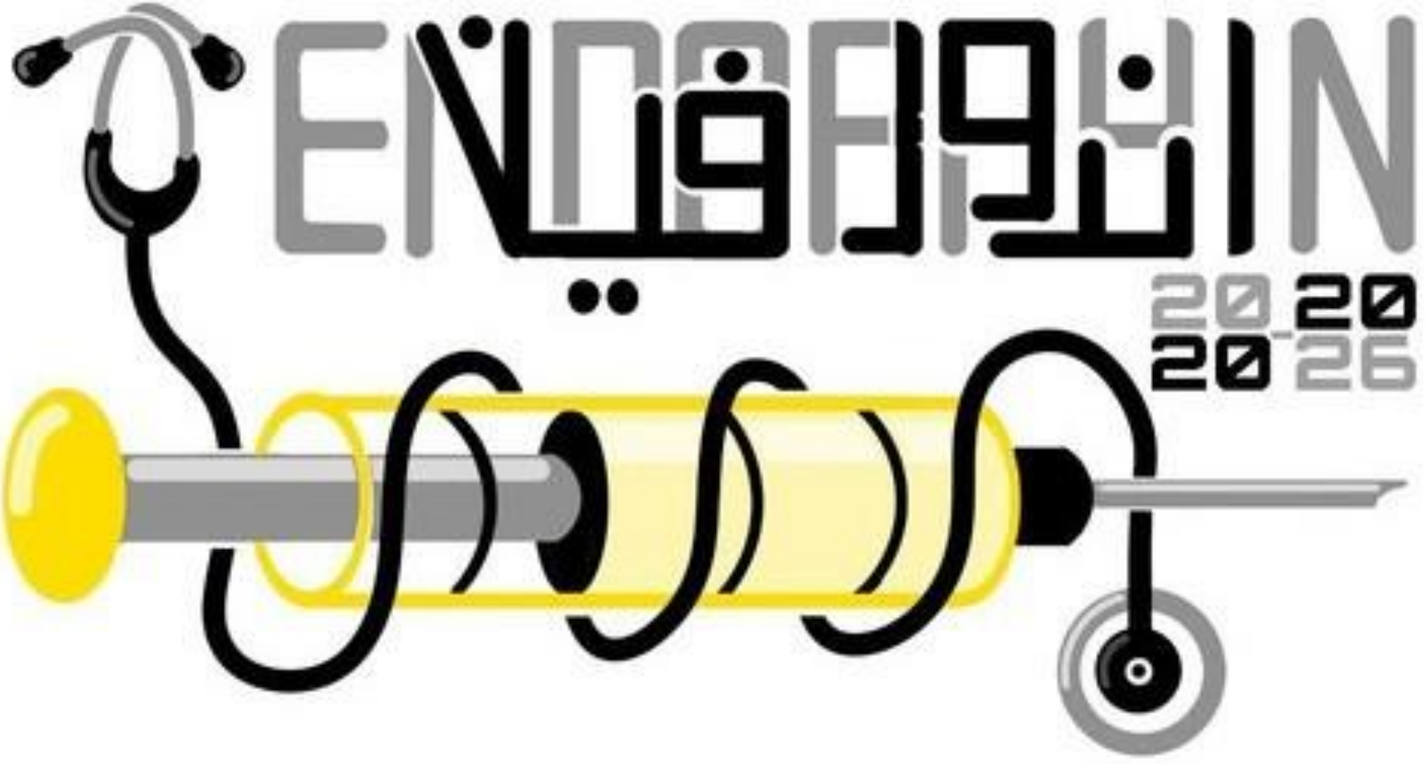
Anatomy



Sheet: #2

Lecture title: **blood cells and hemopoiesis**

Date:28/2/2022

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Edited by: Aseel N Alqutifan

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Leukocytes

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

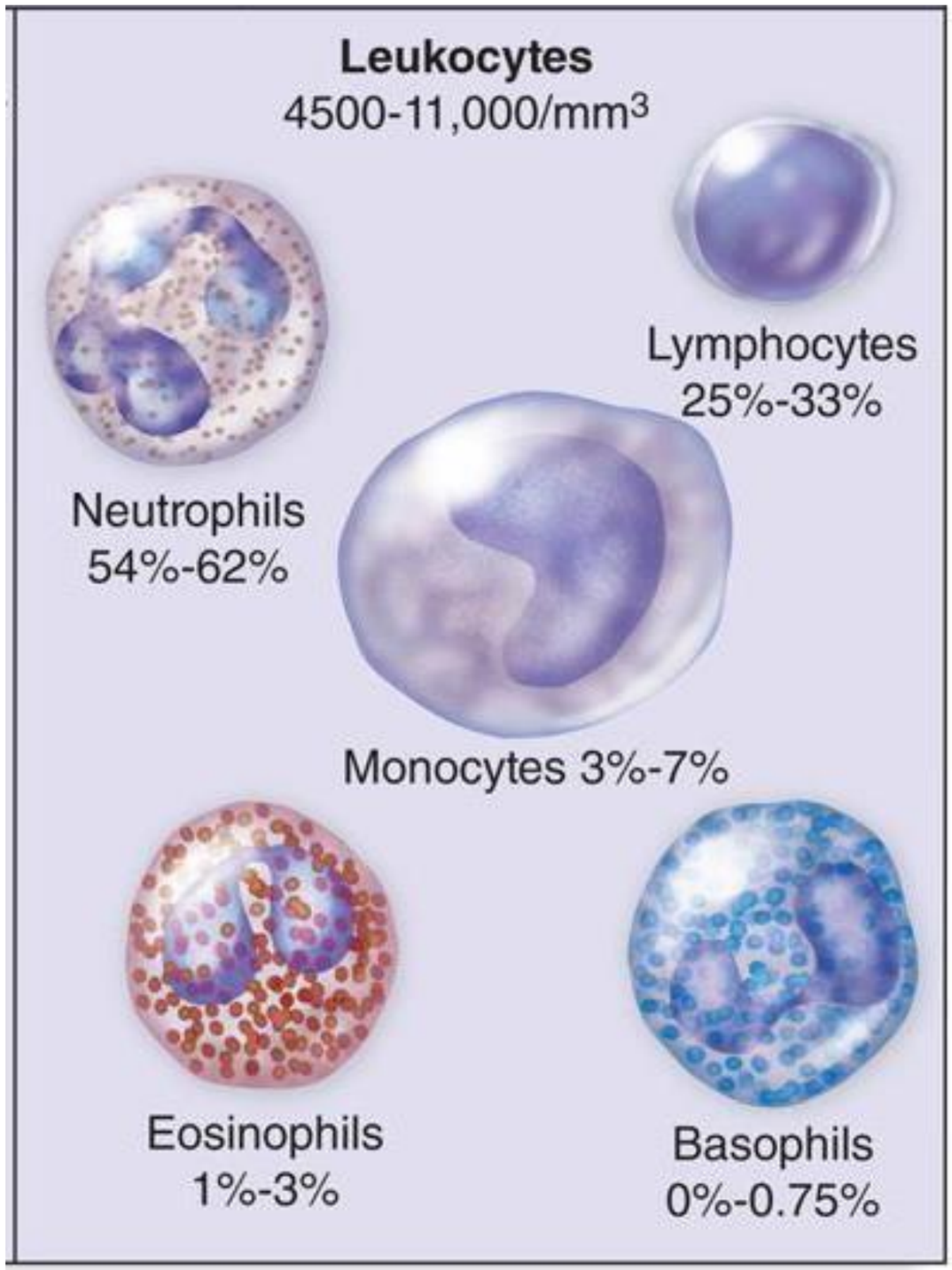
- <u>5 types organized into 2 groups depending on nuclear shape and cytoplasmic granules</u>

–Granulocytes (single, multi-lobed nucleus)

I. Neutrophils
II. Eosinophils
III. Basophils

–Agranulocytes (mononuclear leukocyte)

I. Lymphocytes
II. Monocytes



- Red bone marrow → main function is production of blood .
- Yellow bone marrow is filled with adipose tissue and it doesn’t produce blood.
- Function of leukocytes is outside the circulation, they function in the connective tissue

- تصنيف خلايا الدم البيضاء حسب ال granules فكرو انه ال monocytes +lymphocytes ما فيهم، بس طلع فيهم

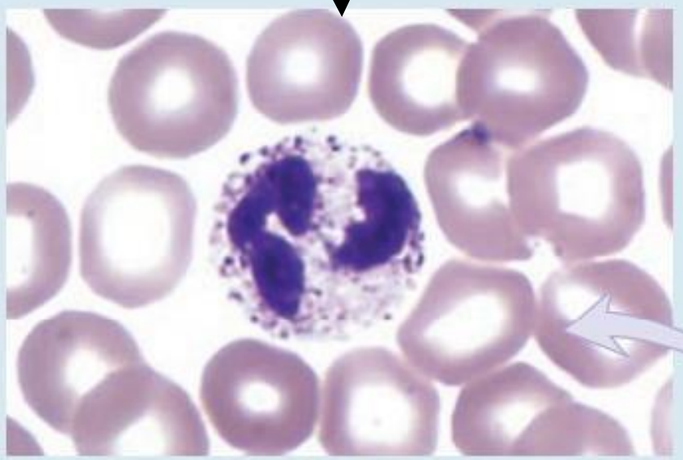
- Both types have granules but the **granulocytes** have special(specific) granules.
- The agranulocytes have only lysosomes(primary granules)
- Multi-lobed nucleus (but single) is associated → granulocytes
- Mononuclear is associated → agranulocytes

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

هون مش multinucleated بس multi-lobed nucleus
ومرتبطات ببعض بخط رفيع اسمه كروماتين chromatin

Neutral affinity for both dyes, so the granules are barely seen small granules

Single nucleus, multi-lobed nucleus



Neutrophil

These specific granules stain red with acidic stain such as eosin

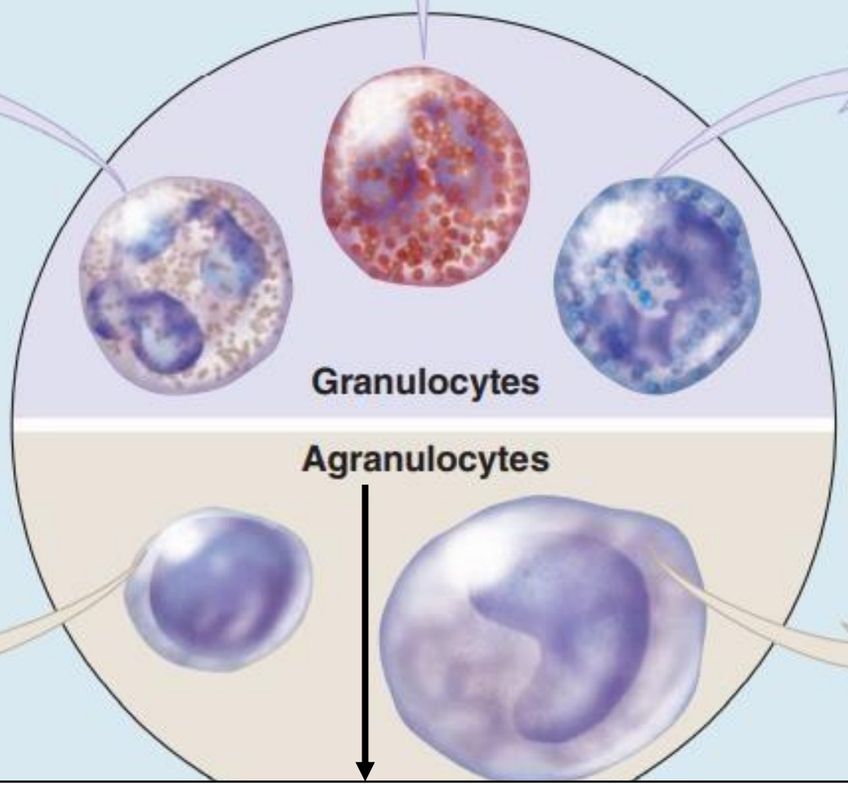
Large granules, acidophilic → pink granules

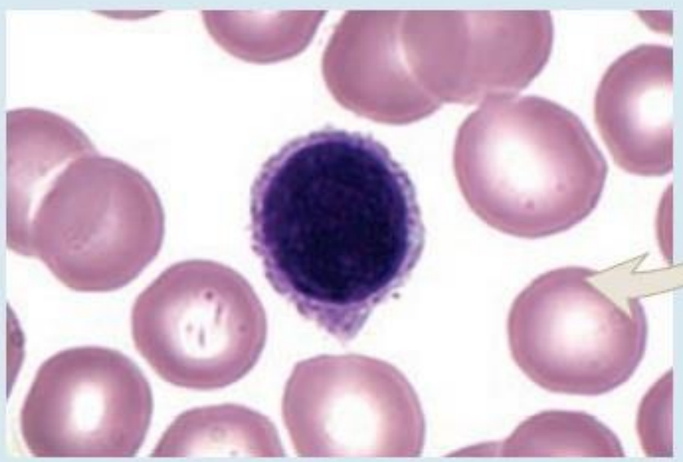
Eosinophil

Large granules, basophilic → deep blue granules

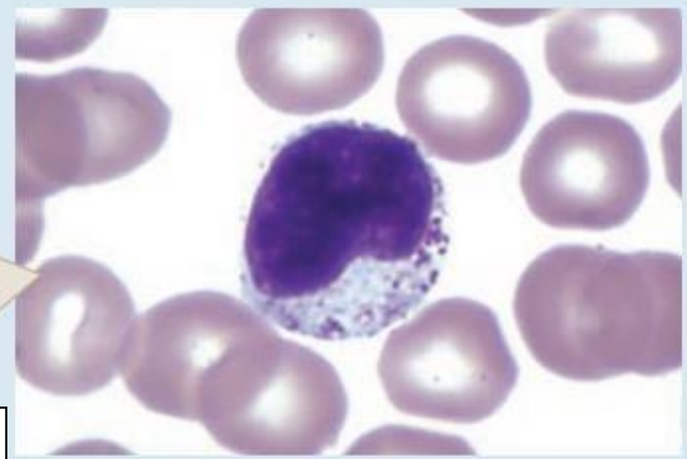
These specific granules stain with basic stain

Basophil





Lymphocyte



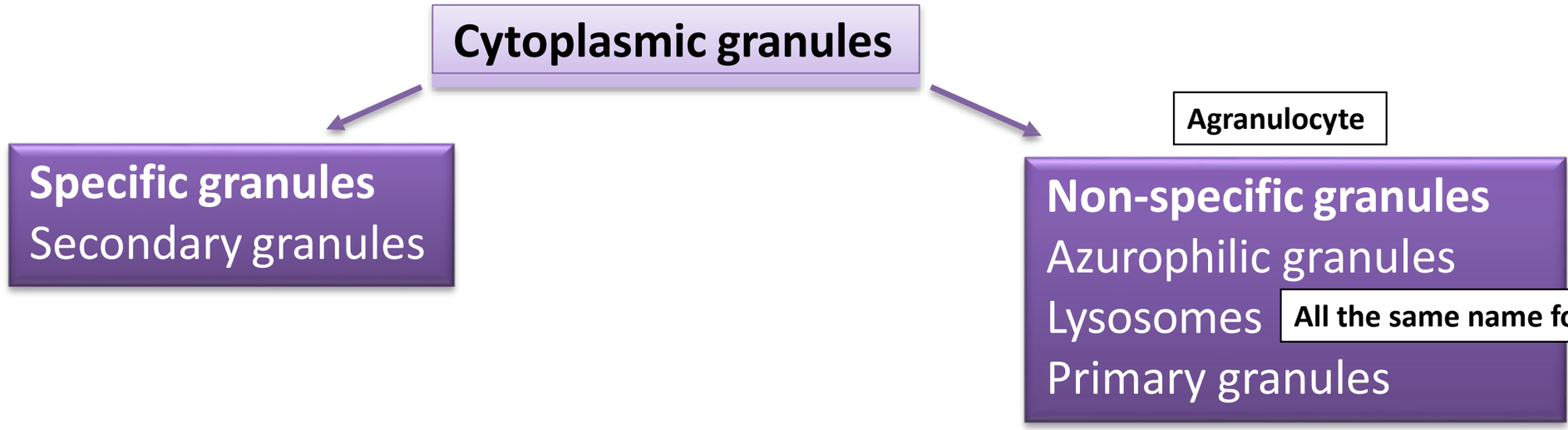
Monocyte

Nonspecific granules → lysosomes → stained by azure dye → azurophilic
Lysosomes=Primary granules= Nonspecific granules

Lymphocyte play a key role in all immune responses, in contrast to the other leukocytes their activity is always directed against specific foreign agents

All the leukocytes perform their function in the tissues and merely use the blood asa vehicle for transit between sites of formation, storage, activity

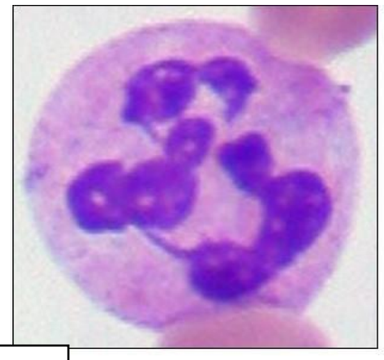
Neutrophils and monocytes are highly phagocytic and engulf micoorganisms, cell debris in a non-specific manner.



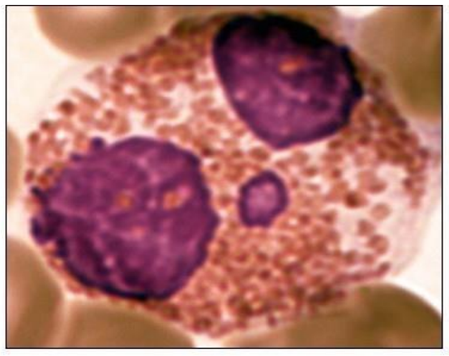
Granulocytes

- 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:

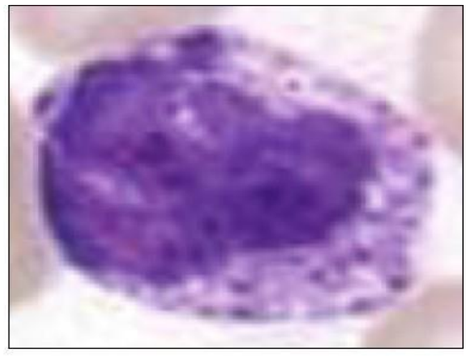
The granules are hardly seen?
Because it doesn't have specific affinity for dyes
It needs high magnification to be seen.



Small granules, pale pink/salmon pink



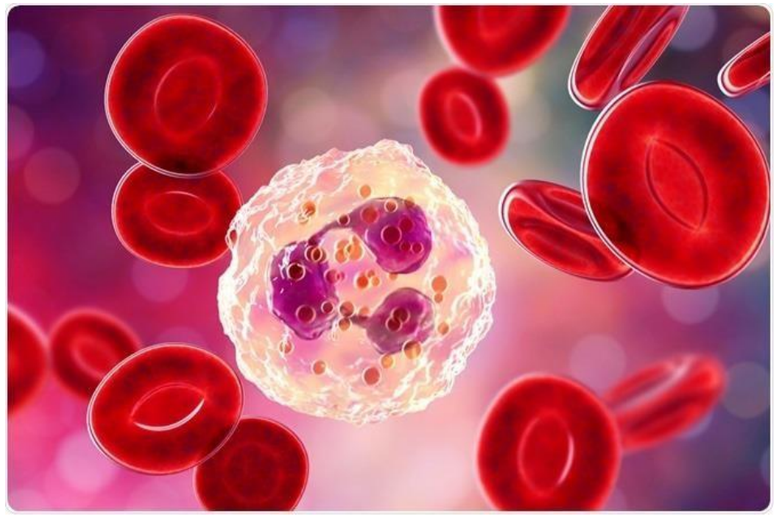
Large granules, Red

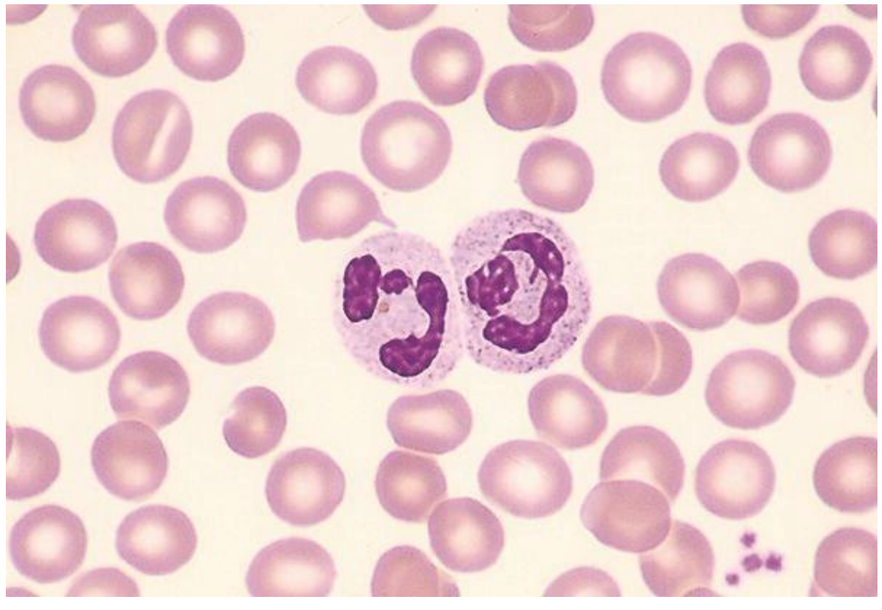


Large granules, blue

Neutrophil

- The **most common** leukocyte in blood
- constitute <u>40-75%</u> of circulating leukocytes
- Characterised by the shape of the nucleus which contains small lobed connected by thin filaments
- When mature there are usually 5 lobes connected by fine strands of nuclear material. In less mature neutrophils the nucleus is less lobulated
- 2-5 lobes in nucleus connected by “threads” of nuclear material (**polymorphs)** → Same name for neutrophiles in clinical application
- Light pink cytoplasm
- Called neutrophils because cytoplasm takes up red (acidic) and blue (basic) stains equally





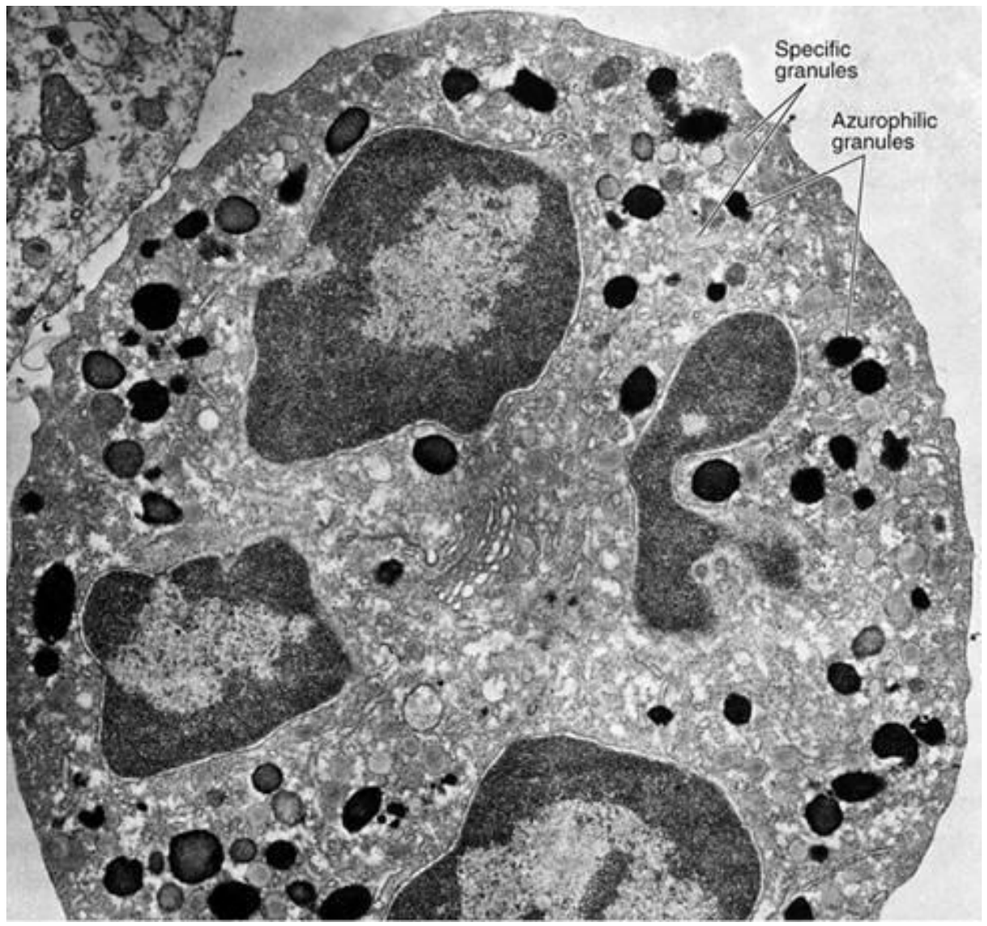
The specific granules color is light pink
The number of lobes of the neutrophiles differs from to other **according to AGING** → **اول ما تتصنع(2 lobes)** → **at site of infection (5 lobes)**
site of infection **اول خلايا توصل ال-**

- Specialized for responding to:

1. bacterial invasions
2. Acute infections
3. acute pyrogenic infections **Pyrogenic = infections with (fever حسب الدكتورة), (pus حسب جوجل)**

- 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.

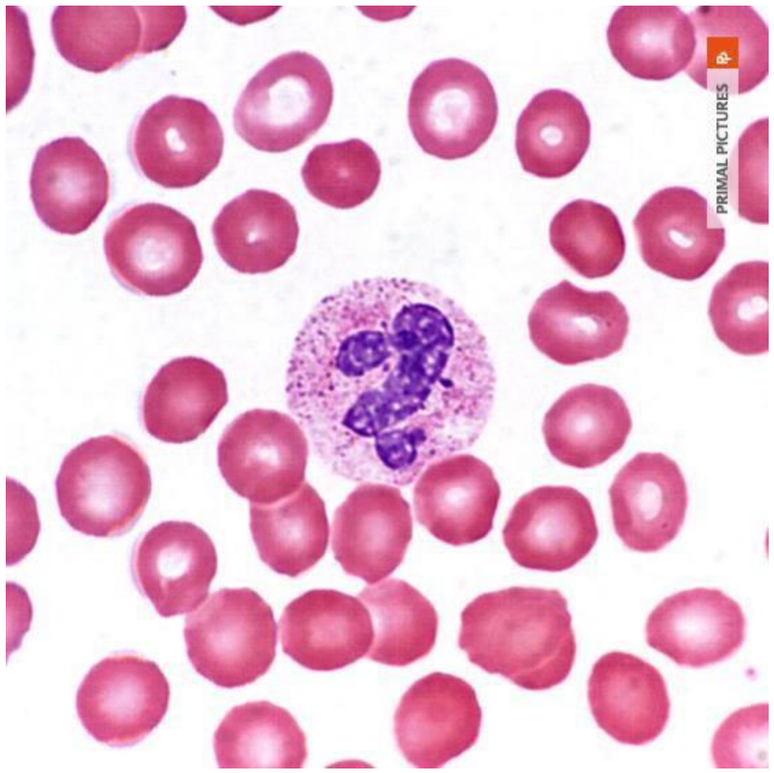
Half life in tissues → Days(dies by apoptosis), Half life in circulation → hours

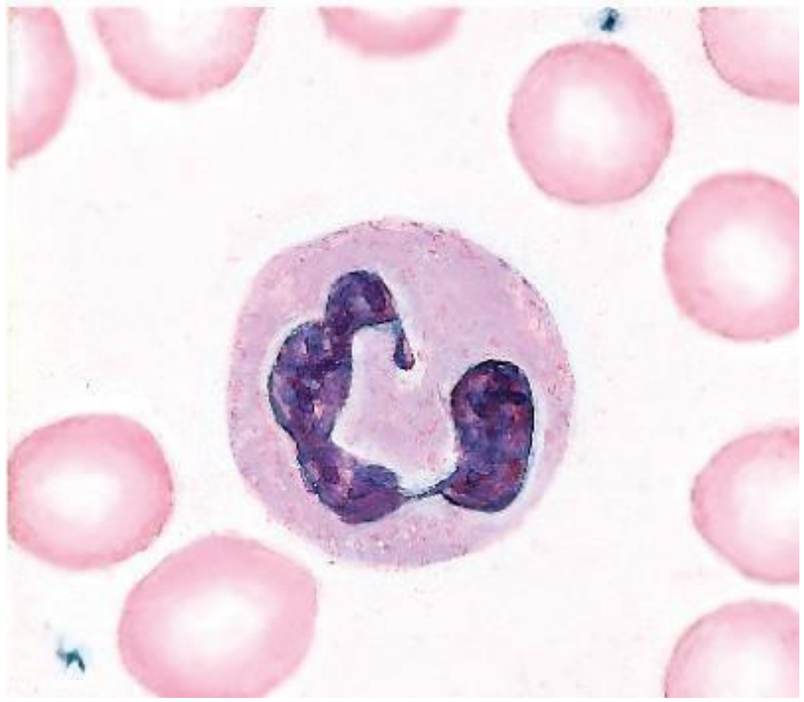


Neutrophils are the first WBCs that leave the blood in large numbers to reach the site of inflammation

Cells of acute infection

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





Sheet note

How to know that this blood sample is from female?كيف تعرف انه عينة الدم هاي من انثى

-Ans: Drumstick like appearance (structure), which is due to Barr body (the inactive X of the female (xx) sex chromosomes
-Can there be a 2 Barr bodies?
Ans: Yes, in super female case (xxx), because it's must be only one active (X)

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)**

Granules in neutrophils

- **Specific granules (secondary) (most numerous)**
  Small in size — Lysozyme not lysosome
  -Lysozyme: act against cell wall
  -Phagocytin (bactericidal)
  -Lactoferrin (bacteriostatic)
  -Collagenase — And elastases to gain ability to cross the site of infection
  (barely visible by light miscroscopy)

- **Azurophilic granules (primary) (less numerous)** — اكبر حجما واقل عددا
  Somewhat larger in size
  -Myeloperoxidase (bacteriocidal)
  -Acid hydrolase
  -Defensins

Bactericidal=destruction and killing
Bacteriostatic=stops the differentiation of the pathogen

Different names for neutrophils:

- Polymorphs → Naming reason: the changing of number of lobes according to maturation
- Pus cells → Pus cells → pus is anaerobic environment and it formed after the bacterial infection, so the ability of neutrophiles to work at this condition gave it this name. (it generates power by glycolysis)
- Microphages → Micro not macro, serves the same function as macrophages
- Cells of acute inflammation

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:

- increase in the number of neutrophils in the circulation
- *this does not necessarily imply an increase in neutrophil production*

Intense muscular activity and administration of epinephrine can produce APPARENT neutroplelia they causes neutrophils in the marginating compartment to move into the circulating compartment

Glucocorticoids:

increase the mitotic activity of neutrophil precursors in the marrow → increase blood count of neutrophils

Neutrophilia that occurs during bacterial infections → increase production of neutrophils for short duration of these cells in bone marrow

Neutropenia → Decrease in number of neutrophiles.

Neutrophilia DOESN'T always indicate a pathologic condition. Because the neutrophiles are found at different pools outside the circulation in exercise and stress conditions, the neutrophiles travel to the circulation. and after the (stress, exercise) stops the neutrophiles return to the pools.

Eosinophils

Less compared to neutrophiles

- Accounts for 1-6% of leukocytes in circulating blood

Like glasses زي النظارة

- Usually have bi-lobed nuclei connected by a short “thread” of nuclear material

- Large cytoplasmic granules, which stain red with the acidic eosin dye

- **Functions:**
- Eosinophils are phagocytic cells but less bacteriocidal than neutrophils

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

- Help in ending allergic reactions and in fighting parasitic infections

- All eosinophils have receptors for IgE (important in the destruction of parasites, this is not present on neutrophils

During allergic reactions

Eosinophils undergo *chemotaxis* in response to **histamine** and **eosinophil chemotactic factor of anaphylaxis (ECF-A)** released from basophils and mast cells

↳ **To end allergic reaction**

يعني اول ما يبلش تفاعل الحساسية يتم افرازه لانهاء تفاعل الحساسية وما يطول.

Eosinophils ameliorate some aspects of hypersensitivity reactions

They neutralise histamine and produce a factor (eosinophil-derived inhibitor) which inhibits mast cell degranulation

Eosinophilia: increase number of circulating eosinophils

are found in

1 many types of *parasitic disease* (defense against parasites is one of their principle functions)
2 in some *allergic disease* such as hay fever and asthma

Specific granules (Crystalloid granules): Specific granules in eosinophiles

-Oval in shape, with flattened crystalloid cores

-Two parts:

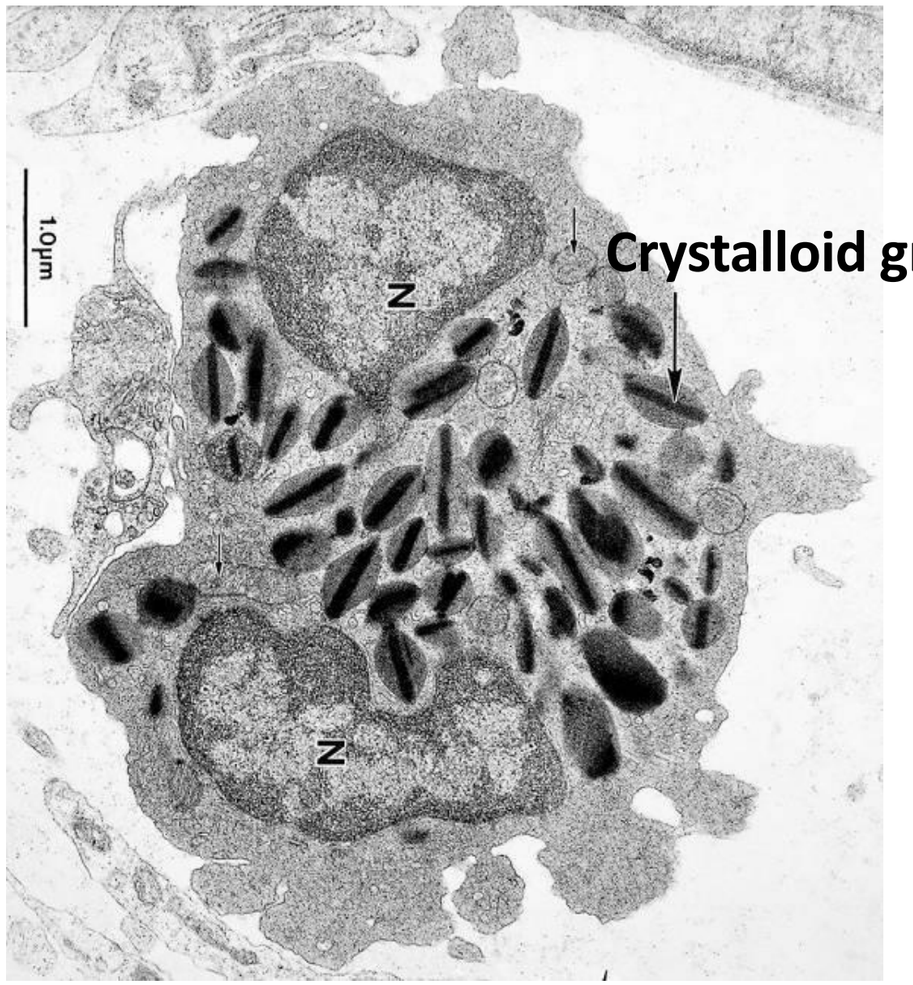
يوقف الhistamine

يوقف ال heparin

1 Externum(pale):contains histaminase and sulfatase

2 Internum(dark):contains basic protein to kill parasites For parasitic infections

The eosinophils granules are **lysosomes** and contain the usual lysosomal enzymes, they show a higher content of peroxidase than do the azurophilic granules of neutrophils and lack lysozyme and phagocytin



طيب إذا عندها granules اكثر من ال neutrophiles تعتبر اقل bactericidal
-اقل عدد (نسبتها 6%)
-جوا ال neutrophiles انزيمات بتخليها اقوى في قتل البكتيريا. Lysozyme, Phagocytin

Basophils

- Rarest leukocyte –might not see these under the microscopes (less than 1%)

Very large specific granules, blue in color, which covers the nucleus

- Usually have bi-lobed, S-shaped nuclei obscured by the large basophilic granules **زي النظارة Eosinophils ال S shaped هاي**

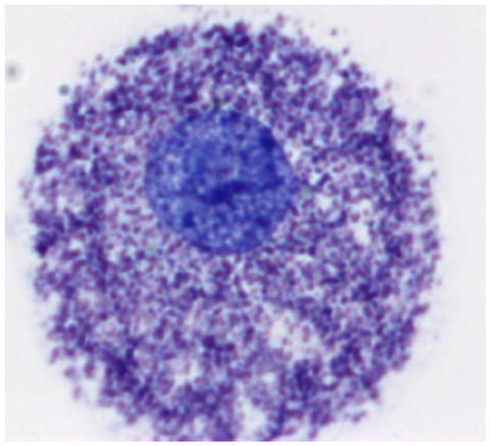
- Has large granules that stain dark purple/ blue in basic dyes (basophil= basic loving)

- Granules contain histamine, heparin and eosinophilic chemotactic factor that mediate inflammation in allergic reactions and parasitic infections **Initiate allergic reaction**

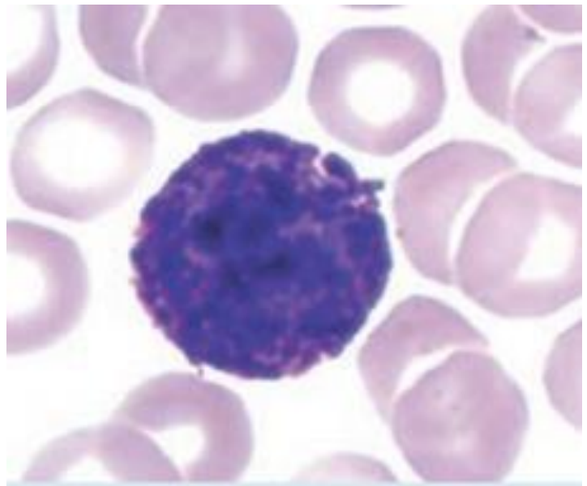
ECF-A

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

To initiate immune reaction



Mast cell



Basophil

الاختلاف بينهم مكان التواجد basophiles ⟵ blood stream
mast cells ⟵ connective tissue

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

كيف تأكدو انه اله دور في تفاعل الحساسية؟ ?allergic reaction
-in skin dermatitis → basophiles increase from 1% to 15%

Allergic reaction

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

التعرض ل Allergen antigen

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.

ما في اعراض بالتعرض الاول لمولد الحساسية No symptoms for the first exposure to allergen antigen
بس بتعرف على الانتيجن(مولد الضد للحساسية) ويتذكره للمرات الجاي للتعرض اله نفسه

Second exposure

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

عند التعرض اله مرة ثانية رح يرتبط ال antibody(IgE) with the antigen ويعملو bridging الي بعمل degranulation of basophils ف بصير allergic reaction

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.**

اذا اثر على اكثر من system in the body
↓
Anaplylactic shock

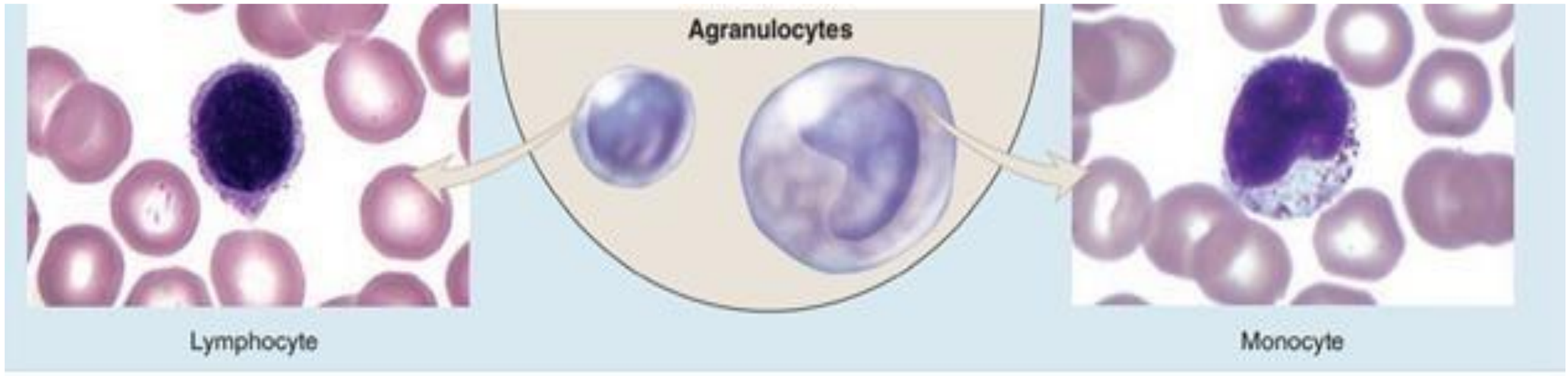
Agranulocytes

Just primary granules- not lobulated.

• 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

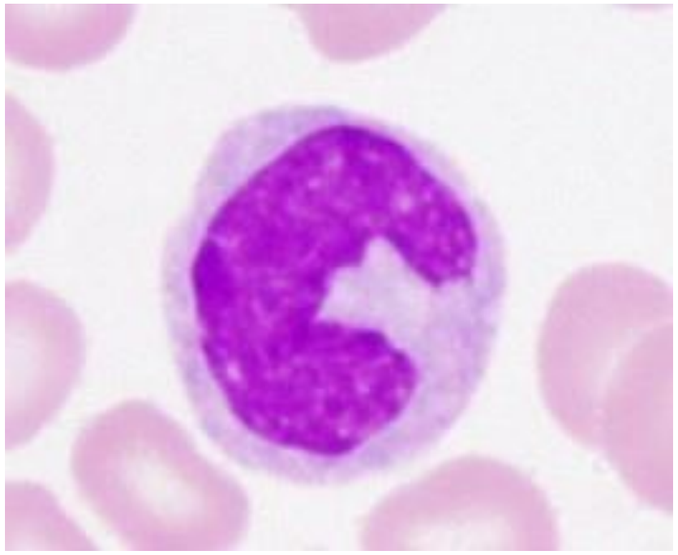
- Largest leukocytes
- Constitute 2-10 % of leukocyte in peripheral blood

شكل السيتولازم زي الزجاج المغشى نتيجة؟تواجد ال lysosomes بكثرة

- 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)**

بس توصل النسيج بصير اسمها macrophage

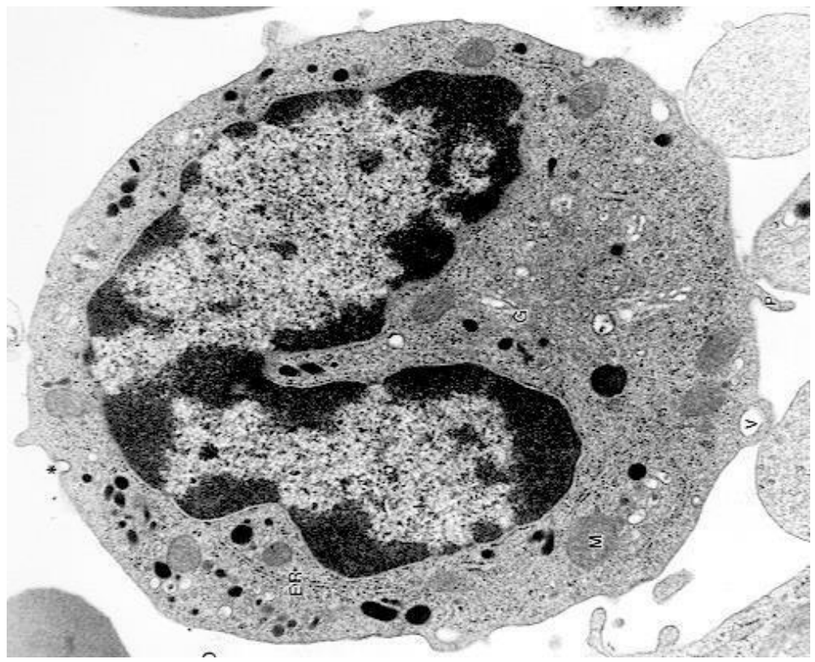
- **Chronic infections**



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**

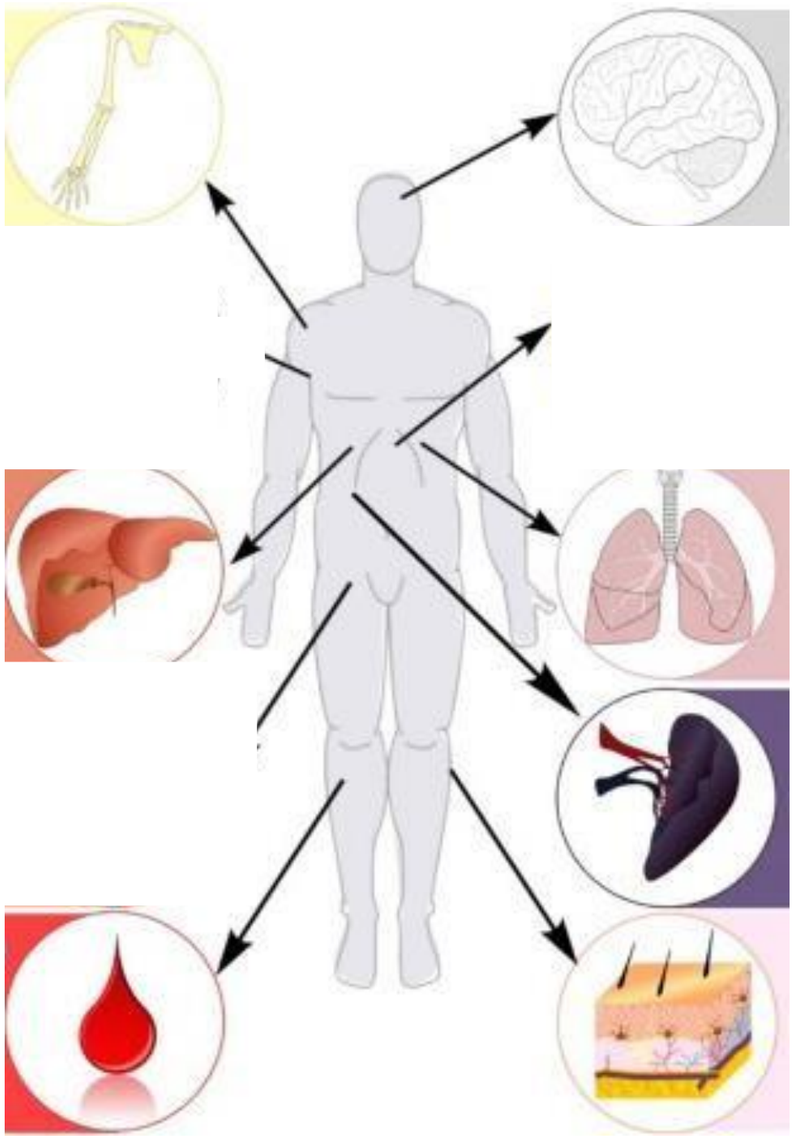
To recognize the receptors.



MONONUCLEAR PHAGOCYTIC SYSTEM

(all characterized by phagocytic activity)

osteoclasts
Bone



Microglia
CNS

Kupffer Cells
liver

Dust cells
lung

Pulmonary macrophage

Dendritic cells
Lymph node
spleen

macrophages
Bone marrow
Connective tissue

No specific name for them

Langerhans cells
epidermis

Are found in skin, because the skin is the first defensive system.

- الوضع الطبيعي تطلع ال monocytes من الدم وتروح ل site of infection وبصير اسمها macrophage
- بس في اماكن محدةة بتكون دايما ال macrophagesمتواجدة فيها resident ؛ليش؟لأنه هذه الأماكن بتكون من أكثر الأماكن المعرضة لل infections (infections are very common in these places)

Lymphocytes

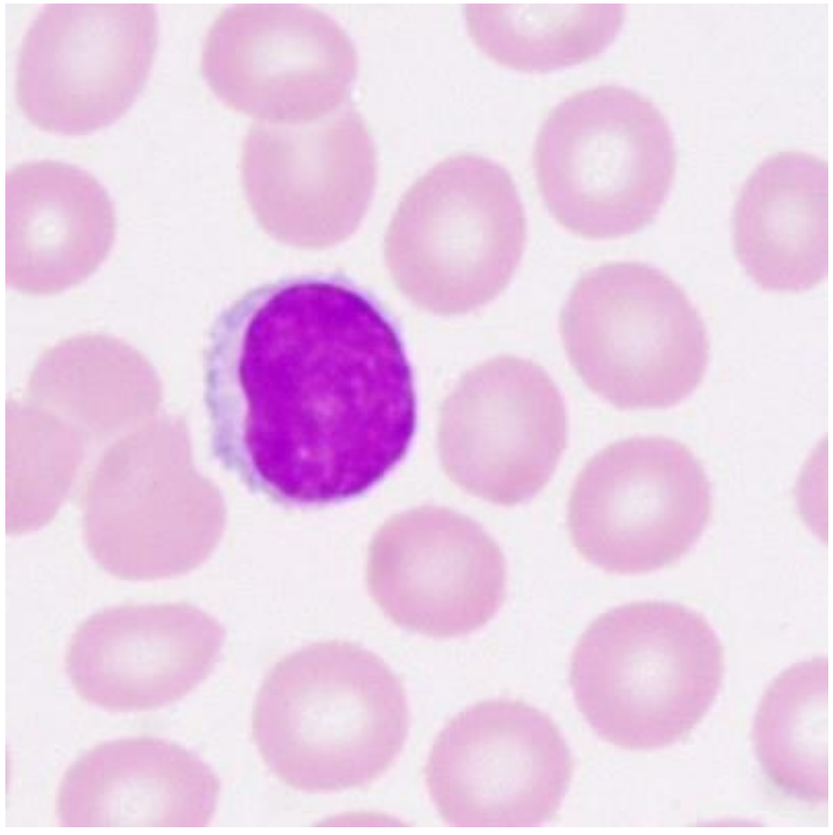
- Smallest leukocytes (slightly larger than erythrocytes) **تقريبا نفس حجم ال erythrocytes**

- The **second most common** leukocyte in circulating blood and make up 20-25% of differential white cell count

- Round nucleus occupies most of cell volume

- Cytoplasm is light clear blue **Large nucleus with small rim(حافة او اطار) of cytoplasm**

- Increased numbers are commonly seen in **viral infections**



Lymphopoiesis: the process by which lymphocytes are formed

In bone marrow*

Precursor cells in bone marrow

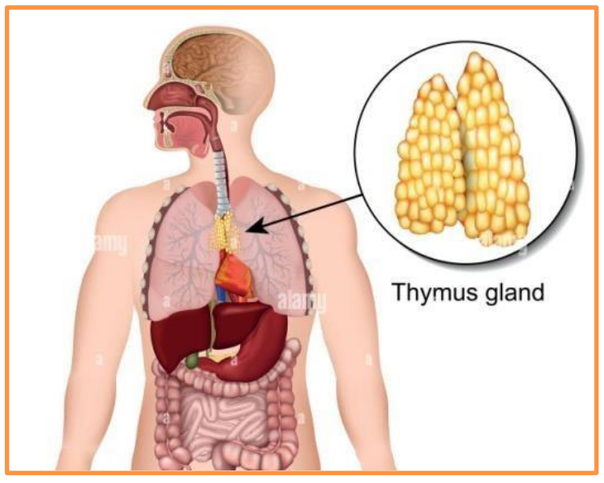
But they are still, immunocompetent(inactive) which are capable to differentiate between self and non self antigen.

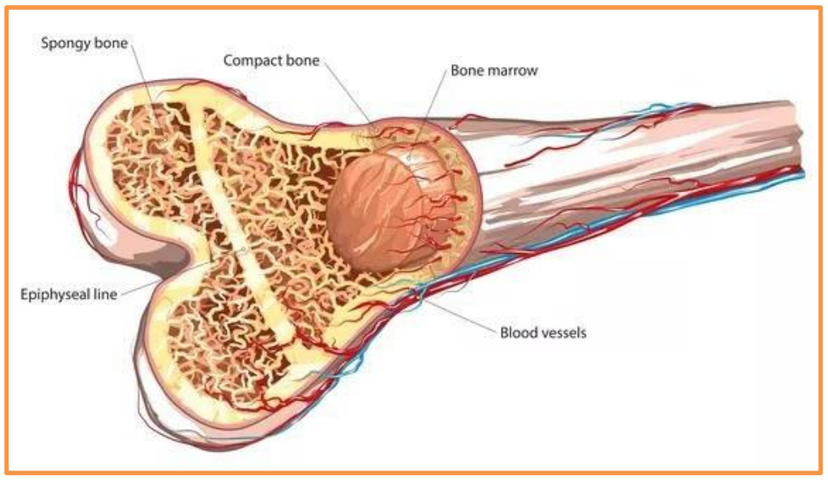
بس اذا راحت عالدم بتصير طوالي active

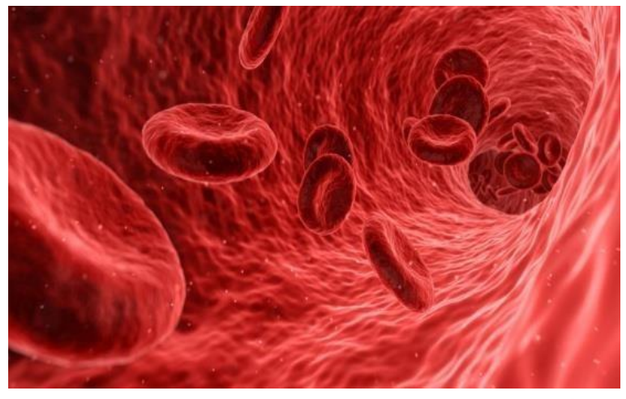
Thymus → **T Lymphocytes**

Bone Marrow → **B Lymphocytes**

Directly into blood → **Natural killer lymphocytes**







The amount of cytoplasm depends **upon state of activity** of the lymphocyte, in circulating blood there is:

When in it is inactive, slightly larger than erythrocyte (and small rim of cytoplasm with large nucleus)

1 Predominance of small inactive lymphocytes (6-9 µm in diameter)

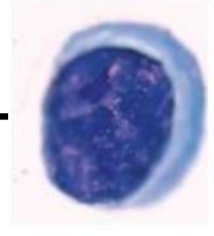
2 Large lymphocytes (9-15 µ m) make up about 3% of lymphocytes in peripheral blood

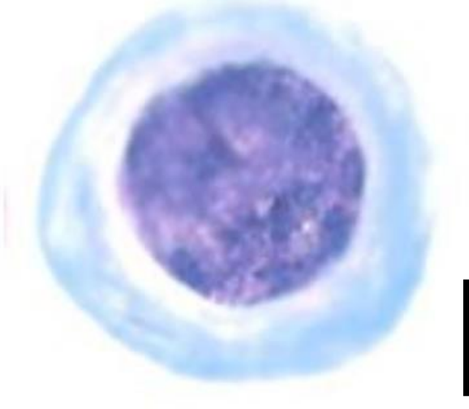
When it becomes active the cytoplasm becomes less dark-blue, and the amount of cytoplasm increased

represent activated lymphocytes en route to the tissues where they will become antibody-secreting plasma cells, they also include natural killer cells

In the large lymphocyte → the cytoplasm is readily visible but in the small lymphocyte the cytoplasm is almost too sparse to be seen (contain few mitochondria, rudimentary golgi apparatus, minimal endoplasmic reticulum but large number of ribosomes→ account for basophilia (blue cytoplasm)

Can be differentiated to T or B lymphocyte





لما تشوفها هيك طوالي:
Active lymphocyte of natural killer cells

Small
(6-9 µm)
Inactive lymphocyte

Large
(9-18 µm)
Active lymphocyte

Darkly stained cell

Lightly stained cell

•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 → **Unlike the macrophages and neutrophiles immunity which it's immunity name(innate immunity) (which do the phagocytosis to all antigen**

- **T cells**

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

Lymphocytes → highly specific, adaptive immunity response for specif antigens

Humoral immunity

- **B cells**

–Differentiate into plasma cells

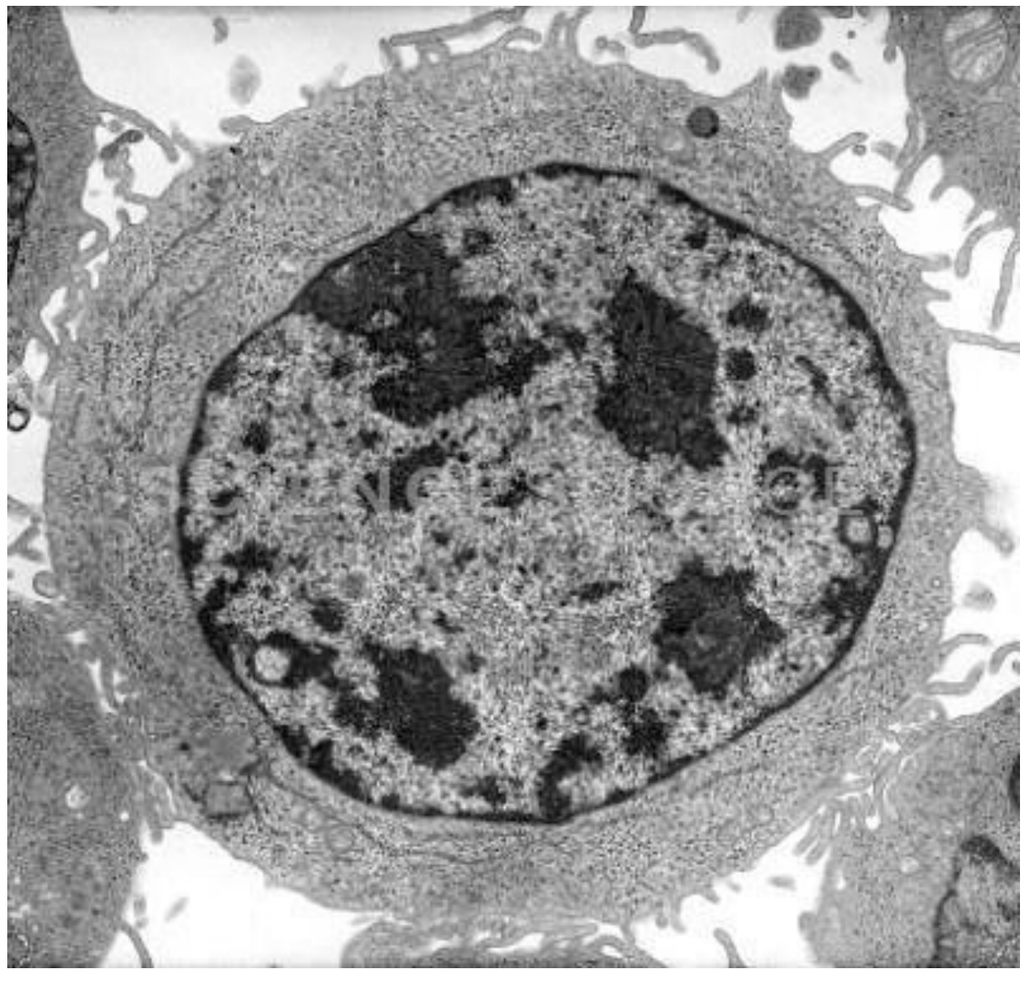
–Secrete antibodies that bind to specific antigens and mark them for destruction by phagocytic cells

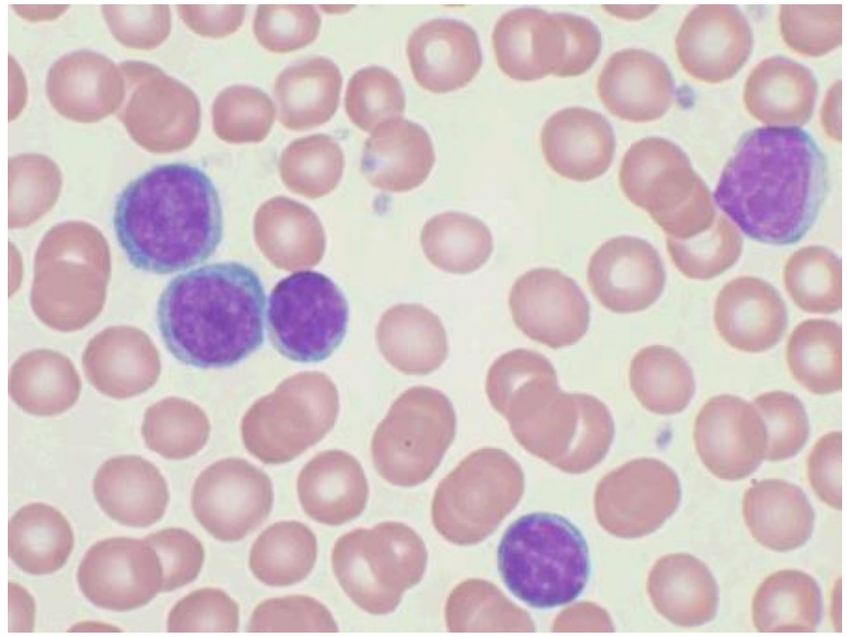
Long term immunity

Do B lymphocytes go to site of infection?
No, but send the antibodies to site of infection (naming reason (humoral immunity الاستجابة السائلة))

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)**





Size relation to erythrocytes

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

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.

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

Cells of adaptive immunity: B and T lymphocytes

Lymphoblast

B Lymphocyte

T Lymphocyte

Natural killer cell

Immunocompetent in bones marrow

Plasma cell
(produce antibodies)

Memory cell

To memorize the antigen, the directly produce antibodies, the principle of vaccination.
مبدأ التطعيم(المطعوم).

Immunocompetent in thymus

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

Helper
Help cytotoxic T cells and B cells in their immune function

Can work as APC to active B and T

Suppressor
Suppresses immune response to self Ag
Suppresses immune response of T and B lymphocytes

After the infection ends, those cells come and inactive T and B.
If there is a problem in these cells there will be an immune disease.

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

Any cell that doesn't present MHC-1 antigen, will recognize it as abnormal cell and destroy it
*****I think MHC-1 is the self antigin**
مولد ضد ذاتي الي ما بخلي هاي الخلايا تهاجم خلايا الجسم

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

Type	Nucleus	Specific Granules[a]	Differential Count[b] (%)	Life Span	Major Functions
Granulocytes					
Neutrophils	3-5 lobes	Faint/light pink	50-70	1-4 d	Kill and phagocytose bacteria
Eosinophils	Bilobed	Red/dark pink	1-4	1-2 wk	Kill helminthic and other parasites; modulate local inflammation
Basophils	Bilobed or S-shaped	Dark blue/purple	0.5-1	Several months	Modulate inflammation, release histamine during allergy
Agranulocytes					
Lymphocytes	Rather spherical	(none)	20-40	Hours to many years	Effector and regulatory cells for adaptive immunity
Monocytes	Indented or C-shaped	(none)	2-8	Hours to years	Precursors of macrophages and other mononuclear phagocytic cells

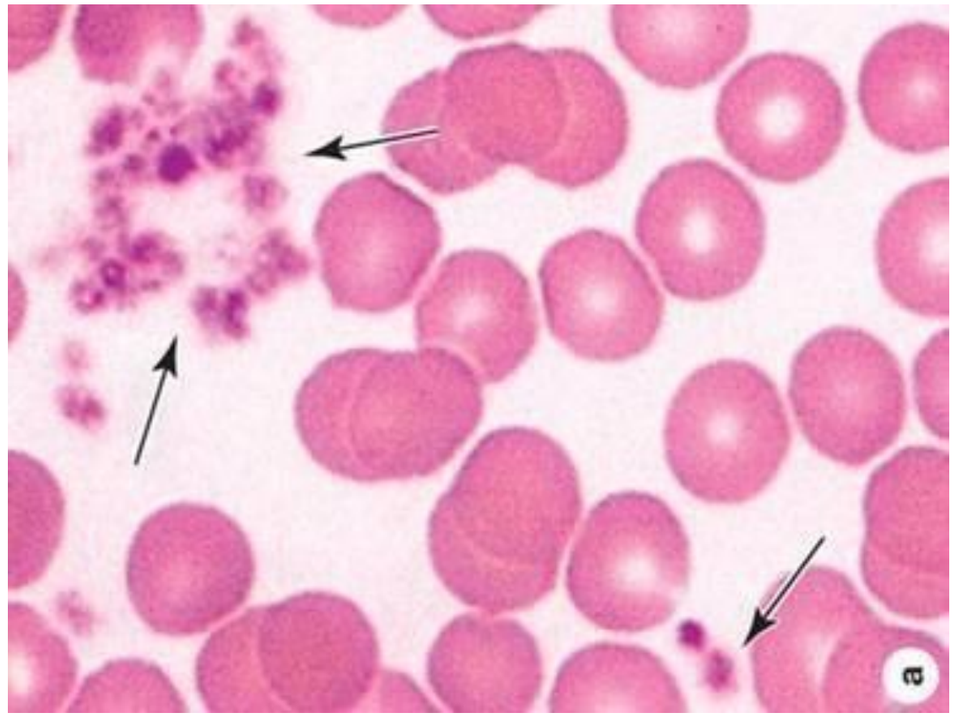
Never **L**et **M**onkeys **E**at **B**ananas

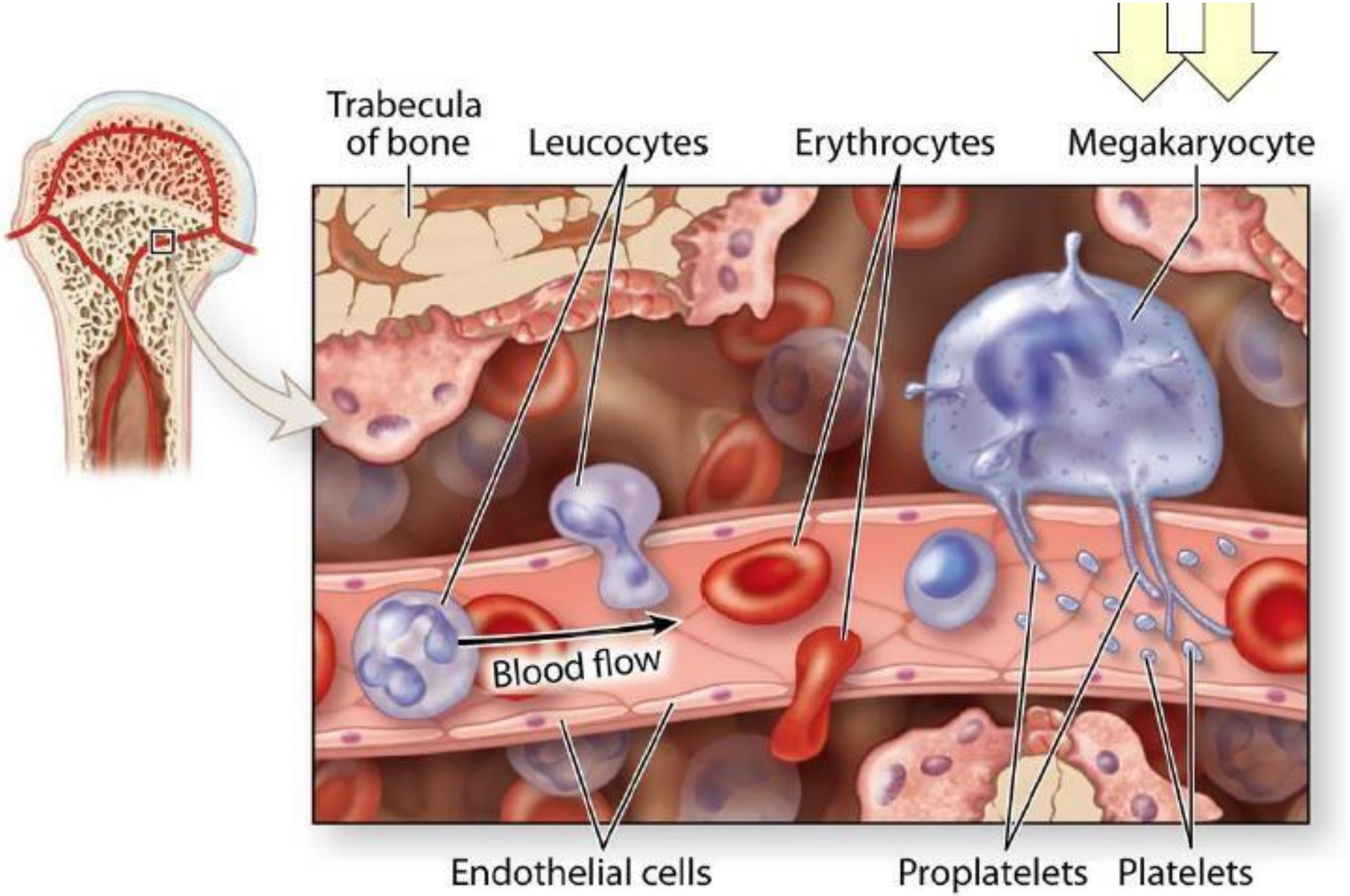
Most common to least

Thrombocytes (Platelets)

أكياس من ال Cytoplasm

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




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

- In bone marrow → sinusoidal capillaries → there is processes of megakaryocyte which have cytoplasmic processes → The blood flow causes the fragmentation of these cytoplasmic processes → and this fragments are the platelets

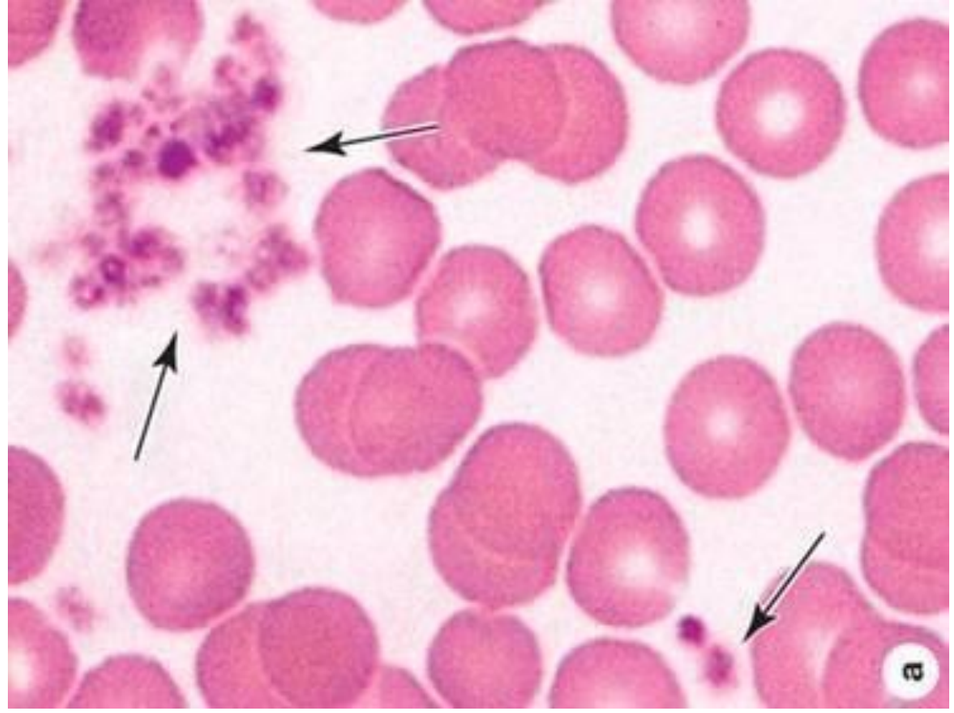
•Control the bleeding by plugging the defects in blood vessels and activating blood clotting cascades

In stained blood smears, platelets often appear in clumps

<u>Platelete has 2 zones</u>

1 <u>Outer pale</u> basophilic (clear) perpheriral zone: **Hyalomere (smooth, glassy like, likely hyaline)**

2 Central dark granular zone: **granulomere**



In stained blood smears, platelets often appear in clumps

Hyalomere:

contains cytoskeleton and membranous channels

Cytoskeletal elements

- Microtubule
- Actin filaments

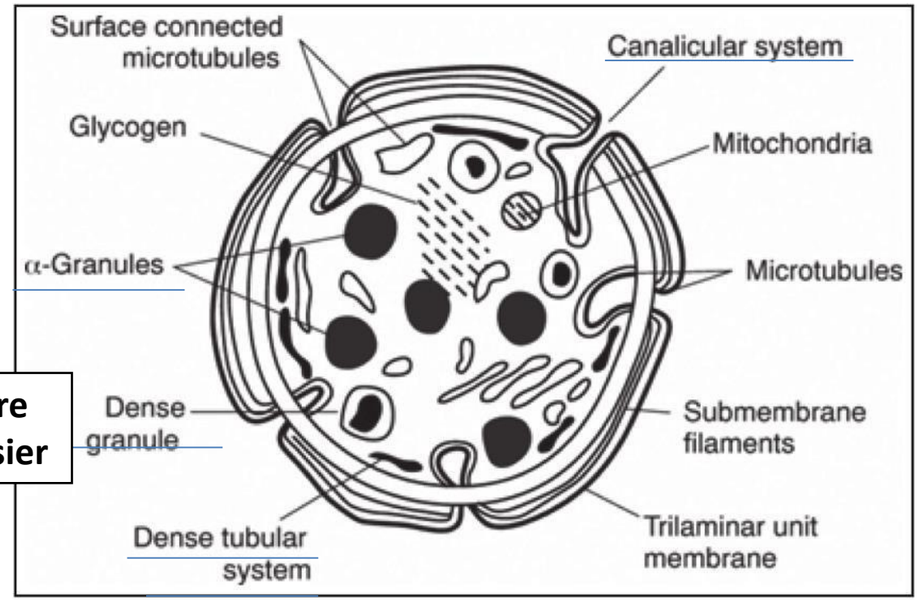
Membrane channels

- Open canalicular system
- Dense tubular system

Invaginations from plasma membrane to granulomere
To increase surface area of exchange and make it easier

Contains Ca+2 (calcium for blood clotting)

Maintain shape and help contractions of platelets and squeezing



Granulomere:

contains granules and organelles

Alpha granules: clotting factors, growth factors

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

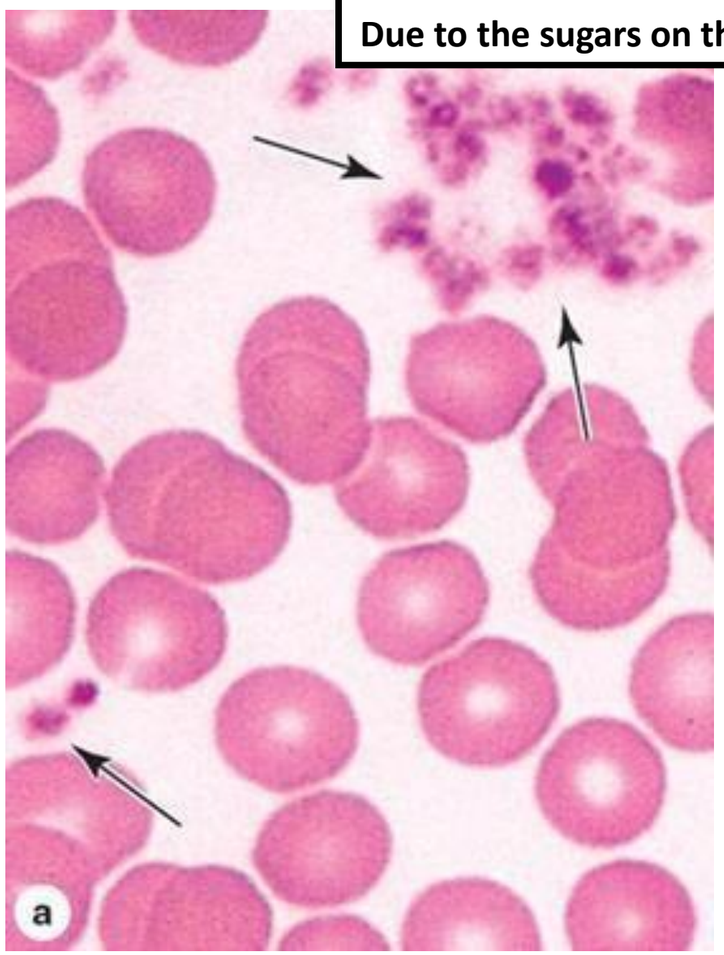
ما بتصنعها بتجيبها من برا

Lambda granules: lysosomes (aid in clot resorption)

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**

اعطت هذا الشكل لانه سطحها سكري ف لزقو ببعض
Due to the sugars on the surface of platelets they get stick to each other



Hemopoiesis

Dr. Silvia Boyajian

Hemopoiesis

Prenatally

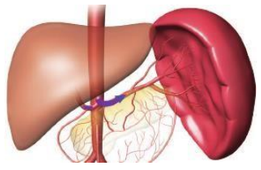
1- Mesoblastic phase: in *mesoderm of yolk sac*
(2nd -6th) weeks of pregnancy

Hemopoietic stem cell forms

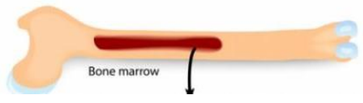
2- Hepatic phase: within the *liver and spleen* also play a role in second trimester

Mostly*

The reason why liver get enlarged at this stage:



3- Myeloid phase: in *bone marrow*
begins in the 3rd trimester



Postnatally

Occurs almost exclusively in *bone marrow*:
Sternum, ribs, pelvis, proximal ends of femur, vertebrae

بكون اغلبه Red bone marrow عند الصغر

Formation of blood cells in bone marrow → medullary hemopoiesis
outside bone marrow → extra medullary hemopoiesis.

Pluripotent hemopoietic stem cells

All the blood is from one cell called:

It is believed that **ALL** blood cells arise from a single type of stem cell in the bone marrow called a pluripotent stem cell
This cell can produce all blood cell types

Means <u>all potential</u> → potential to give all types of blood cells

Proliferate and form TWO major cell lineages:

one for myeloid cells

granulocytes, monocytes, erythrocytes, megakaryocytes

All white cells (except lymphocytes),erythrocytes and platelets
All happens in red bone marrow

One for lymphoid cells

(lymphocytes)

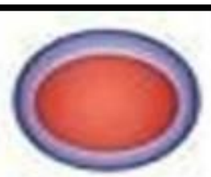
all develop in bone marrow

Early in their development, lymphoid cells migrate from the bone marrow to thymus or to the lymph nodes, spleen, and other lymphoid structures where they proliferate and differentiate

Stem cell

Pluripotent

CFU: colony forming unit



Myeloid stem cell
(Multipotent)

Multiple type of cells

Stem cells

Lymphoid stem cell
(Multipotent)

CFU-E

CFU-M

CFU-G

CFU-M

Progenitor cells
(committed, unipotent stem cells)

Unipotent نوع واحد

CFU-L

E=Erythtocyte

M=Megakaryocyte

G=Granulocyte

M=Monocyte

Precursor cells

Erythroblast

Megakaryoblast

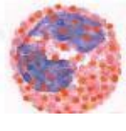
Myeloblast

Monoblast

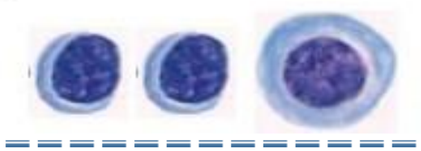
B Lymphoblast

T Lymphoblast

NK Lymphoblast



Mature cells



- When the stem cells duplicates it gives rise to another stem cell, to save and keep a reserve of it, the progenitor cell does the same. But the precursor cell only give rise to mature cell it never gives rise to precursor cell, because it’s not a stem or progenitor cell.

رح يتم ايضاحه باخر سلايدين**

Progenitor and precursor cells:

the pluripotent stem cells give rise to daughter cells with *restricted* potentials called:

Progenitor cells or colony-forming units → CFUs (since they give rise to colonies of ONLY ONE cell type when cultured or injected into spleen)

Progenitor cells are 4 types:

A- Erythroid lineage of CFU-erythrocytes (CFU-E)

B- Thrombocytic lineage of CFU- megakaryocytes (CFU-Meg)

C- Granulocyte-monocyte lineage of CFU- granulocyte- monocytes (CFU-GM)

D- Lymphoid lineage of CFU- lymphocytes of all types (CFU-L)

All four progenitor/ CFUs produce → precursor cells or blasts

Where morphologic characteristics begin to differentiate suggesting the mature cell types they will become

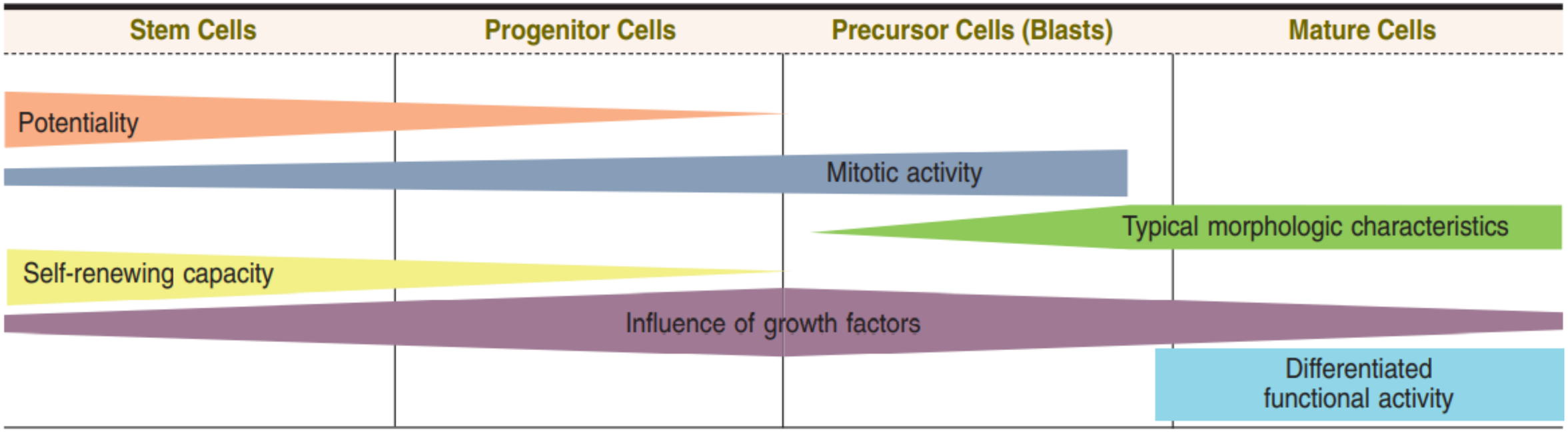
Stem cells and Progenitor cells cannot be morphologically distinguished and resemble large lymphocyte

Notes:

Rate of cell division : slow in stem cells
rapid in progenitor and precursor cells

Progenitor cells: can divide and produce both progenitor cells and precursor cells

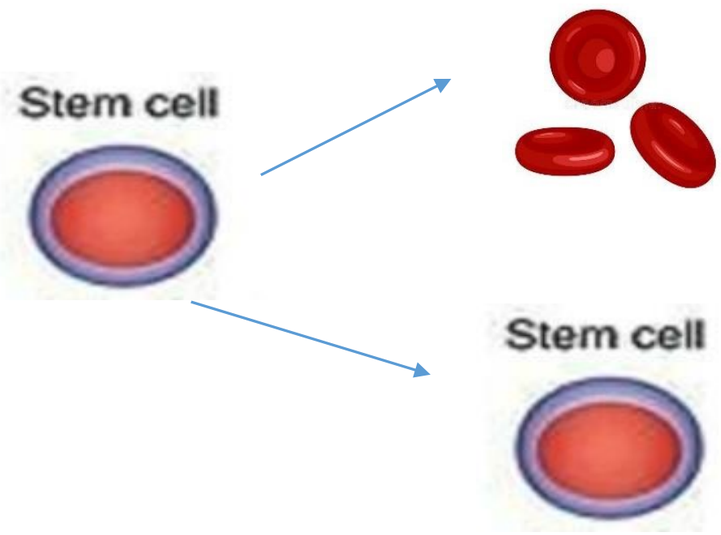
Precursor cells: produce only mature blood cells



1-Potentiality is the potential to give rise to more than one type of cell
2-mitioc activity is the highest at precursor cells and mature cells don't divide
3-you can't differnitae between the blood cells until they reach the mature cell phase (even at precursor cell(blast phase) the cells almost the same
E.g. T,B and natural killer cells are derived from lymphocytes.
4-self renewing القدرة انها تنقسم وتعطي خلية مماثلة الها 5-differentiated functional activity: انه ما بتكتسب الوظيفة الا تقريبا لما توصل لاخر مرحلة

Stem cells are capable of asymmetric division and self-renewal

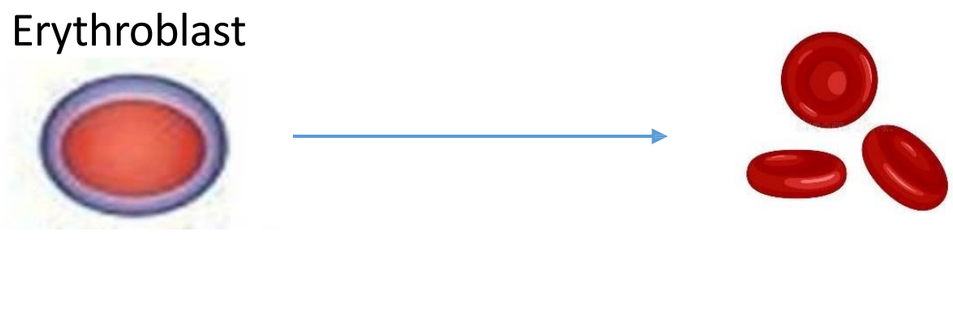
<u>Stem cells can maintain the original population</u>



Every time the stem cell multiplies, it will give two cells, one differentiate into mature RBCs and the other cell add to the original population

STEMcell gives rise to erythrocytes and renew itself by giving rise to another stem cell

<u>Precursor cells produce only mature blood cells</u>



All erythroblasts multiply and differentiate into mature RBCs (erythrocytes) and no erythroblasts are left in the end

erythroBLAST it will only give rise to erythrocytes it will not give erythonlast Or renew itself

تجربة بتوضلحك لو حطينا growth factors مع نوعين من الخلايا