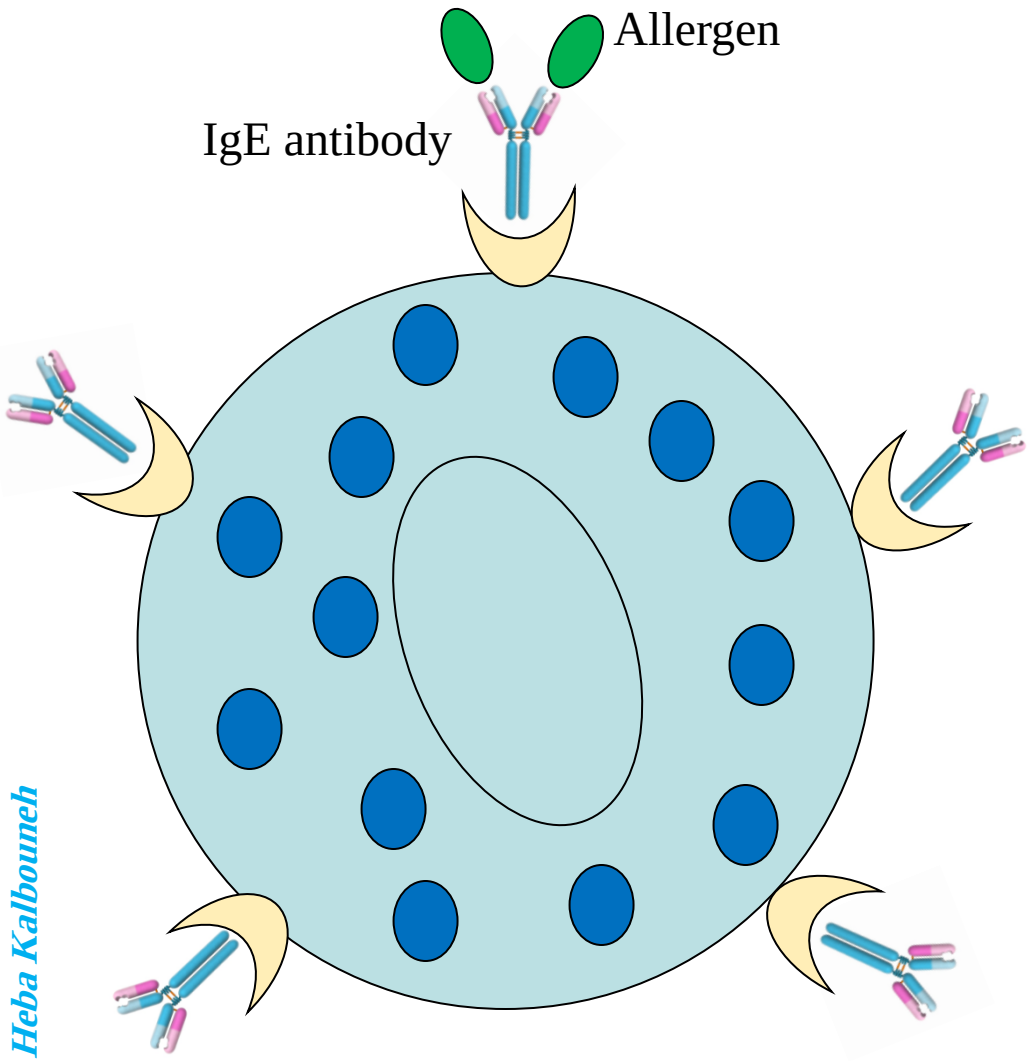
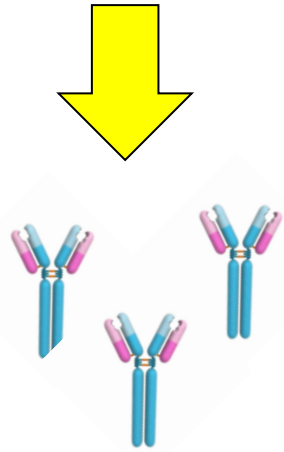
Both basophils and mast cells have surface receptors for immunoglobulin E (IgE), and secrete their granular components in response to certain antigens and allergens.



Plasma cell



Exposure may be by ingestion, inhalation, injection, or direct contact

First exposure

In some individuals substances such as certain pollen proteins or specific proteins in food are allergenic, that is, elicit production of specific IgE antibodies, which then bind to receptors on mast cells and immigrating basophils.

Second exposure

Upon subsequent exposure, the allergen combines with the receptor-bound IgE molecules, triggering rapid exocytosis of the cytoplasmic granules.

Release of the inflammatory mediators in this manner can result in bronchial asthma, cutaneous hives, rhinitis, conjunctivitis, or allergic gastroenteritis.

Immediate or type 1 hypersensitivity

In some individuals a second exposure to a strong allergen, such as that delivered in a bee sting, may produce an intense, adverse systemic response. Basophils and mast cells may rapidly degranulate, producing vasodilation in many organs, a sudden drop in blood pressure, and other effects comprising a potentially lethal condition called **Anaphylaxis or anaphylactic shock**.

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Basophils account for up to 15% of infiltrating cells in allergic dermatitis and skin allograft rejection

Allergic dermatitis (eczema) is an itchy skin rash that develops when you come into contact with an **allergen**

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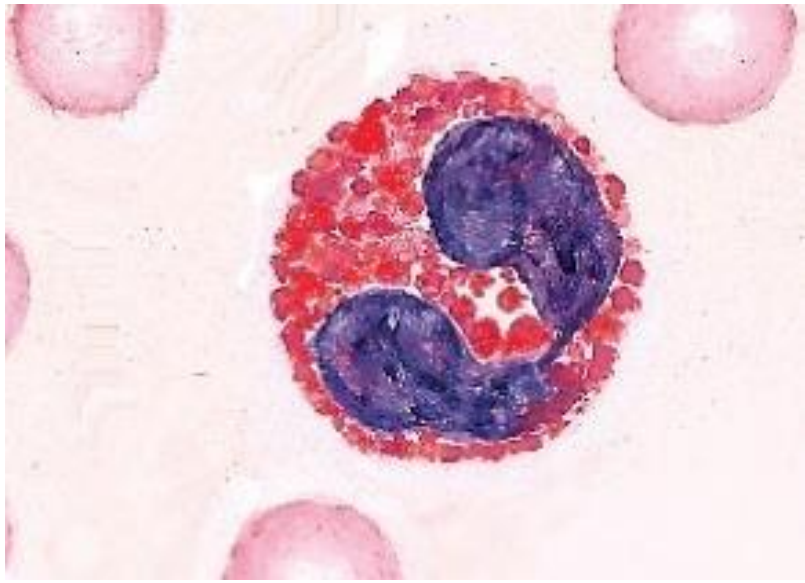
Eosinophils

- Usually have bi-lobed nuclei connected by a short “thread” of nuclear material
- Large cytoplasmic granules, which stain red with the acidic eosin dye (*eosinophil* = eosin loving)
- Help in ending allergic reactions and in fighting parasitic infections



Crystalloid granule

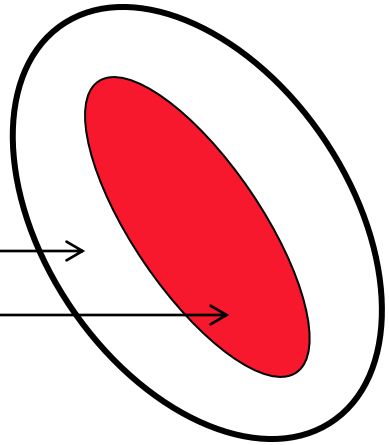
Specific granules (Crystalloid granules):

- Oval in shape, with flattened crystalloid cores

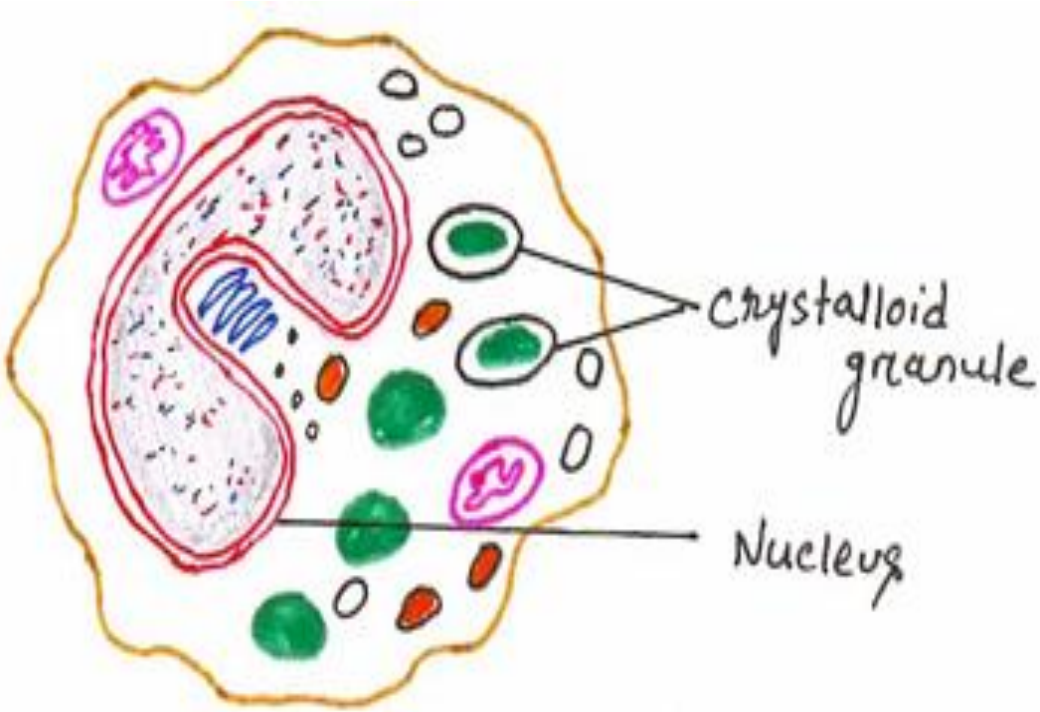
-Two parts:

Externum (pale): contains histaminase and sulfatase

Internum (dark): contains basic protein to kill parasites



Eosinophils have a particular phagocytic affinity for **antigen-antibody complex**



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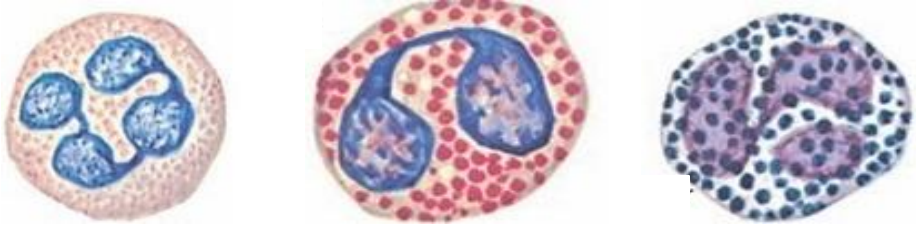


	Neutrophil	Eosinophil	Basophil
Percentage (WBCs)	Most →		Least
Size	12-15um	12-15um	12-15um
Life span	Few days	Few days	Few days
Nucleus	2-5 lobes	2 lobes	Irregular (S-shaped)
Phagocytic activity	Most →		Least
Motility	Most →		Least

Diapedesis
(Gr. dia, through + pedesis, to leap)

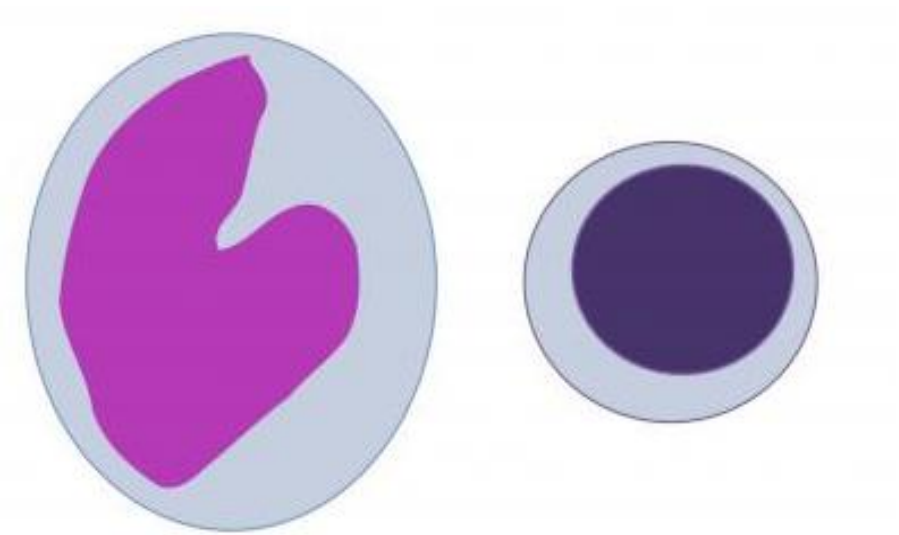
General features of granulocytes

-Spherical in blood stream, irregular in connective tissue
-Highly motile with different shapes due to their amoeboid movement
-Leave blood stream by migrating between the endothelial cells by a process called **diapedesis**

Agranulocytes

- Single non-lobulated nucleus
- Granules in cytoplasm are too small to see (nonspecific granules, azurophilic granules, primary granules, lysosomes)

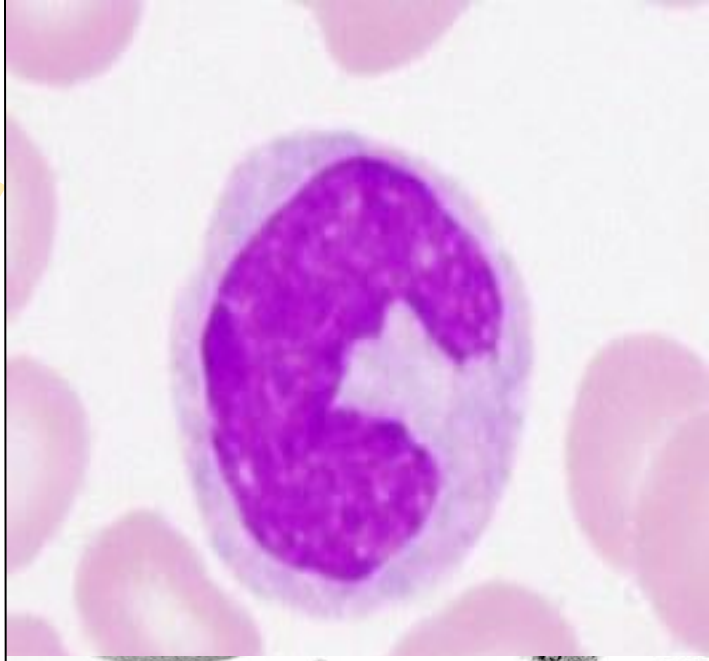
- 2 types based on structure (not cell lineage):
  - **Lymphocytes**
  - **Monocytes**

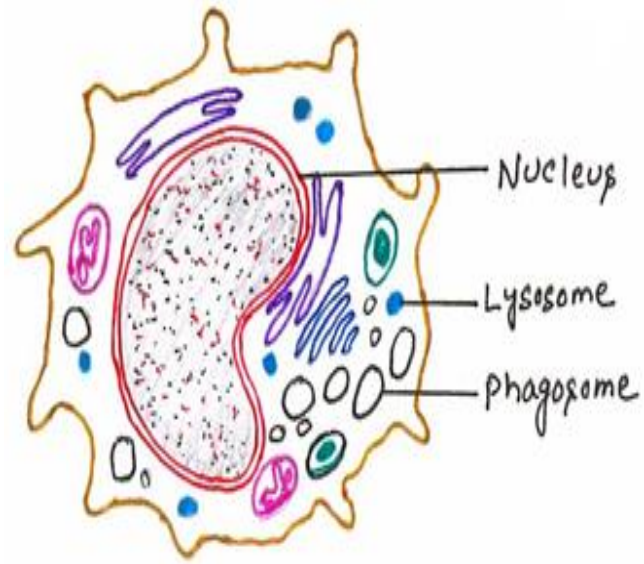


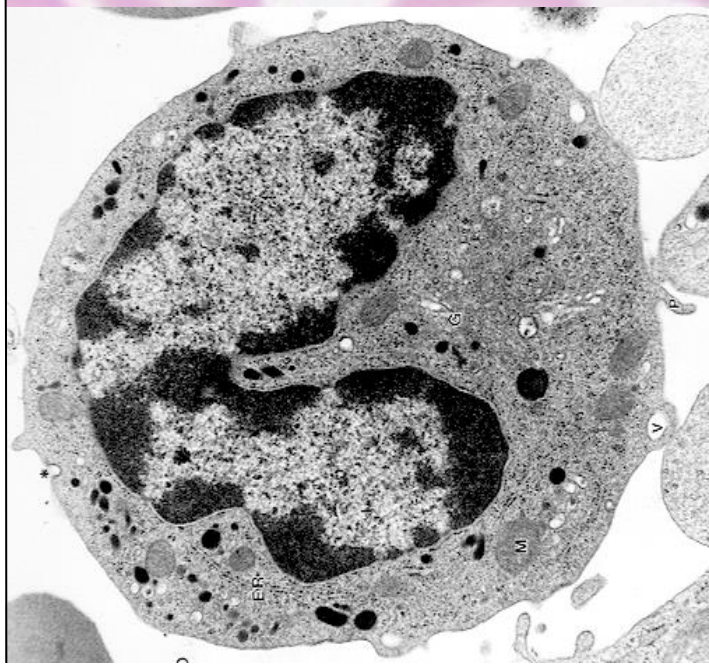
Monocytes

- Largest leukocytes
- Bluish cytoplasm *(frosted glass appearance)* & a large C-shaped nucleus
- Highly motile and phagocytic
- Travel through bloodstream to reach connective tissues, where they transform into **macrophages** (large phagocytic cells)

Azurophilic granules (lysosomes)







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Are precursor cells of macrophages, osteoclasts, microglia, and other cells of the **mononuclear phagocyte system** in connective tissue

All monocyte-derived cells are **antigen-presenting cells**

Monocytes and macrophages are the same cells at different stages of maturation

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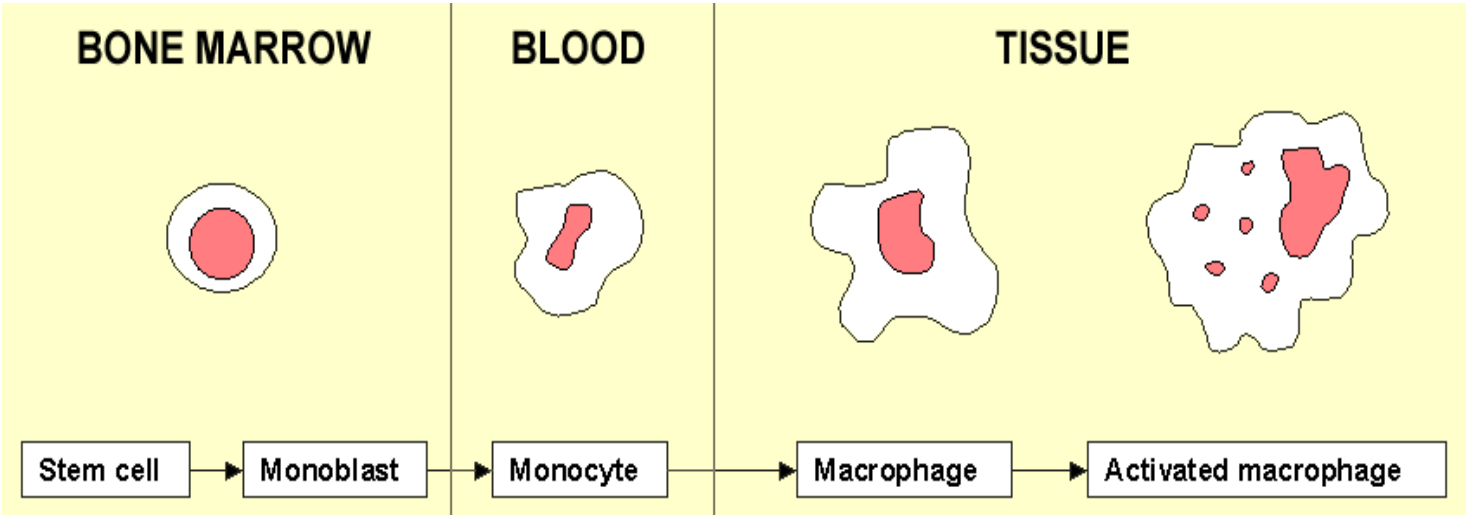


MONONUCLEAR PHAGOCYTIC SYSTEM

Kupffer Cells
Liver

Macrophages
Bone marrow
Connective tissue

Osteoclasts
Bone resorption

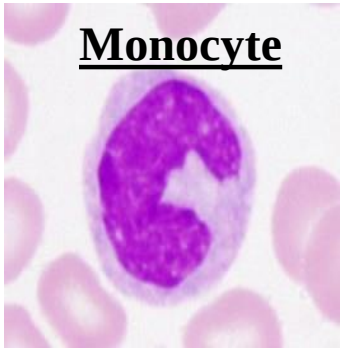
Dust cells
Lung

Microglia
CNS

Dendritic cells
Lymph node
Spleen

Langerhans cells
Epidermis

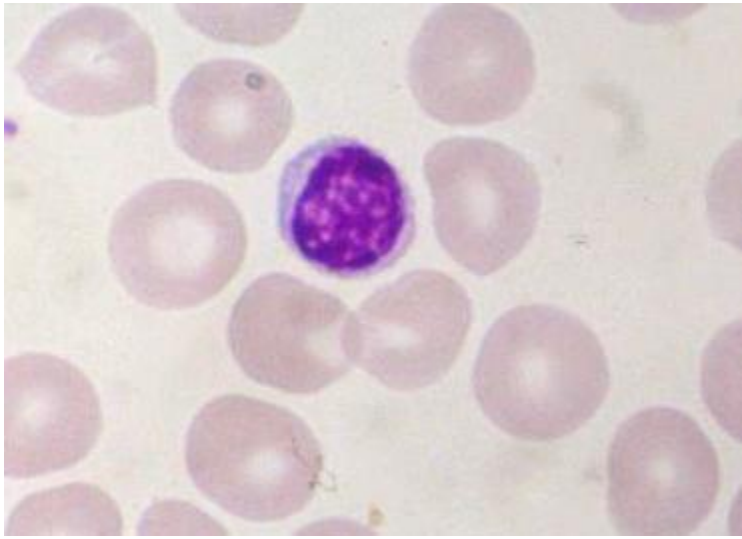
Monocyte



(all characterized by phagocytic activity)

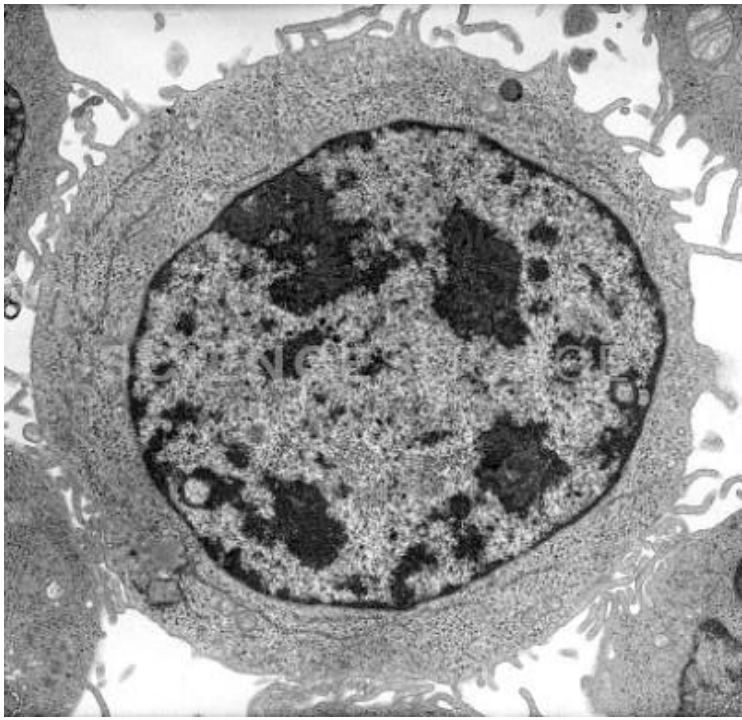
Lymphocytes

- Smallest leukocytes
- Round nucleus occupies most of cell volume
- Cytoplasm is light clear blue
- Increased numbers are commonly seen in **viral infections**
- Lymphocytes vary in life span according to their specific function, some live for a few days and some live for many years



Cell mediated immunity

- **T cells**
  - Has different types, some directly kill foreign or infected cells; others activate phagocytes to destroy microbes



Humoral immunity

- **B cells**
  - Differentiate into plasma cells
  - Secrete antibodies that bind to specific antigens and mark them for destruction by phagocytic cells

Humoral means body fluids

Long term immunity

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Lymphopoiesis: the process by which lymphocytes are formed

Precursor cells in bone marrow

Thymus

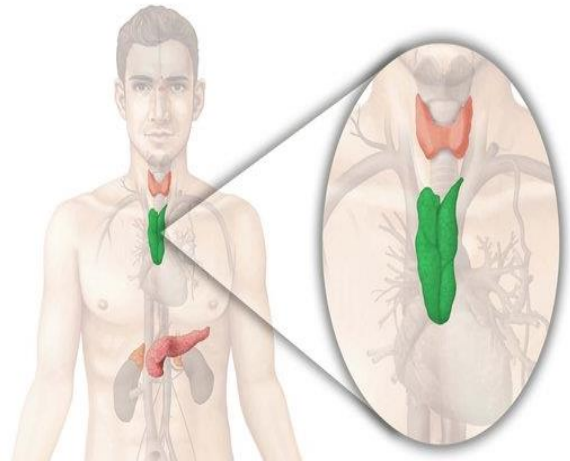
BM

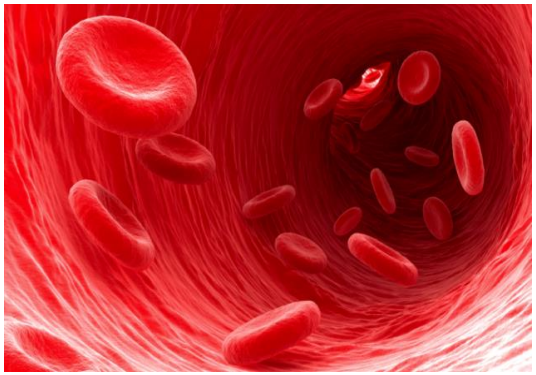
Directly into blood

T Lymphocytes

B Lymphocytes

Natural killer lymphocytes





Morphologically lymphocytes can be classified into:

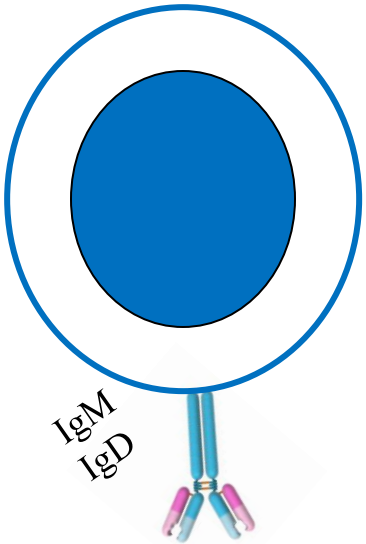
The amount of cytoplasm depends upon **state of activity** of the lymphocyte

In circulation blood there is **predominance of small inactive lymphocytes**

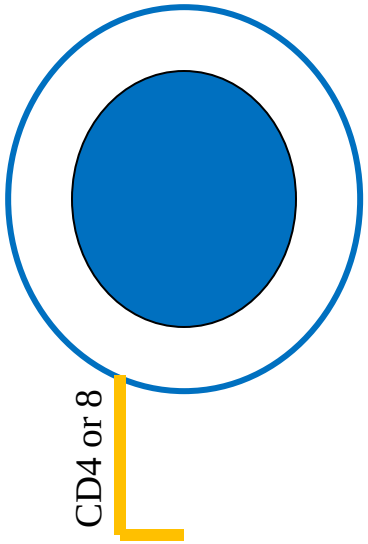
Large
(9-18 μm)
Active lymphocyte

Small
(6-9 μm)
Inactive lymphocyte

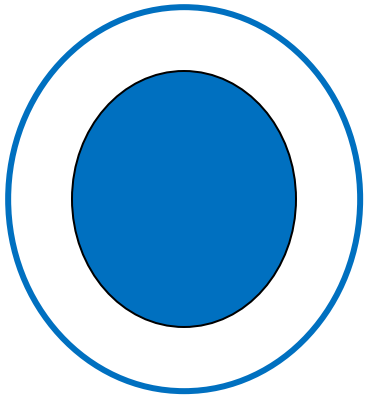
Different types express specific cell surface proteins



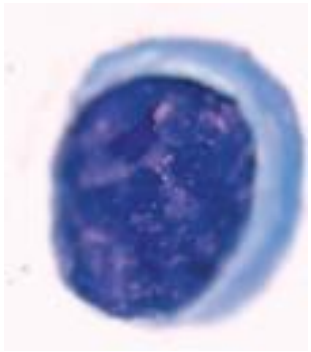
B lymphocyte



T lymphocyte

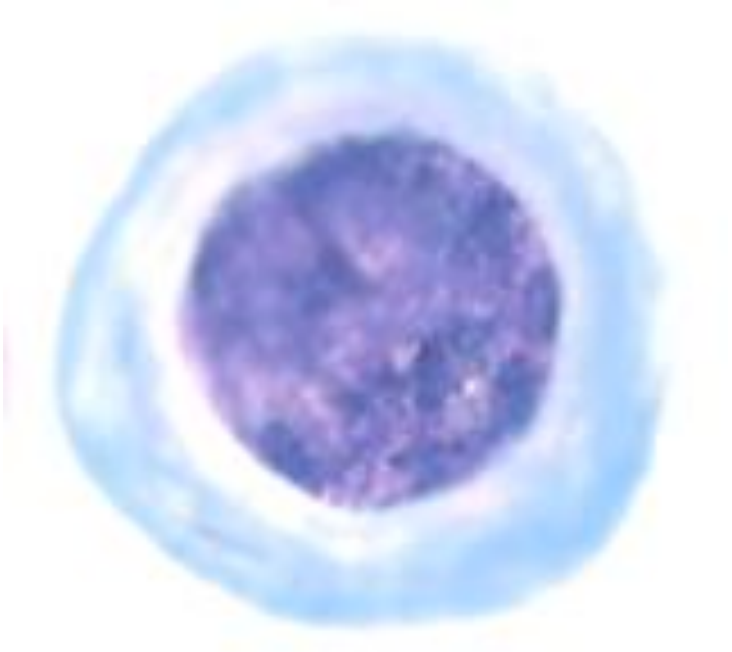


Natural killer lymphocyte



Small
(6-9 μm)
Inactive lymphocyte

Darkly stained cell

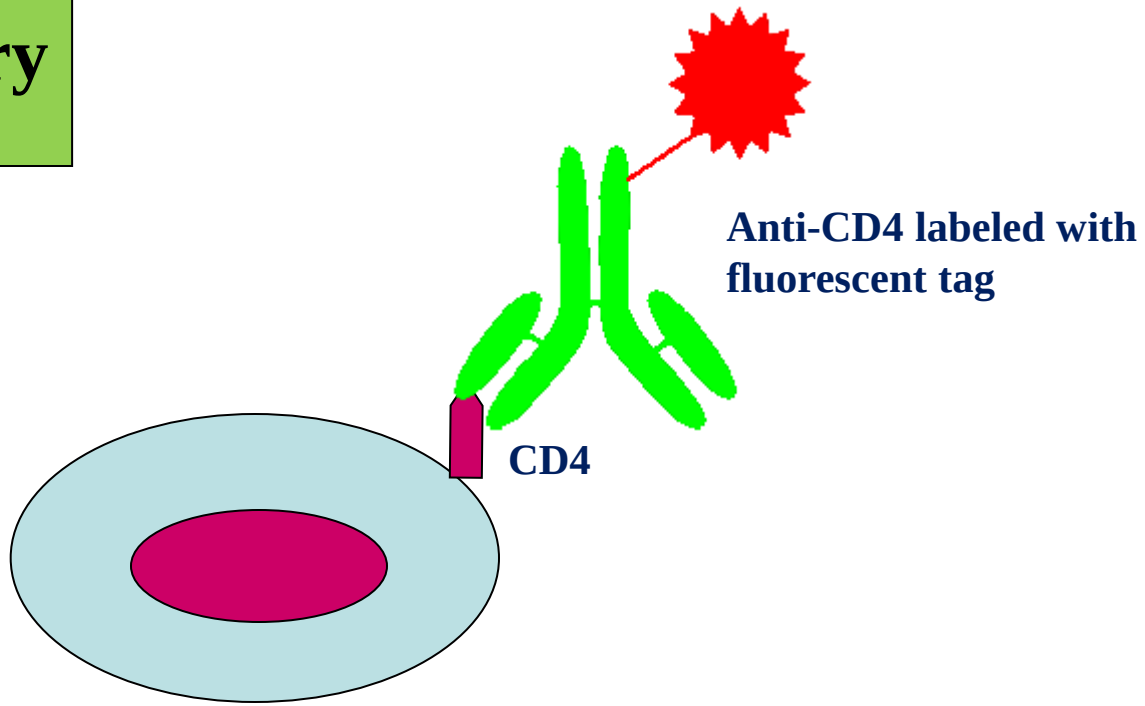


Large
(9-18 μm)
Active lymphocyte

Lightly stained cell

Immunohistochemistry

Direct method

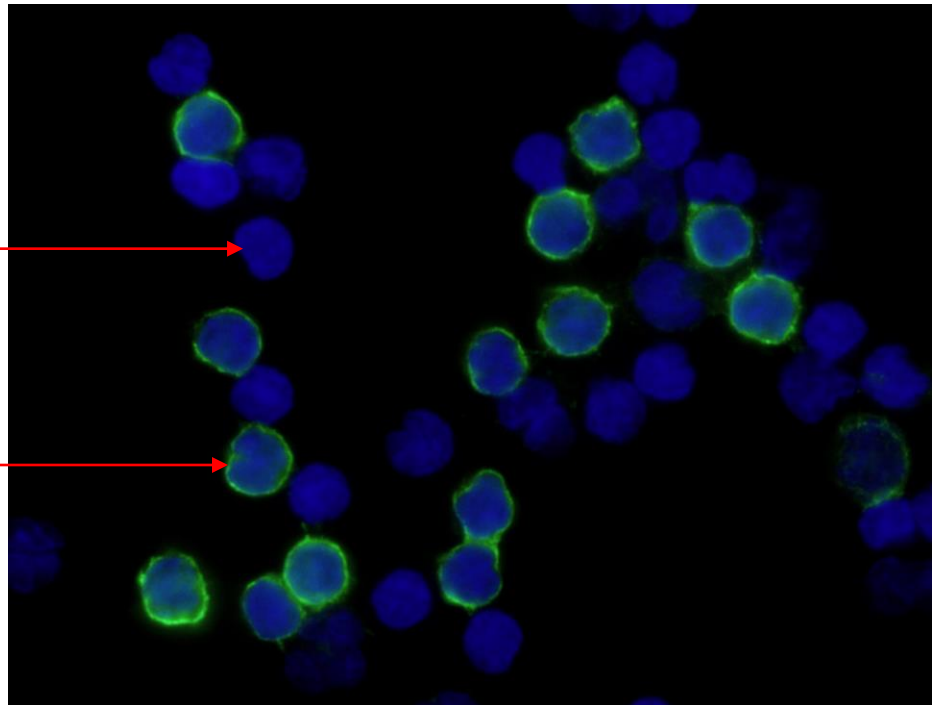


Immunohistochemistry

Using CD 4 Antibody

???????

CD 4 +
T Helper lymphocyte



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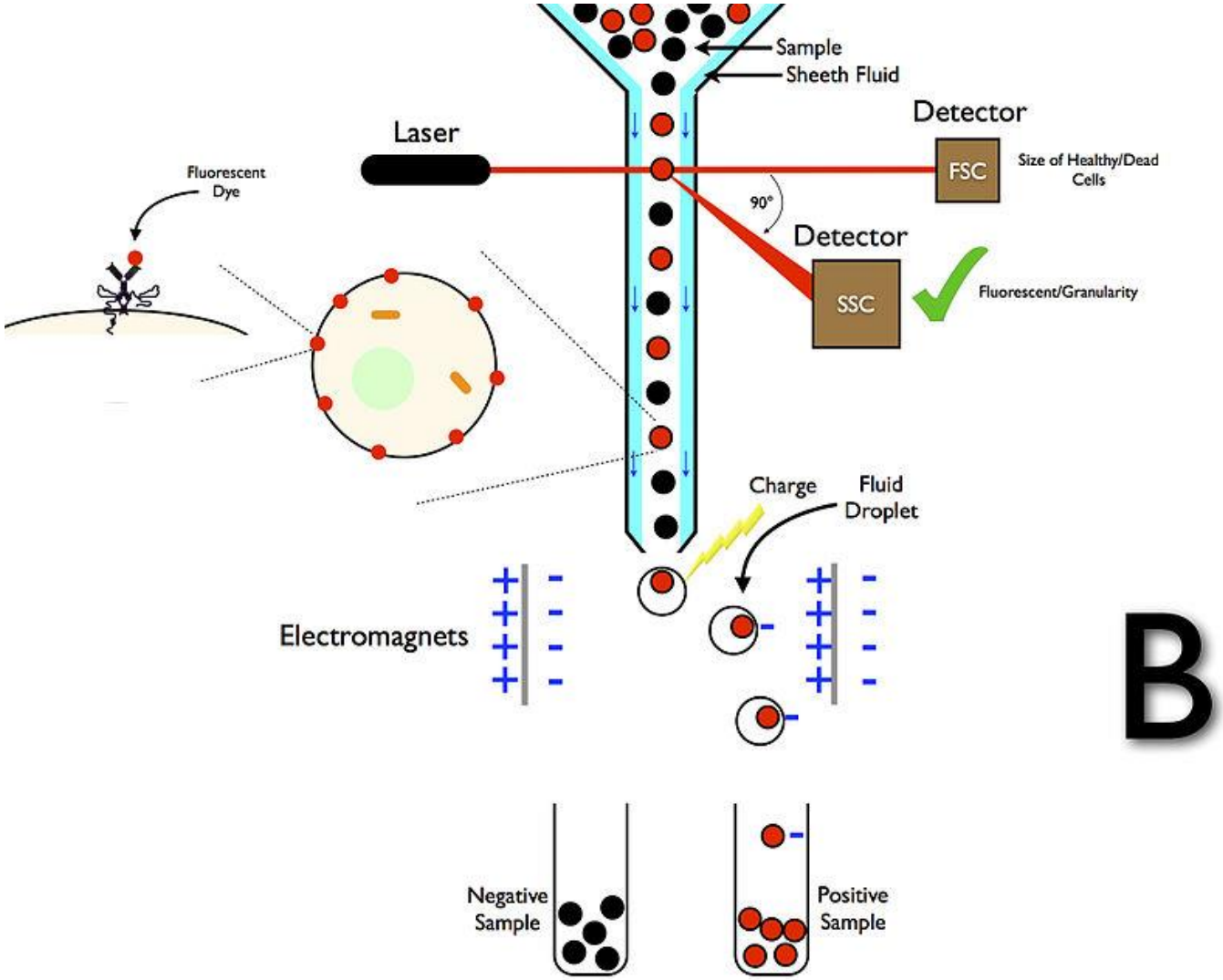
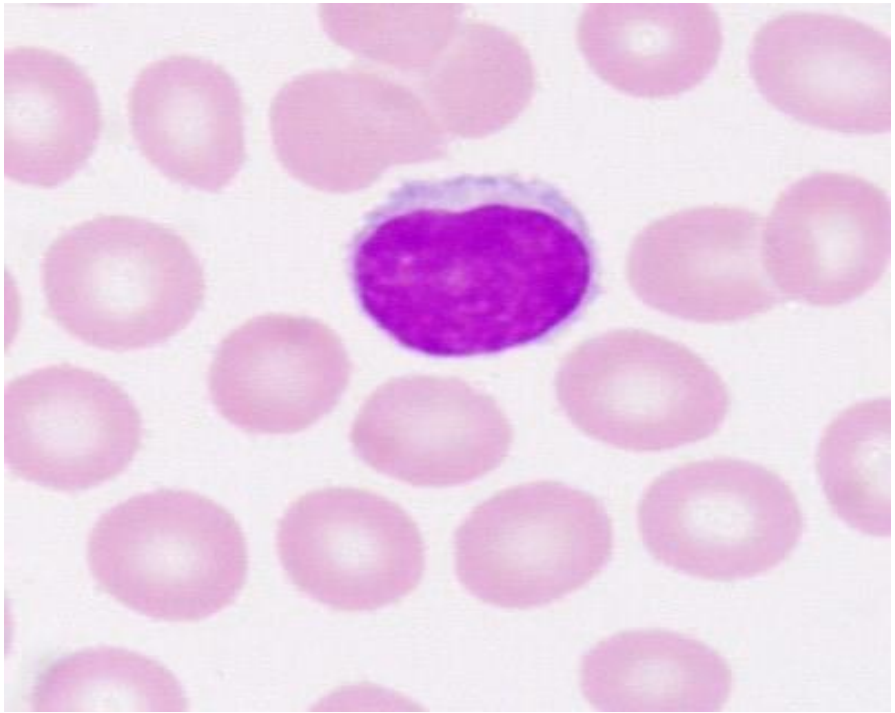
Flow cytometry (FACS)



Neutrophils and monocytes are highly phagocytic and engulf microorganisms and cell debris in a **NON-SPECIFIC** manner **(Innate immunity)**

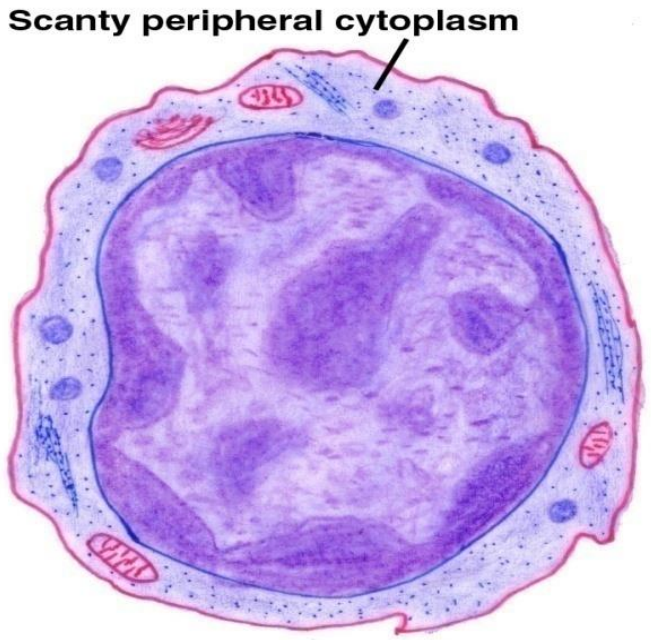
While

The activity of lymphocytes is always directed against **SPECIFIC** foreign agents (**Adaptive immunity)**



The small lymphocyte has scanty cytoplasm (contain few organelles but large number of ribosomes)

Account for basophilic cytoplasm



Lymphocytes

B Lymphocyte

- **Memory cell**
- **Plasma cell**
  - Produces antibodies

T Lymphocyte

- **Cytotoxic**
  - Kill virus-infected, transplanted and neoplastic cells (adaptive immunity)
- **Helper**
  - Help cytotoxic T cells and B cells in their immune functions
- **Suppressor**
  - Suppresses immune response to self Ag
  - Suppresses immune response of T and B lymphocytes

Natural killer cells (NULL Lymphocyte)

- Kill virus-infected, transplanted and neoplastic cells (innate immunity)

Large granular lymphocytes
Activated lymphocytes

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Innate immunity: We are born with innate immunity. It is non-specific, which means that the innate cells are not able to distinguish one type of pathogen from another.

Cells of innate immunity: Neutrophils, Basophils, Eosinophils, Mast cells, Monocytes (macrophages and dentritic cells), natural killer cells

Adaptive (acquired) immunity is the body's ability to recognize and respond to specific foreign substances (antigens: microbes, parts of microbes, or non-microbial substances, such as pollen)

Cells of adaptive immunity: B and T lymphocytes

Suppressor T cells switch off the immune response when the stimulus is removed

↓↓↓

Damage to suppressor cells can result in **autoimmune disease**

Memory cells allow a more rapid response if the antigen appears again later

↓↓↓

which allows a very rapid response upon subsequent exposure to the same antigen.

Basis of immunity/vaccination

Natural killer cells and T cells play a major role in **graft rejection**

HIV affects **Helper T cells**

The retrovirus that produces acquired immunodeficiency syndrome (AIDS) infects and rapidly kills helper T cells.

↓↓ ↓ ↓↓↓↓

Reduction of this key lymphocyte group cripples the patient's immune system rendering them susceptible to opportunistic bacterial, fungal, protozoan, and other infections that usually dealt with easily in immunocompetent individuals.

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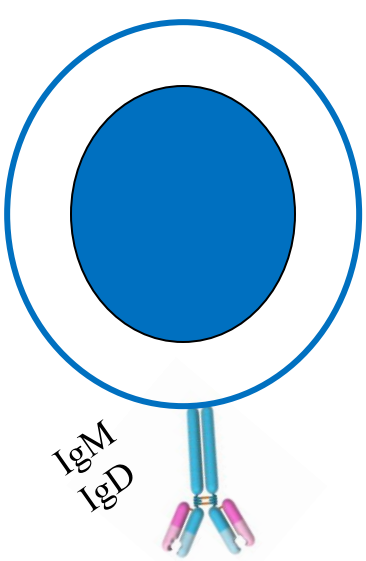
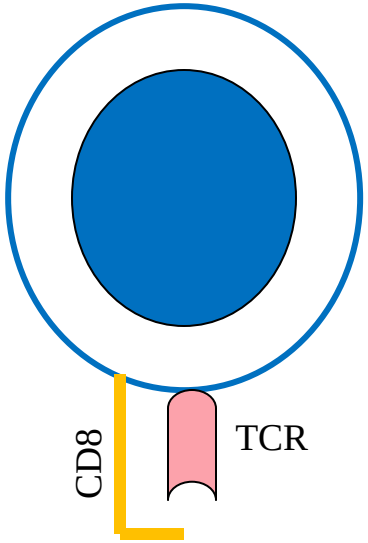
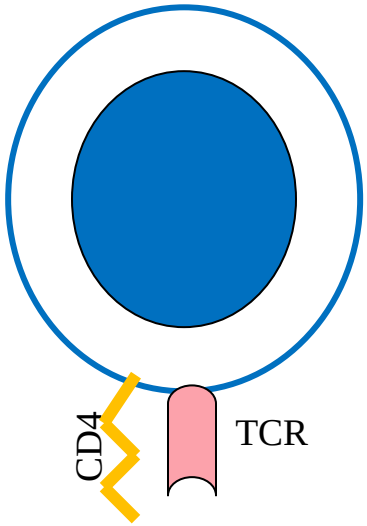
Different types express specific cell surface proteins



B cell



Cytotoxic T cell



Helper T cell

Note: Receptors of B cells are immunoglobulins that bind antigens directly; those on T cells react only with antigen on MHC molecules and this requires the additional cell surface proteins CD4 or CD8.

T lymphocytes are said to be **MHC restricted**

*"**CD**" stands for "cluster of differentiation": are surface molecules that help differentiate one cell type from another*

Major histocompatibility complex
MHC

Also called human leukocyte antigens (HLAs)

Glycoprotein on cell membrane
Two classes:

MHC-I
On surface of all nucleated cells
Coupled to peptide formed within the cell

MHC –II
On surface of APCs
Coupled to peptide product of proteins the cells had ingested (peptide product of Ag digestion)

T lymphocytes are specialized to recognize both classes of MHC proteins and the antigens they present

If the MHCs on cells of a tissue graft are not similar to those that T lymphocytes encountered during their development, the grafted cells will induce a strong immune reaction by T cells of the recipient.
To these lymphocytes, the unfamiliar MHC epitopes on the graft's cells are recognized as markers of "non-self " cells that they must eliminate.

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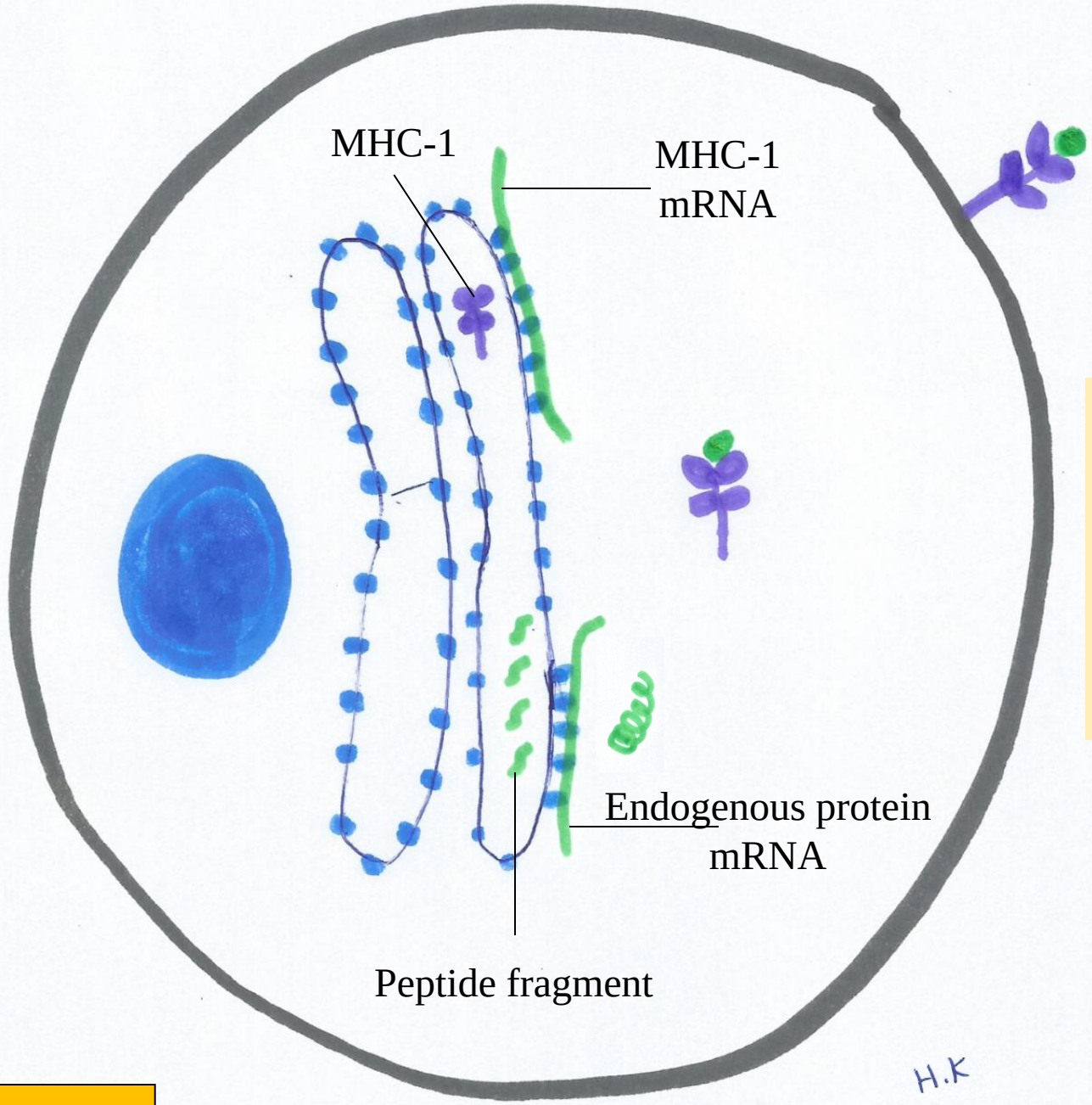
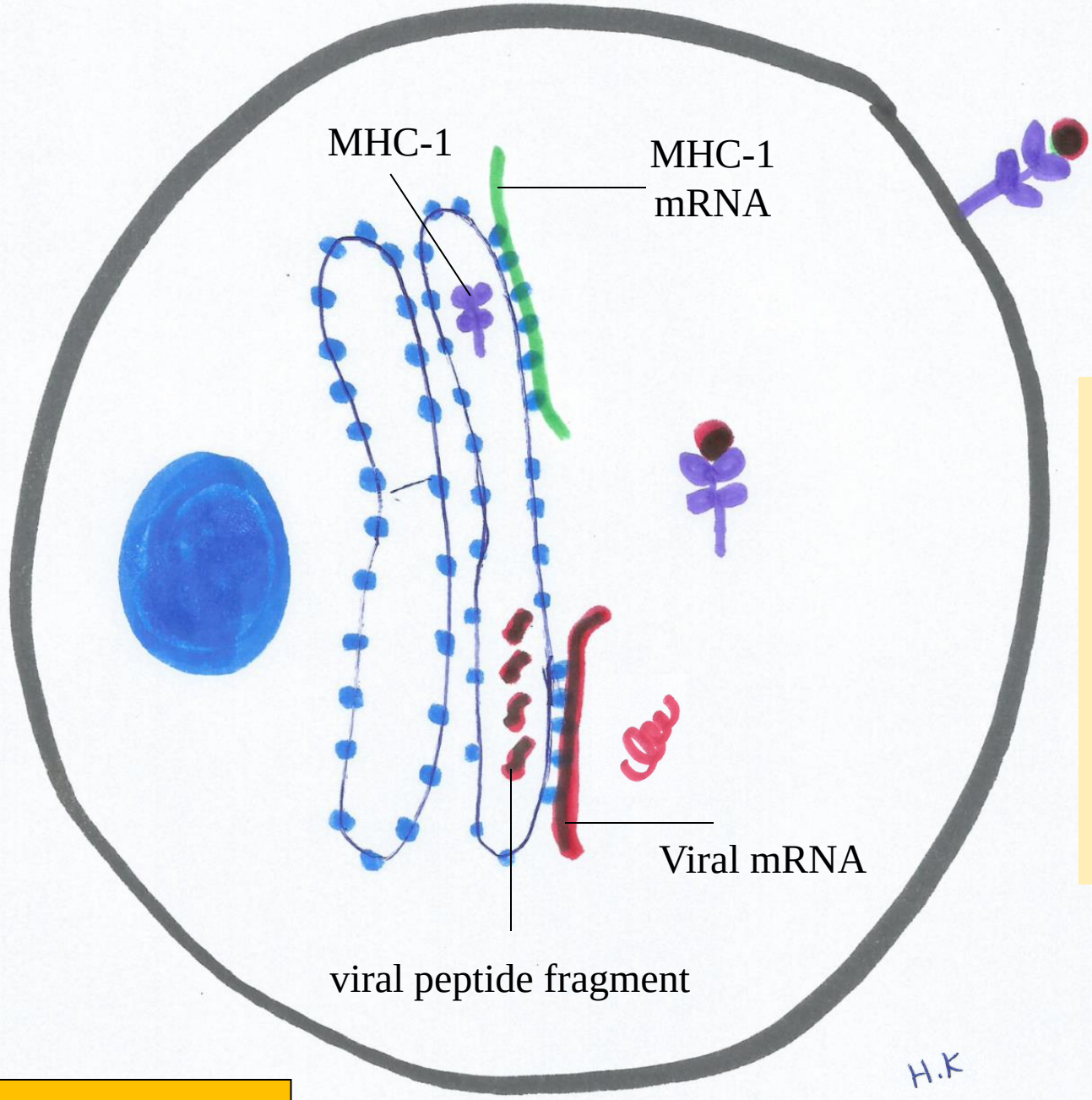


Self- peptide bound to MHC-1

Self-peptide is derived from the proteins that are synthesized by the cell (Self Antigen)

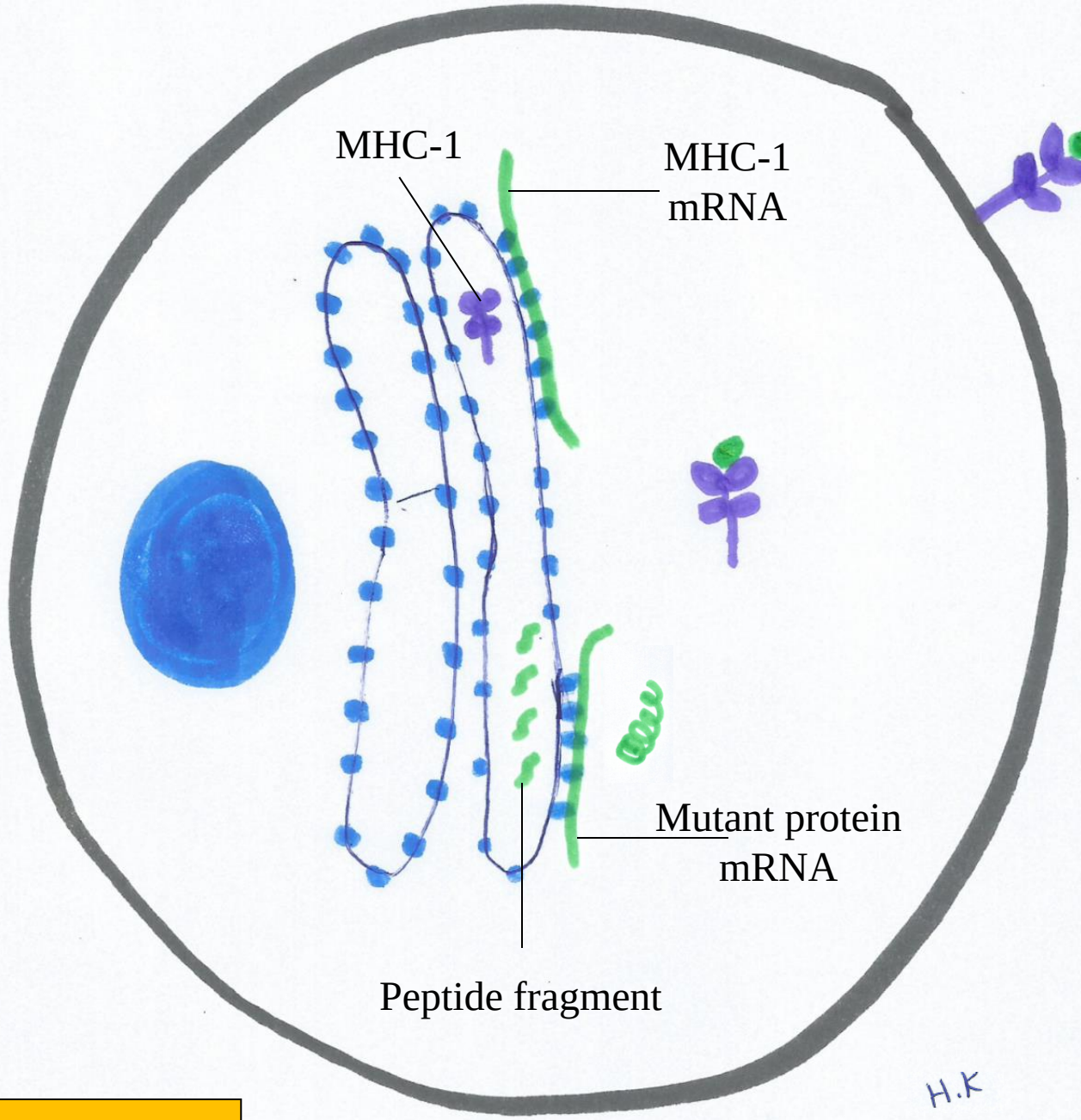
Normal cell



Viral- peptide bound to MHC-1

Viral peptide is derived from the viral proteins that are synthesized by the viral infected cell (non-self Antigen)

Viral infected cell



Mutant peptide bound to MHC-1

Mutant peptide is derived from the mutant proteins that are synthesized by the cancerous cell (non-self Antigen)

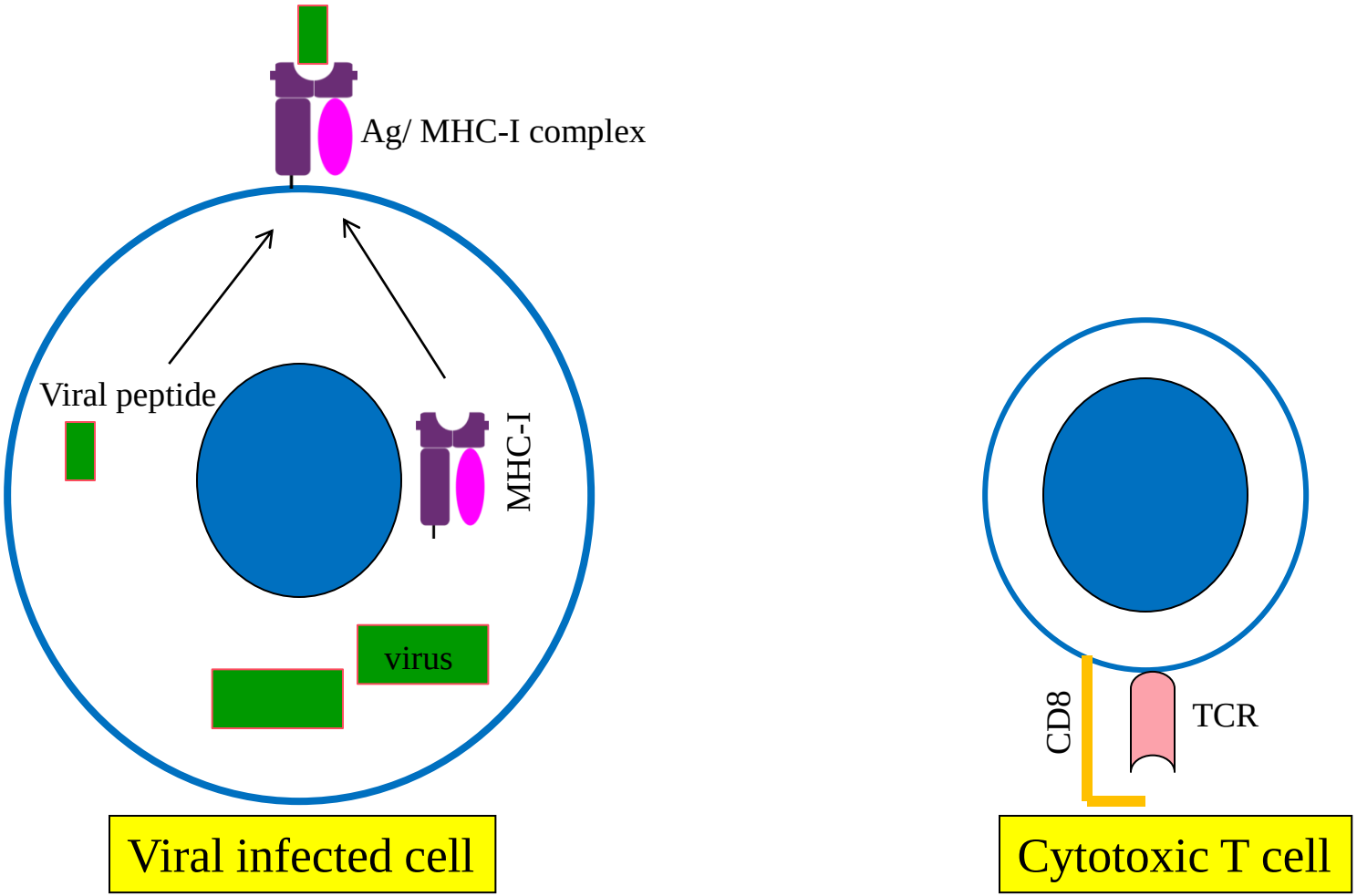
Cancerous cell

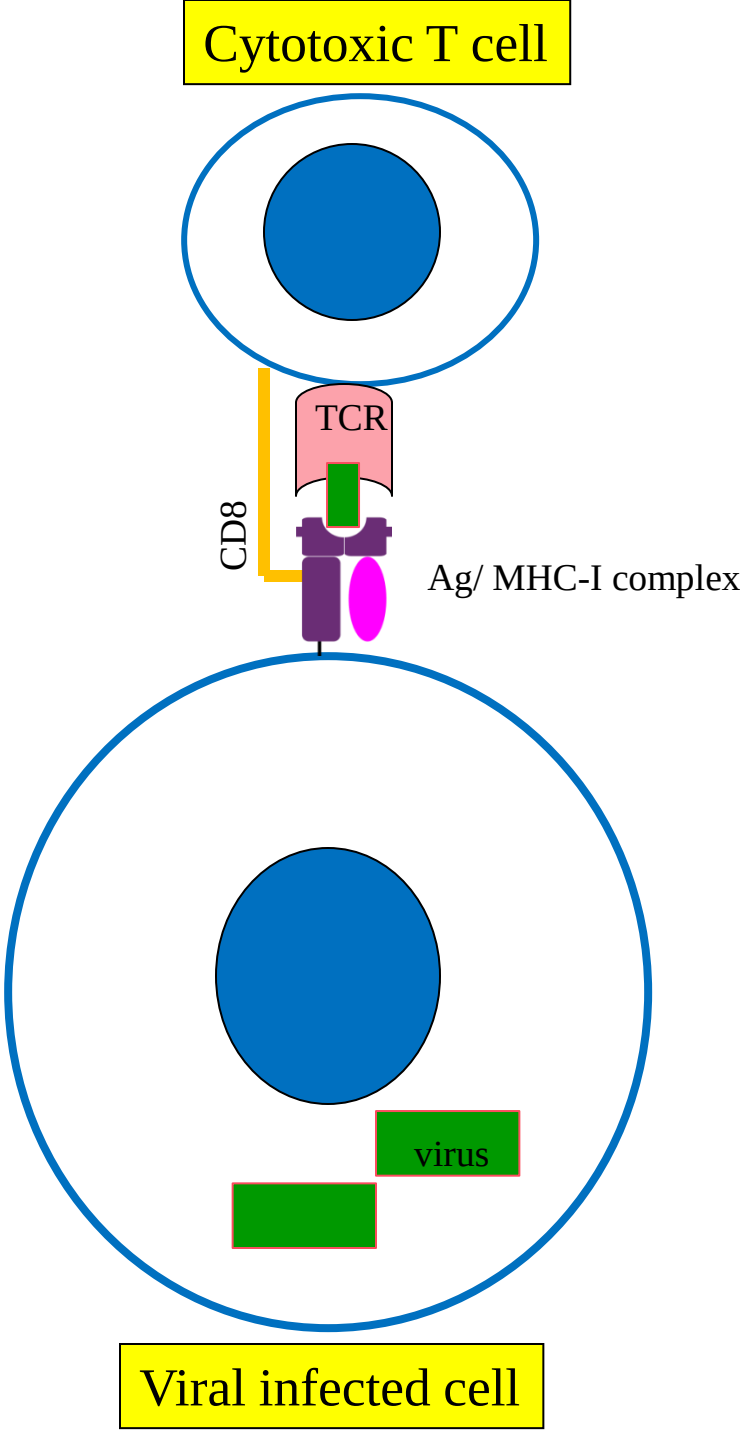
Cytotoxic CD8 T cells:

Antigen in virus infected, transplanted or neoplastic cells bind to MHC-I molecules

Cell- mediated immunity

Ag-MHCI complex



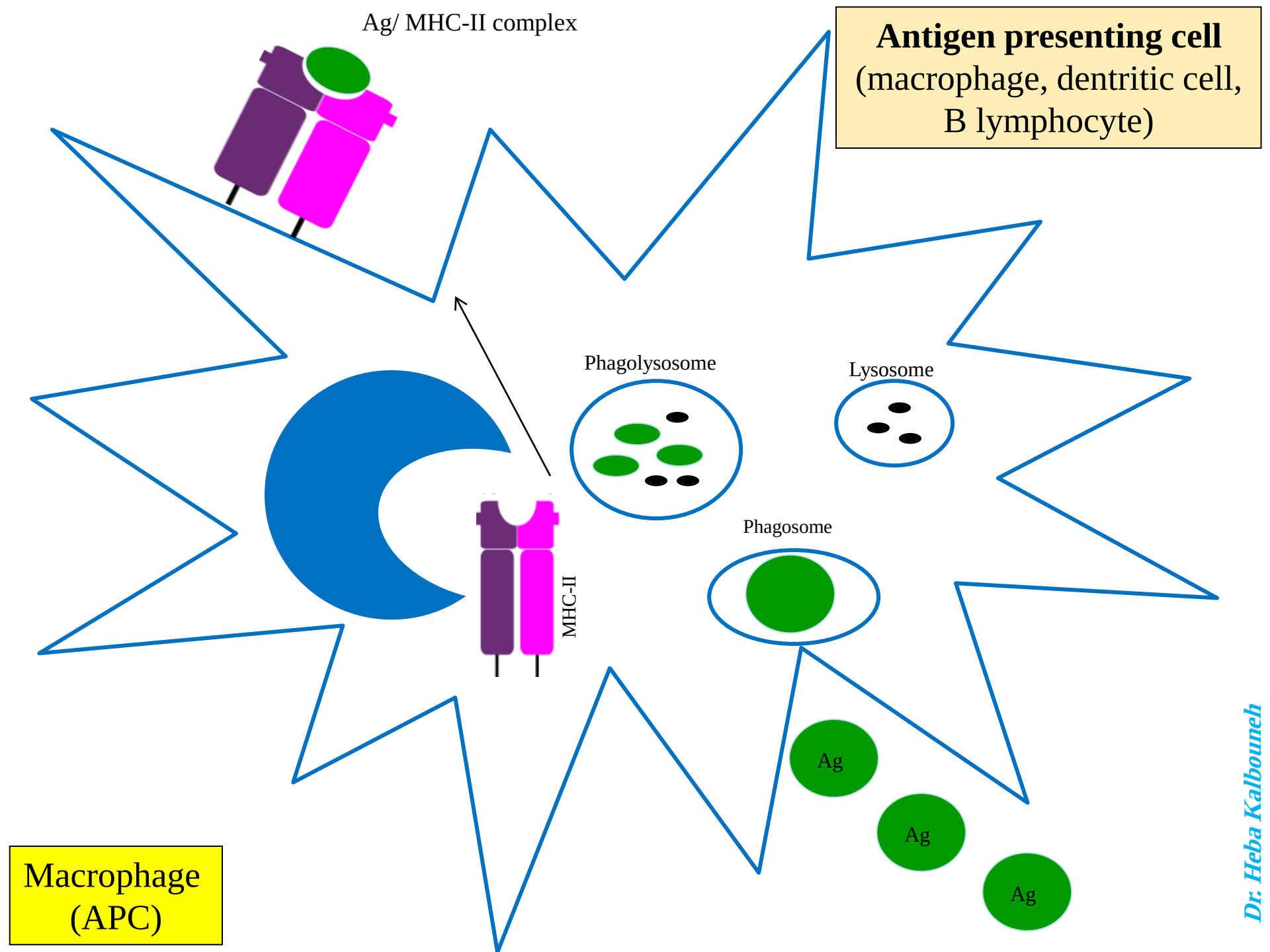


When the Ag- MHCI complex binds to receptors on cytotoxic CD8 T cells They

Proliferate
Activate

Release
Perforins and granzymes (proteases)

Perforins form pores in the cell membrane through which granzymes can enter, inducing apoptosis



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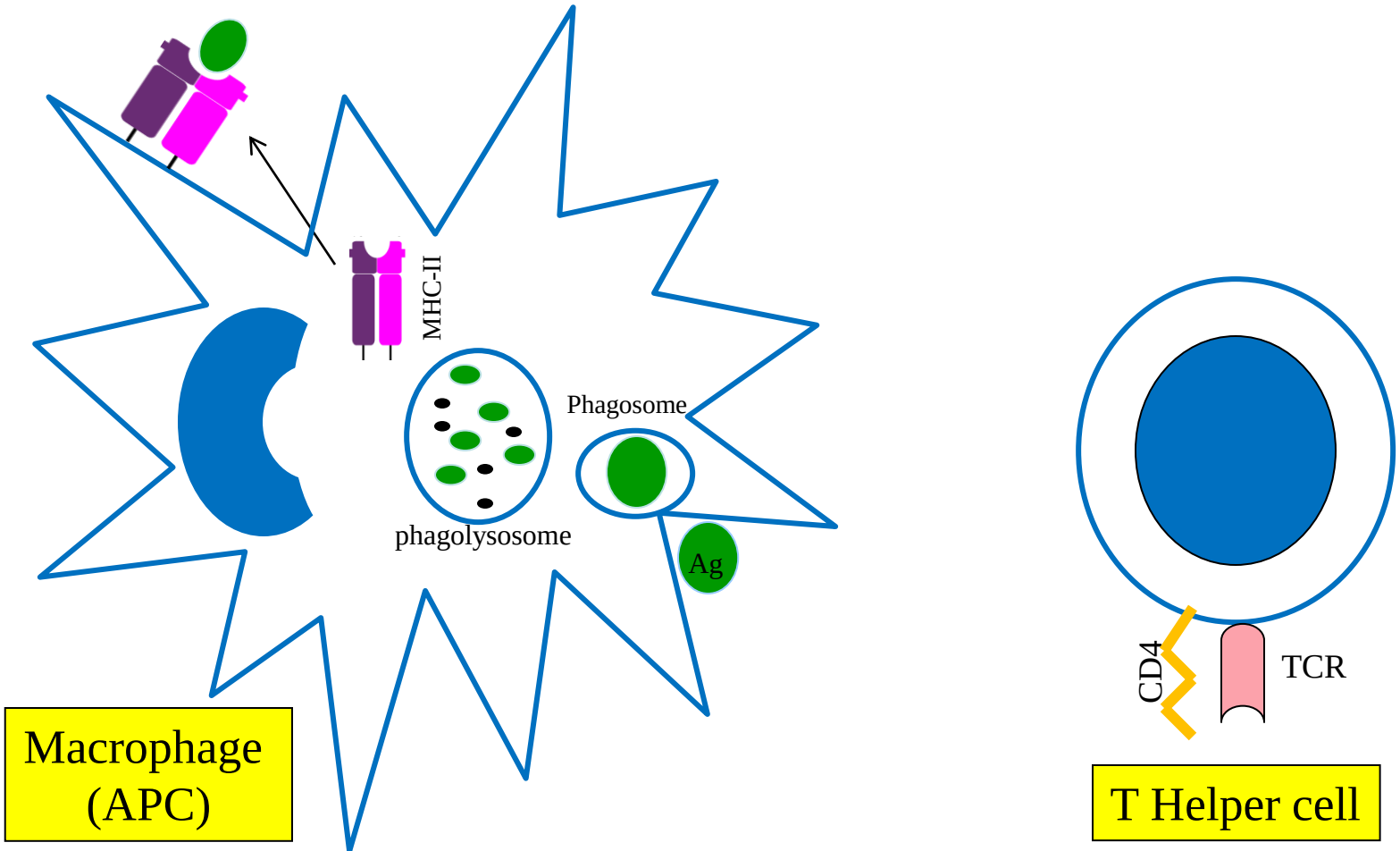
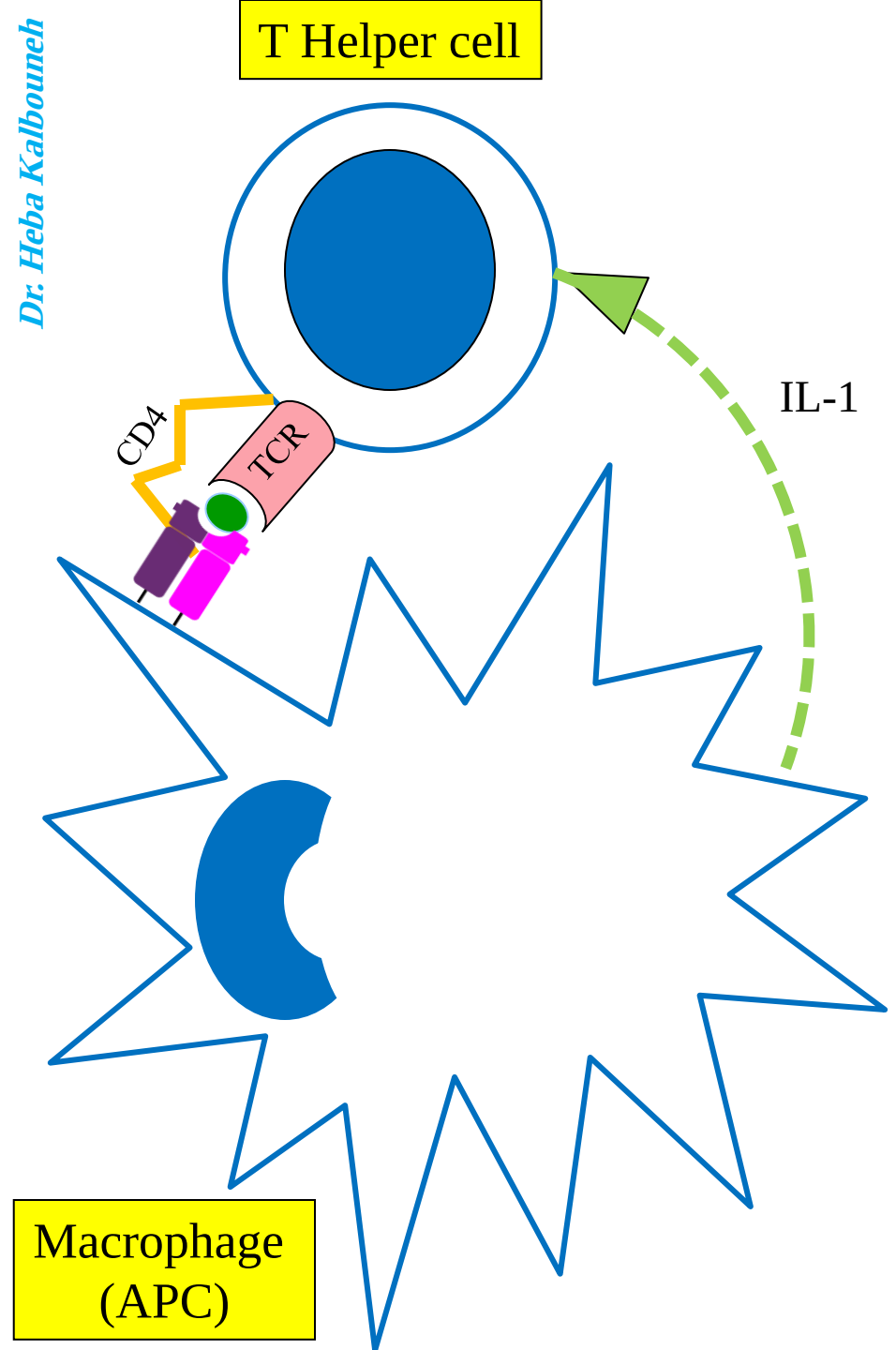
Helper CD4 T cells:

When Ag is phagocytosed by antigen presenting cells (APCs)
e.g macrophages, dentritic cell and B lymphocytes
It binds to MHC-II molecules

Ag-MHCII complex

Ag/ MHC-II complex

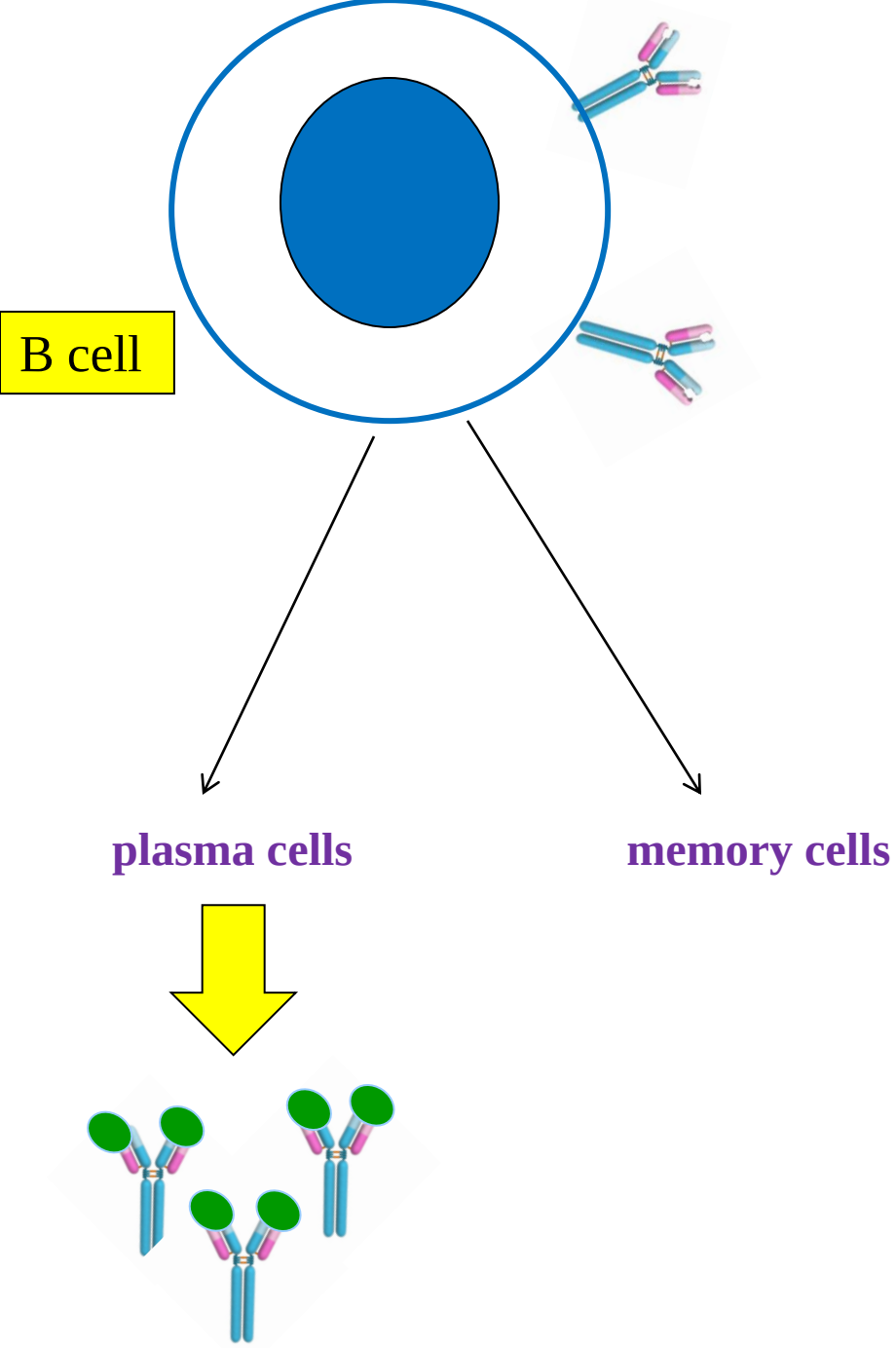




When the Ag- MHCII complex binds to receptors on Helper CD4 T cells
They

Proliferate
Activate

Secrete Lymphokines (cytokines) to Stimulate T and B cells



When a B lymphocyte is stimulated by T helper cells

Proliferate
Activate

Activated B lymphocytes:
1- differentiate into **plasma cells** (secrete antibodies)
2- differentiate into **memory cells**
(Rapid response on the 2nd exposure to the same Ag)

Life long immunity (vaccination)

Humoral immunity

B cells:

When the specific Ag binds to receptors on B cells

receptor-mediated endocytosis and fragments of the Ag bind to MHC-II molecules

Ag-MHCII complex

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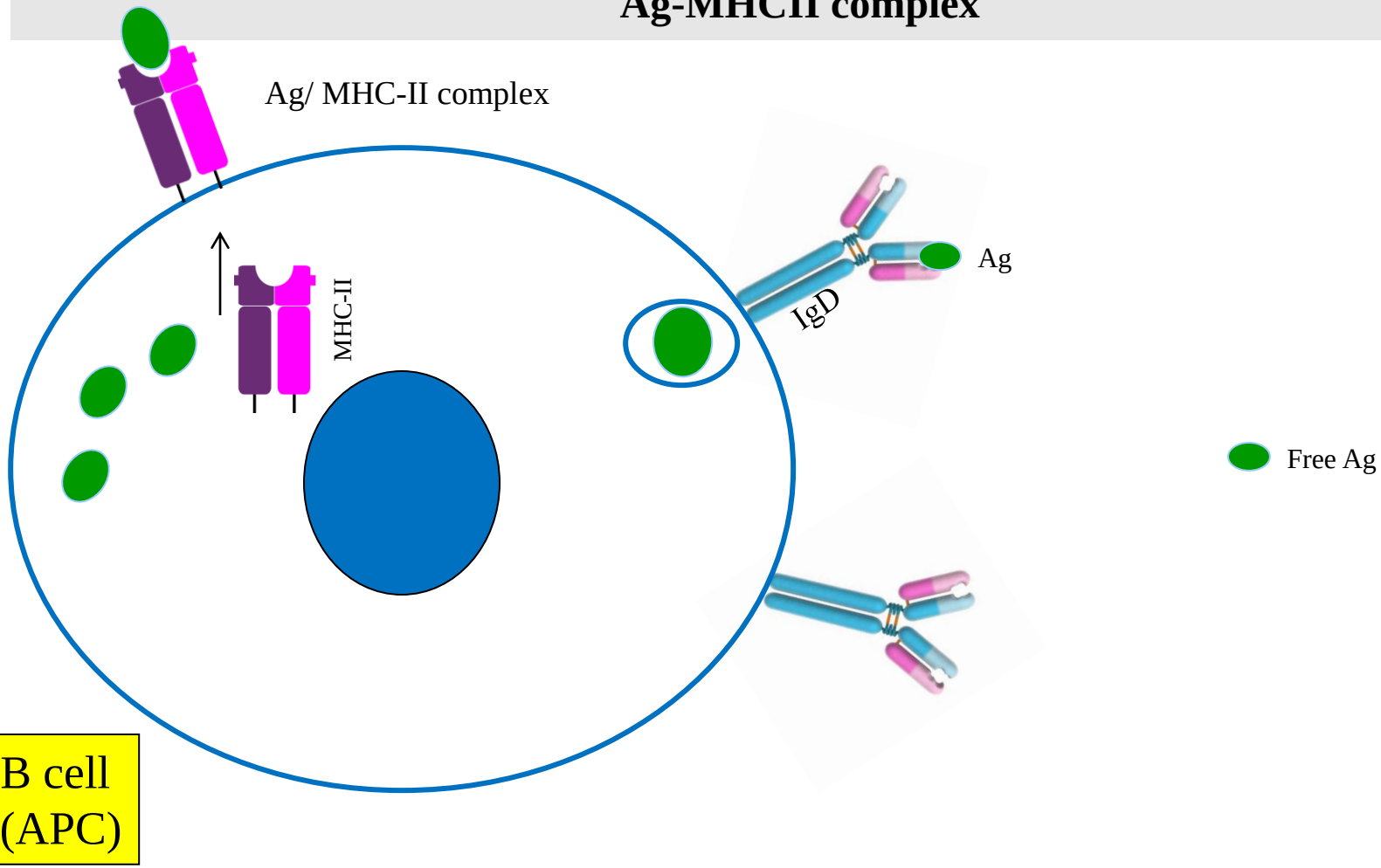

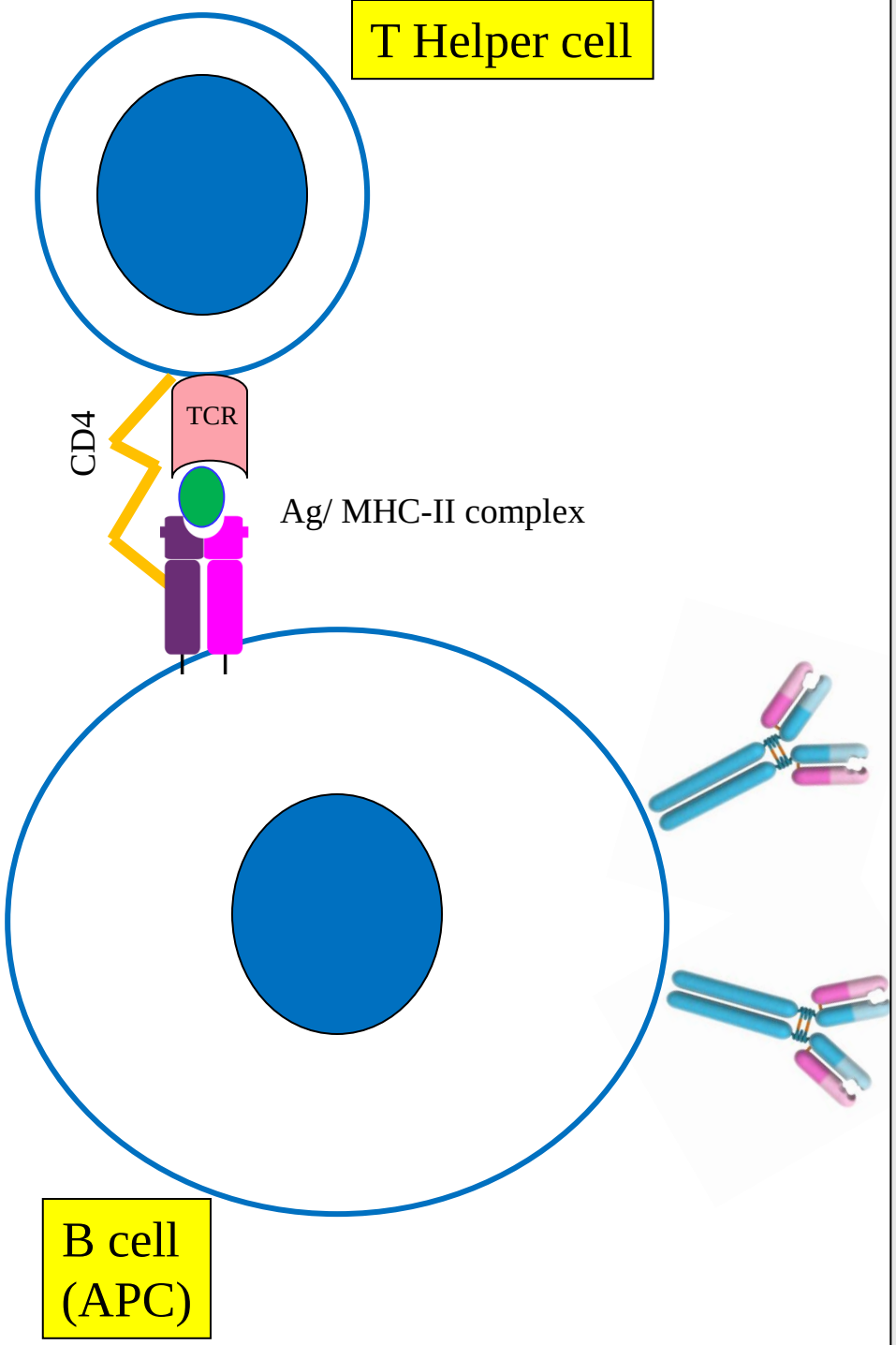

T Helper cells bind to Ag-MHCII complex on the B cells

↓

Stimulates proliferation and differentiation (activation) of B cells

↓

B cells

Proliferate
Activate

Activated B lymphocytes:
1- differentiate into **plasma cells** (secrete antibodies)
2- differentiate into **memory cells** (Rapid response on the 2nd exposure to the same Ag)

↓

Life long immunity (vaccination)

Never **L**et **M**onkeys **E**at **B**ananas

Most common to least

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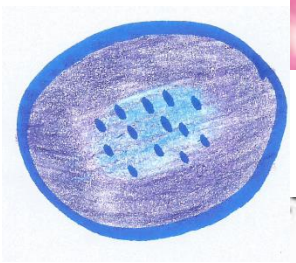
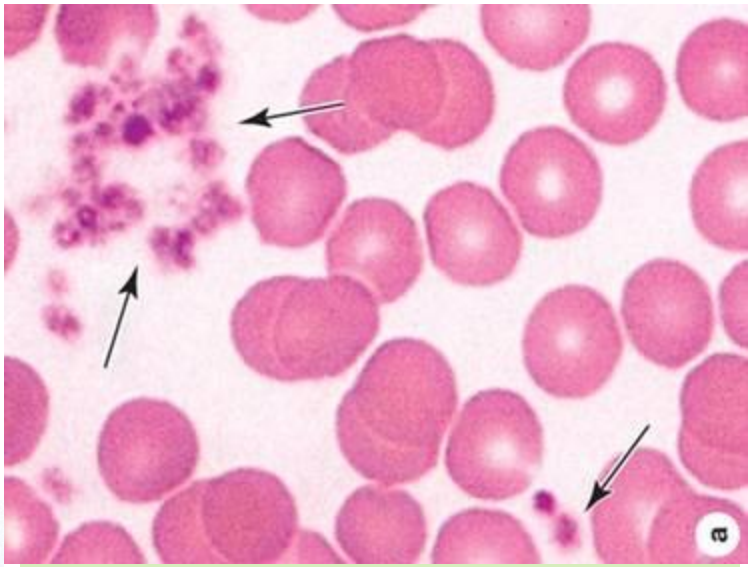
Thrombocytes (Platelets)

- Small non-nucleated cytoplasmic fragments
- Formed by fragmentation of the cytoplasm of **megakaryocytes** in the bone marrow
- **Number: 200,000-400,000/mm3**
- **Shape: biconvex discs**
- **Cytoplasm: purple, granular**
- **Diameter: 2-4 um**
- **Lifespan about 10 days**



- Control the bleeding by plugging the defects in blood vessels and activating blood clotting cascades

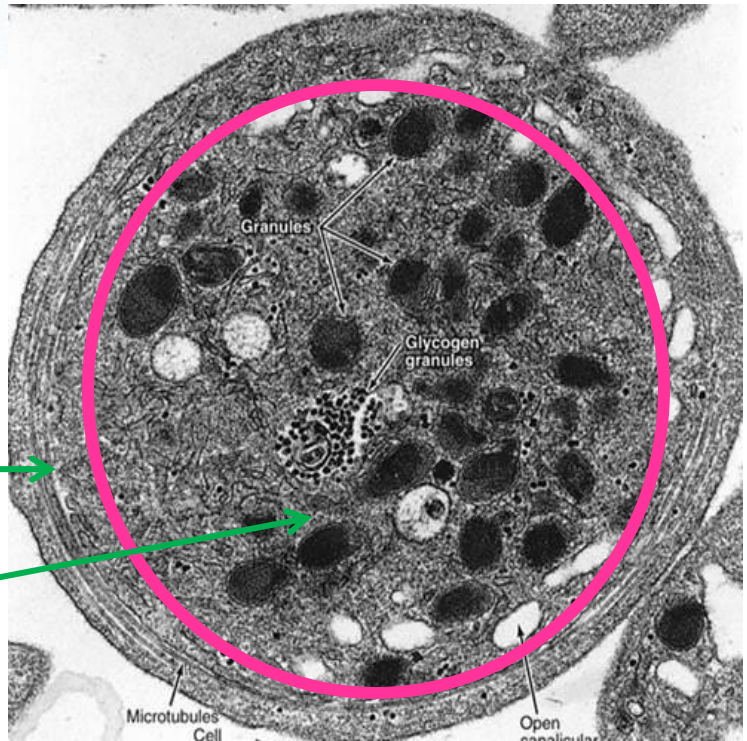


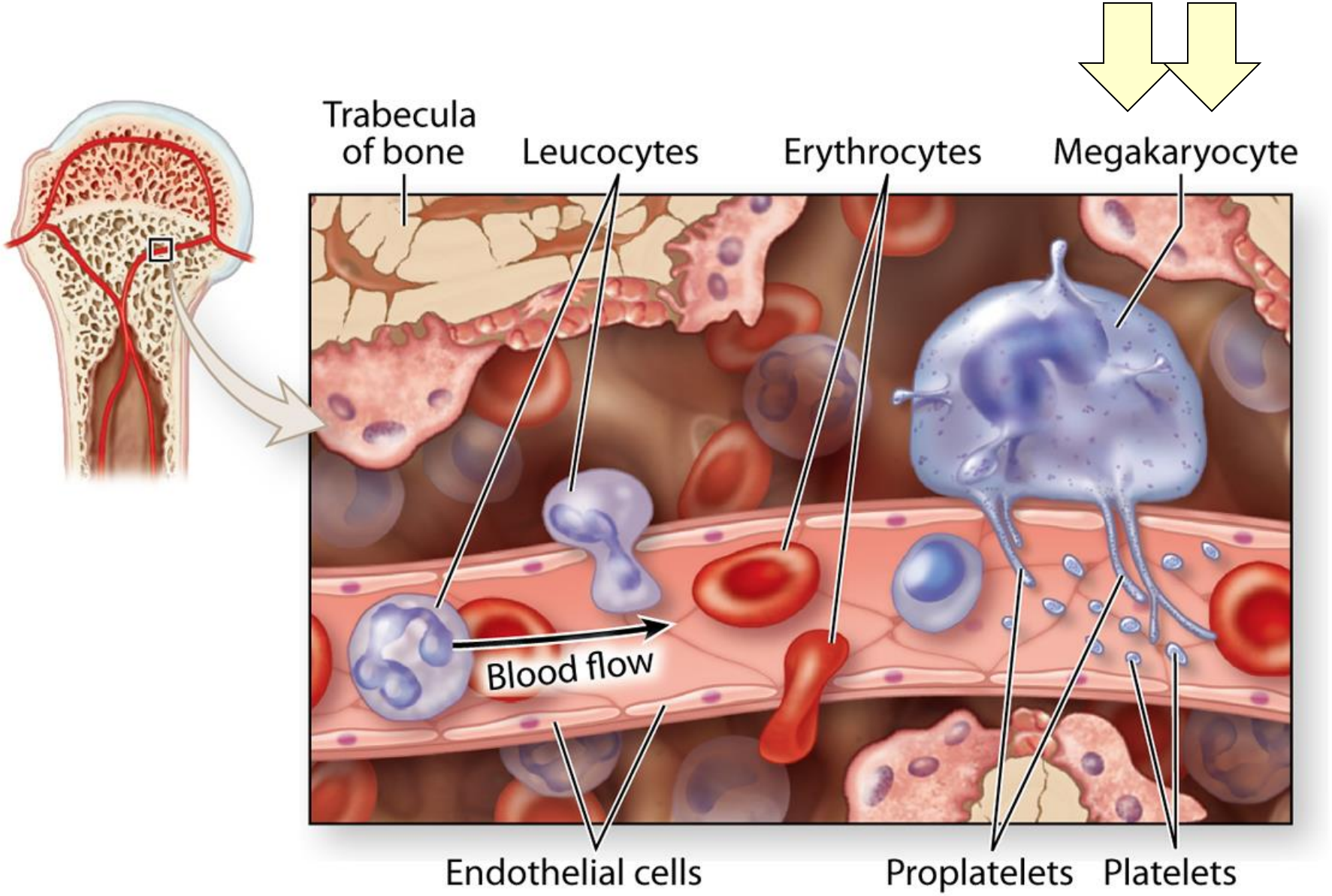
In stained blood smears, platelets often appear in clumps

Platelete has 2 zones

➢ Outer pale basophilic (clear) perpheriral zone: **hyalomere**

➢ Central dark granular zone: **granulomere**




Trabecula of bone
Leucocytes
Erythrocytes
Megakaryocyte
Blood flow
Endothelial cells
Proplatelets
Platelets

Hyalomere: contains cytoskeleton and membranous channels

Cytoskeletal elements

- Microtubule
- Actin filaments

Maintain shape and help contractions of platelets and squeezing, clot retraction

Membrane channels

- Open canalicular system
- Dense tubular system

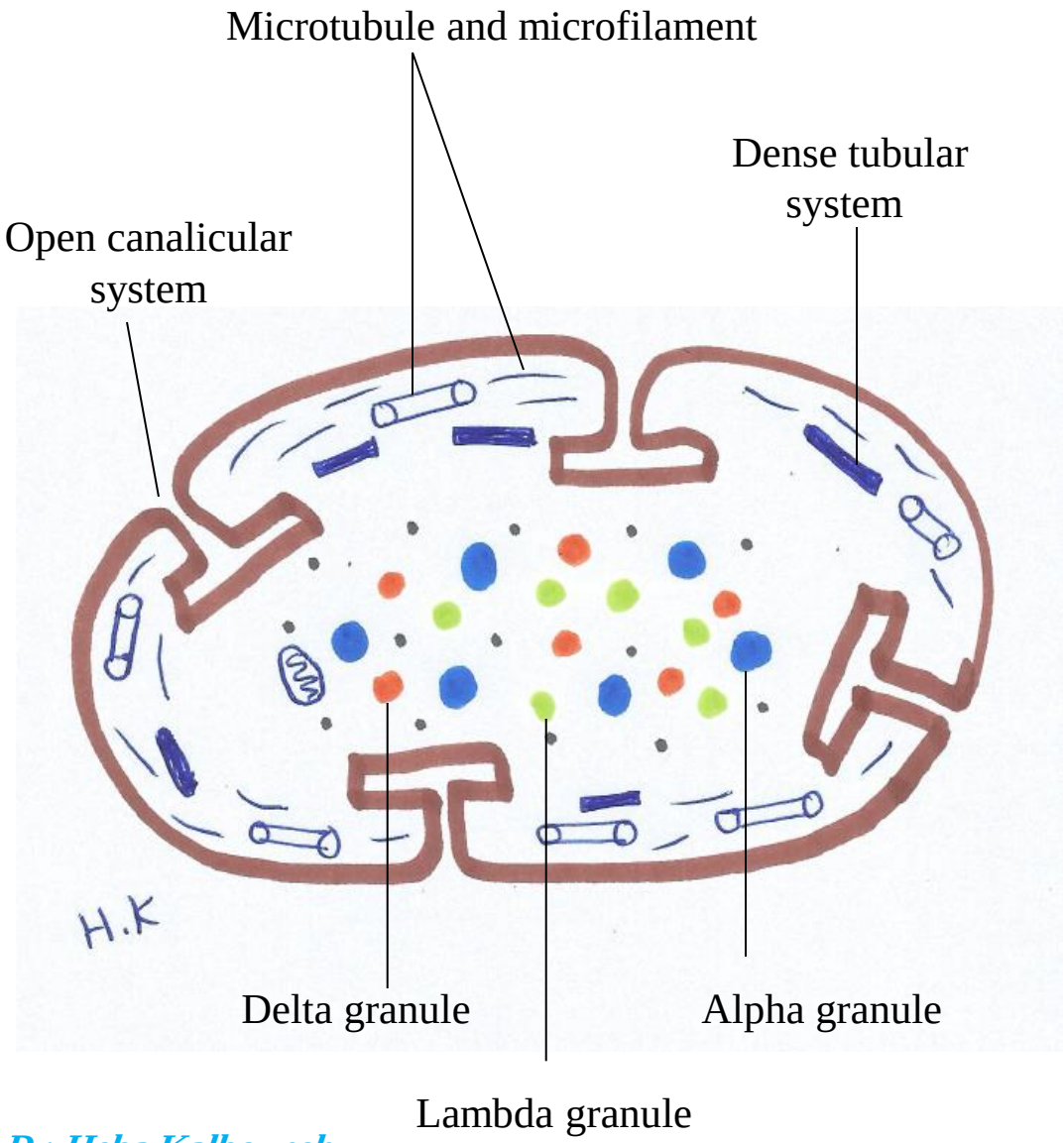
Granulomere: contains granules and organelles

Alpha granules: clotting factors, growth factors

Dense (delta) granules: serotonin (absorbed from plasma), ATP, ADP

Lambda granules: lysosomes (aid in clot resorption)

Have thick glycocalyx



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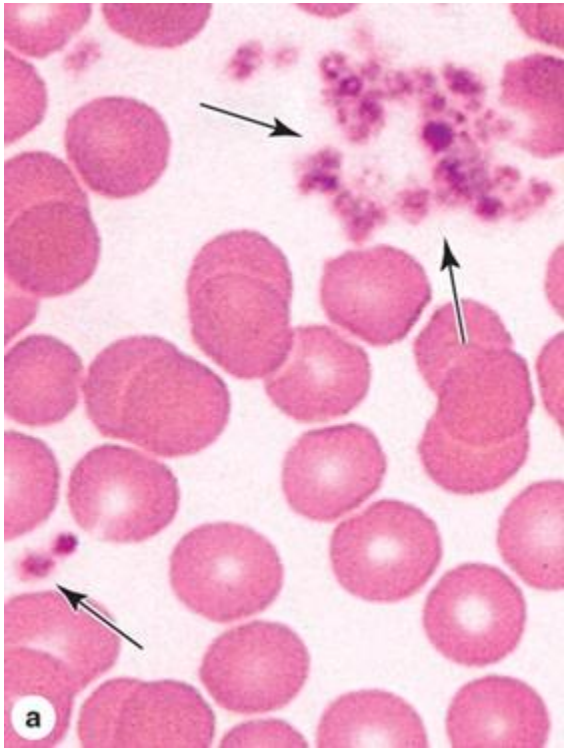
Their main function is to continually monitor the vascular system and detect any damage to the endothelial lining of the vessels. If the endothelial lining breaks, the platelets adhere to the damaged site and initiate a highly complex chemical process that produces a blood clot

Thus preventing blood loss



Useful links (optional)

http://highered.mheducation.com/sites/dl/free/0072507470/291136/t_cell_dependent_antigens.swf

http://highered.mheducation.com/sites/dl/free/0072507470/291136/Cytoxic_T_cell_activity_against_target_cells.swf

http://highered.mheducation.com/sites/dl/free/0072507470/291136/immResponse.swf

Some basic concepts in general histology

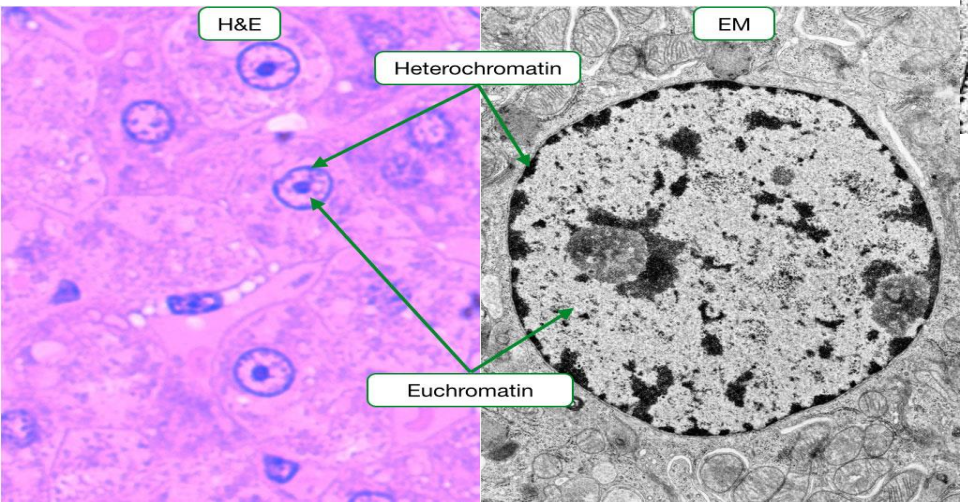
Chromatin

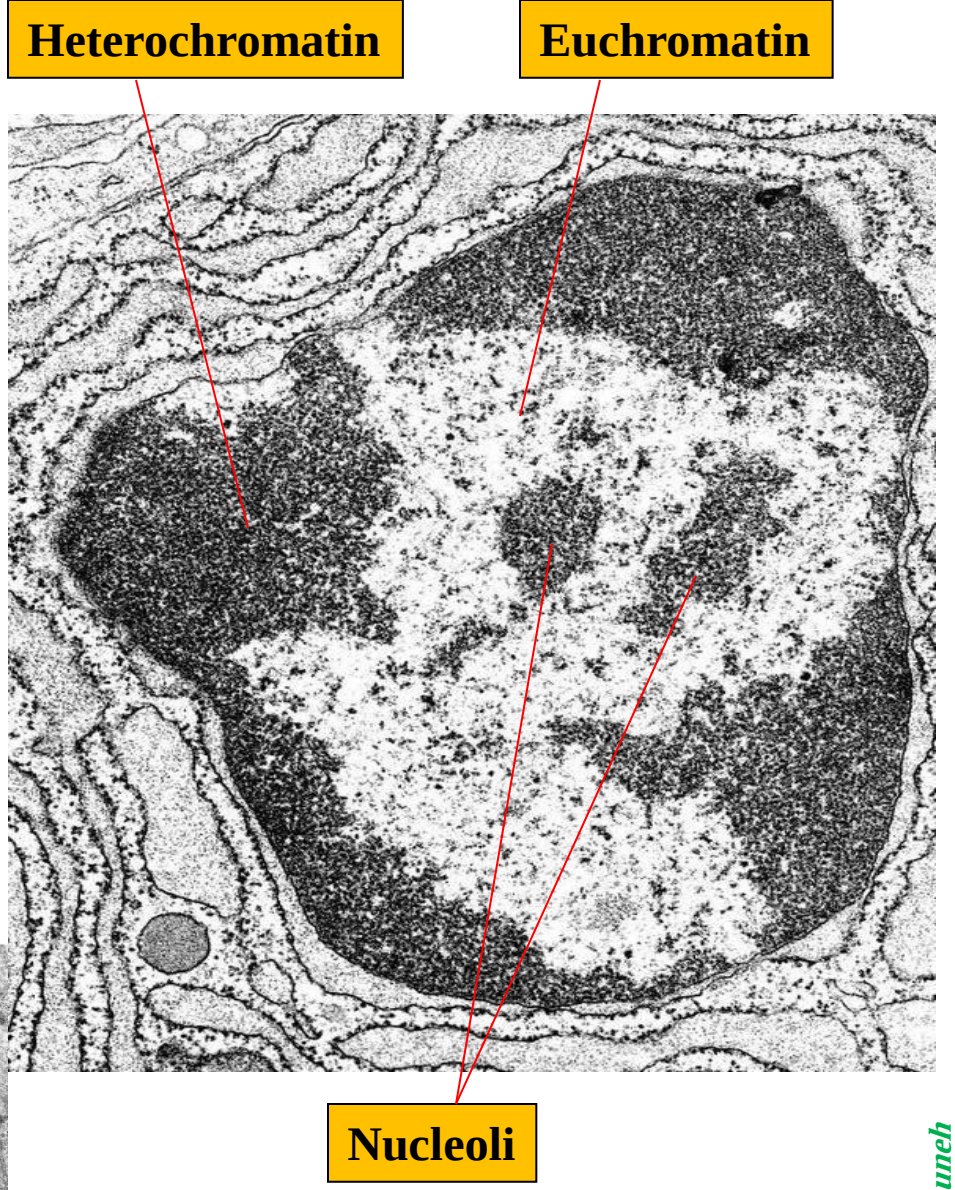
Formed of **DNA**.

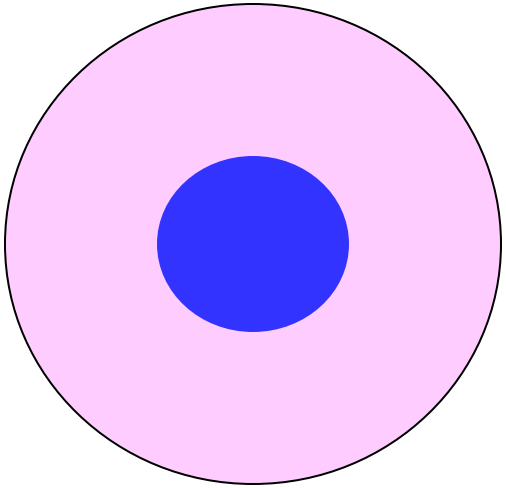
- **2 Forms:**
  - **Euchromatin**: extended active chromatin (pale).
  - **Heterochromatin:** condensed inactive chromatin (dark)

Nucleolus

- It is a spherical dark mass not surrounded by a membrane.
- Usually one.
- **Function:** formation and assembly of ribosomal RNA (rRNA), which is responsible for protein synthesis in the cytoplasm



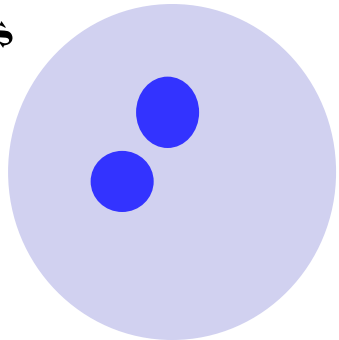




H & E

Active nucleus

Nucleolus is a spherical dark basophilic mass



Inactive nucleus

Note:

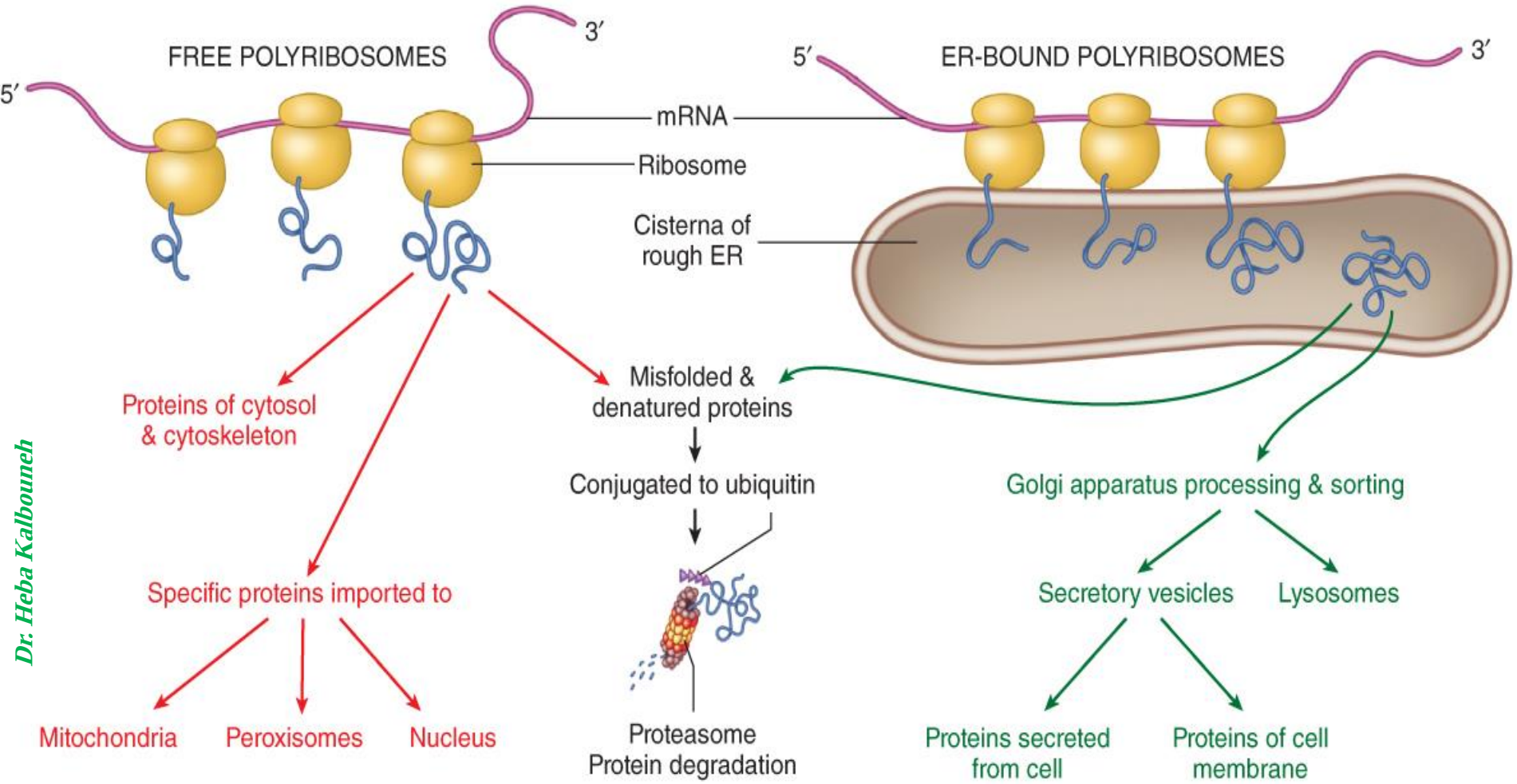
The nucleus stains blue (basophilic) using H&E

Lightly basophilic: active **Deeply basophilic and small: inactive**

Note:

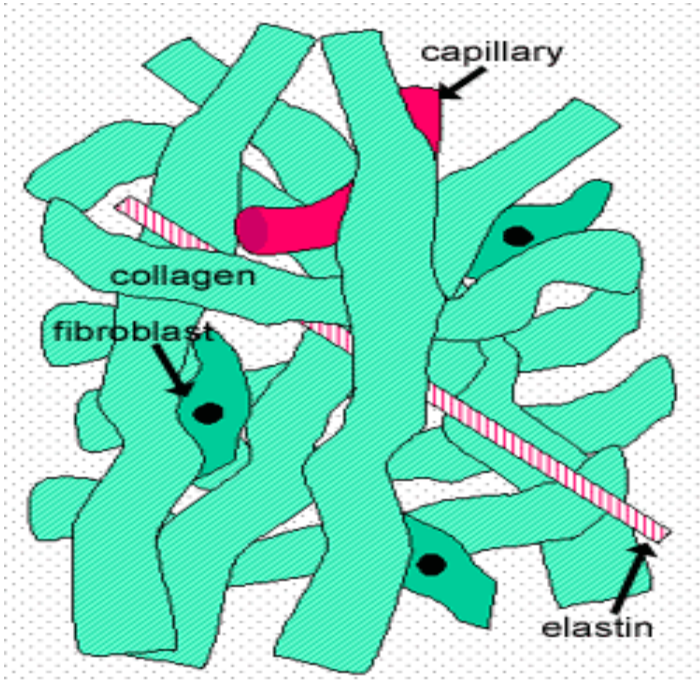
The cytoplasm stains pink/red (acidophilic) using H&E

The organelle (when prominent) that produces basophilia in the cytoplasm is the ribosome



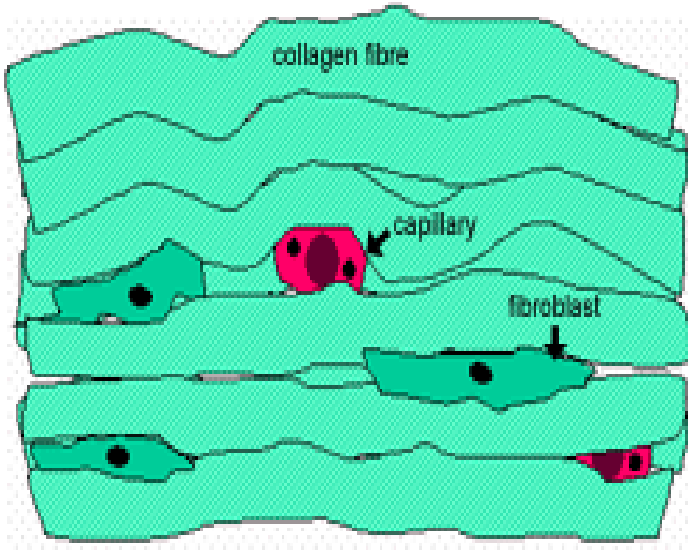
Dense irregular connective tissue

- ✓ Bundles of collagen fibers are randomly interwoven with no definite orientation
- ✓ Provides resistance to stress from all directions
- ✓ Dermis of skin (deeper layer), **organ capsules**, submucosa



Dense regular connective tissue

✓Parallel Bundles of collagen fibers with few fibrocytes aligned with collagen and separated by very little ground substance



Stroma means bed

Parenchyma / Stroma:

The parenchyma of an organ consists of that tissue which conducts the specific function of the organ and which usually comprises the bulk of the organ. Stroma is everything else -- connective tissue, blood vessels, nerves, ducts. It is made up of all the parts without specific functions of the organ

For Example:

The *parenchyma* of the heart is muscle tissue (cardiac muscle cells). The nerves, intrinsic blood vessels, and connective tissue of the heart comprise the *stroma*.

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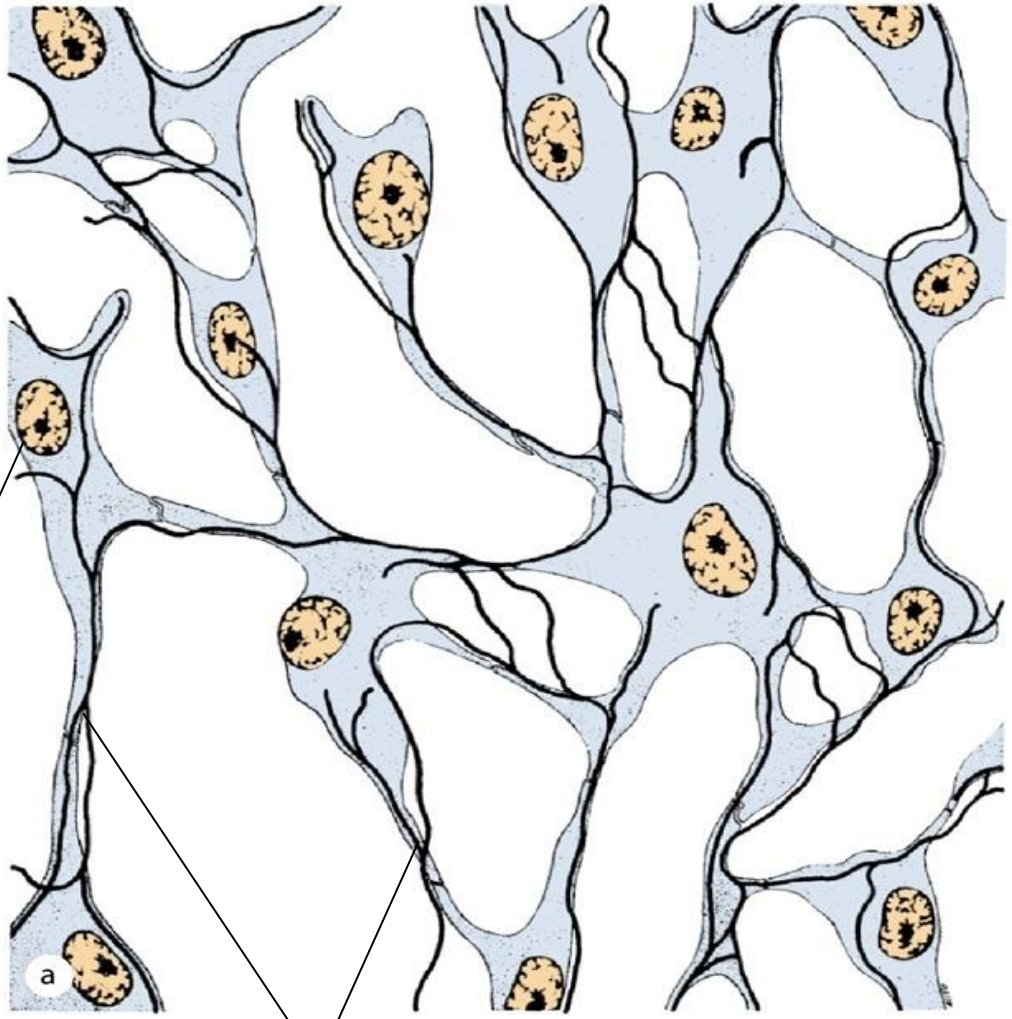
Reticular connective tissue

- Consists of reticular cells (modified fibroblasts) and the network of reticular fibers formed by them
- Forms the structural framework (stroma) in which the cells of the organ are suspended
- In the liver, bone marrow, lymph nodes and the spleen **(Reticulo-Endothelial organs)**



Types of capillaries

Continuous capillaries
- Are most common
- Endothelium forms solid lining
- Adjacent cells are held together with tight junctions
- Found in most organs

Fenestrated capillaries
- Endothelium contains pores (fenestrations)
- Found wherever active capillary absorption or filtrate formation occurs
- Found in endocrine glands, small intestine, and kidney

Sinusoidal capillaries
- Exhibit wide diameters with wide gaps between endothelial cells
- Basement membrane incomplete or absent
- Allow large molecules (proteins and blood cells) to pass between the blood and surrounding tissues
- Found in liver, spleen, and bone marrow