

White Blood Cells (WBC)

Red: very important.

Green: only found in males' slides.

Purple: only found in females' slides.

Gray: notes.

Physiology Team 436 – Foundation block lecture 11

Objectives

- Recognize the general functions of WBC
- Describe different Types of WBC, their formation, and function
- Describe genesis and site of formation of WBC.
- Describe stages of neutrophil formation
- Describe the role of neutrophils in defending the body against infection
- Describe the process of phagocytosis.
- Describe Reticuloendothelial components and functions
- Recognise leucocytosis and leucopenia.
- Recognize type of leukaemia

IMMUNITY

(only found in male slides)

Acquired immunity

(specific, adaptive)

Humoral

*Antibody-Mediated

*B lymphocytes

Cell-mediated

*T lymphocytes

Innate immunity

(non specific)

Example:

1- Phagocytes

2- Complement system

3- Barriers

Barriers:

Chemical

Sweat

Tears

Saliva

Stomach acid

Physical

Skin

Trachea (قصبة هوائية)

Cilia

Note: Macrophages (large phagocytes) are key components of the innate immunity and **activate** adaptive immunity by transforming into Antigen Presenting Cells

Humoral (meaning fluid): mediated by macromolecules found in ECF

The complement system: part of the immune system that enhances the ability of antibodies and phagocytic cells to clear microbes, promotes inflammation, and attacks membrane.

Phagocytes:

Include many types of WBC like:

(neutrophils, monocytes, NK, macrophages, mast cells)

Barriers

(Chemical barriers)

Sweat

Tears

Saliva



Trachea / Cilia
(Physical barrier)

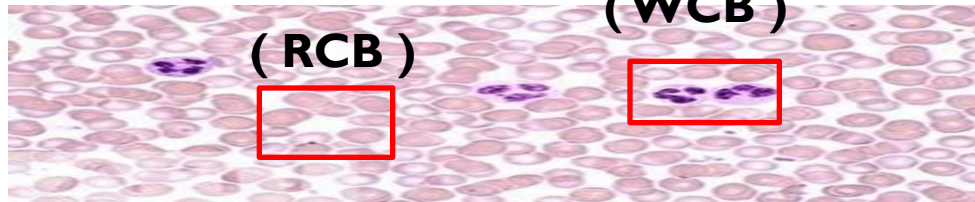
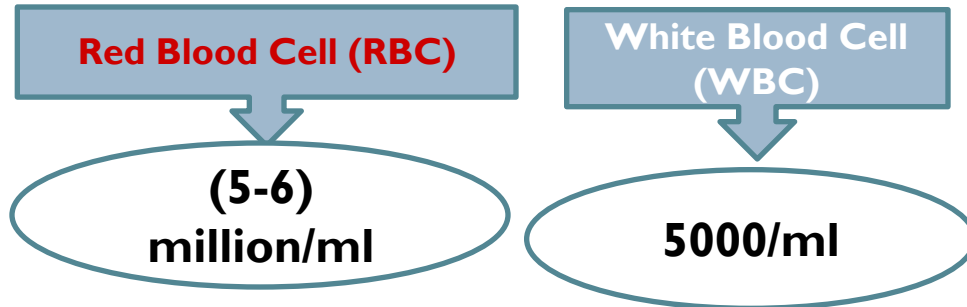
Skin

(Physical barrier)

Stomach acid

(Chemical barrier)

Number of Cells



-This is why blood is red; RBCs are higher in number than WBCs.

White Blood Cells

-**Also called:** leucocytes –
Formed in bone marrow & lymph tissue

I- Recognize the general functions of WBC

General Function:

Protection against infection by:

- **Phagocytosis**
- **Produce (secrete) antibodies**

WBC = 4000—11000/ml

(Depending on certain factors, ex: region and environment.)

-in boys' slides percentages are written in ranges :Neutrophils:50%-70%
 Eosinophils:1%-4% Basophils:0.4% monocytes:2%-8% Lymphocytes:20%-40%

كرات الدم البيضاء ذات
 النواة المتعددة الأشكال.

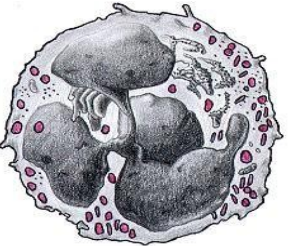
Types of WBC

Agranular = A
 means **not**

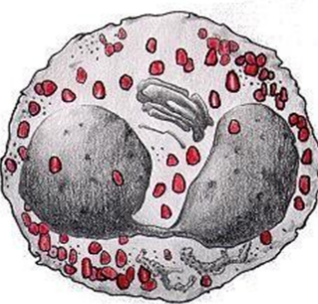
1. Granular (polymorphnuclear PMN)

2. A Granular

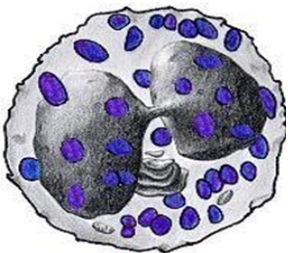
Neutrophil
62%
 10-16um
Nucleus:
 divided into 2-5
 lobes (multi-
 lobed/lobulated
 nucleus) **purple**
cytoplasmic
granules



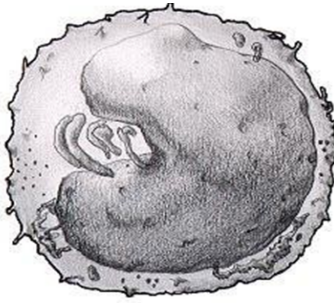
Eosinophil
2.3%
 12-18um
Nucleus:
 2 lobes,
 coarse **red**
granules



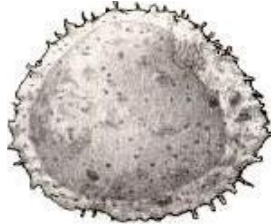
Basophil
0.4%
 -10-14um
Nucleus:
 (Segmented nucleus)
 -hidden by **large**
round blue granules



Monocytes
5.3%
 15-20um
Nucleus:
 Kidney-shaped
(LARGEST CELL IN WBC)



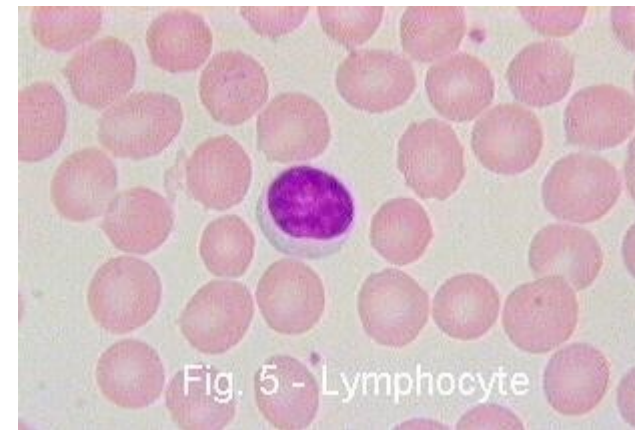
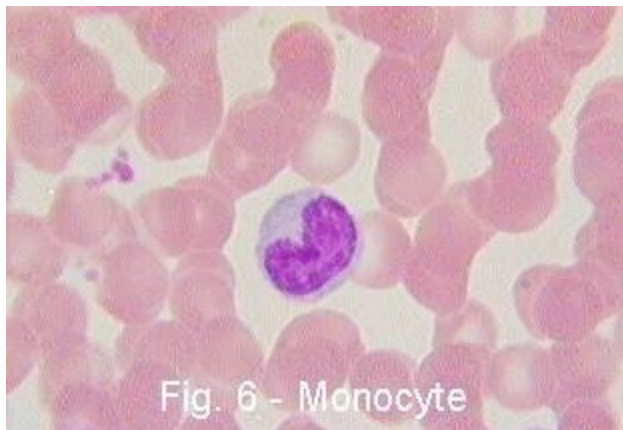
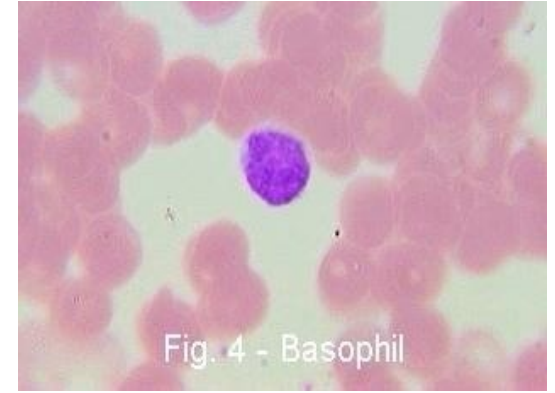
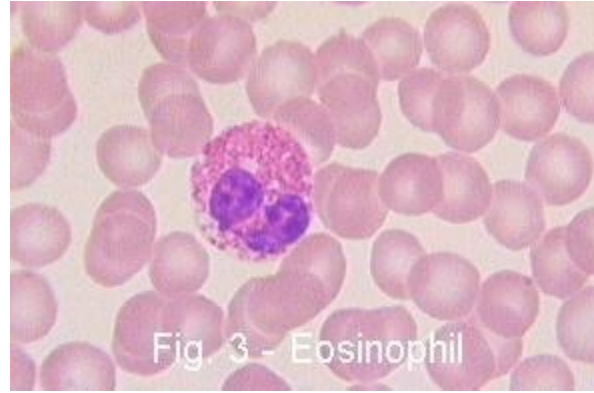
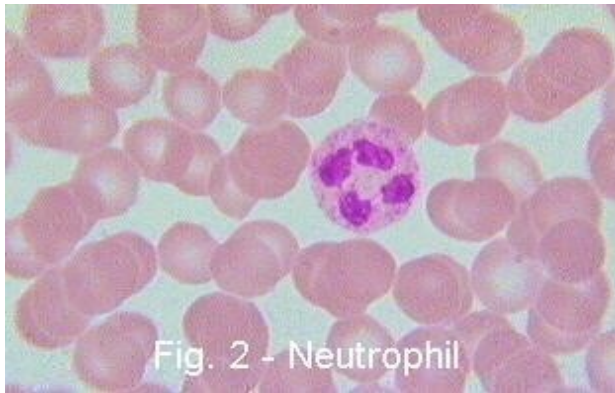
Lymphocyte 30%
 T Lymphocytes
 B Lymphocytes
Nucleus:
 Round
 • small (5-8um)
 • large (9-15um)



▶ 6-Granular: is categorized by: **COLOR**.
 -A granular: is categorized by **SIZE**.

Note: the doctor says that the diameters aren't very important

Microscopic Images of WBC



Genesis of WBC

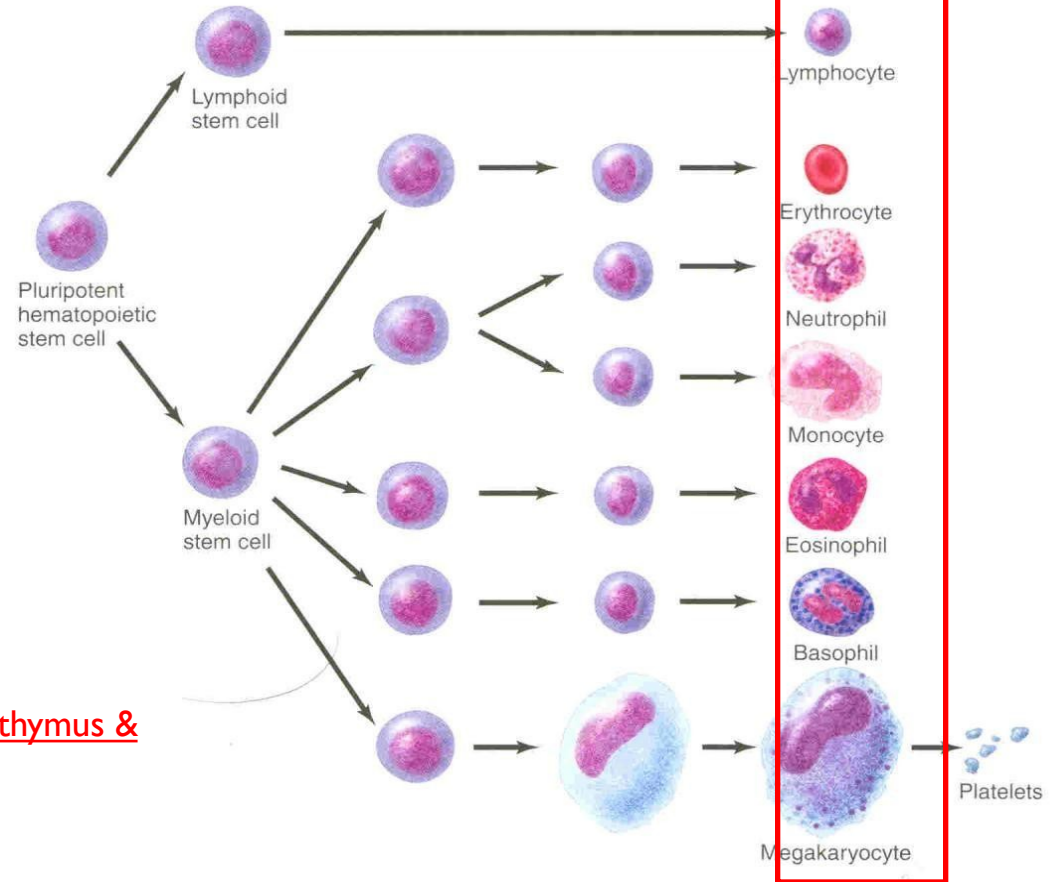
Lineage (line) = الطريق اللي الخليه
بتمشي عليه « تتبعه »

Major lineages of WBC:

1. **Myelocytic** : All granular & monocytes
2. **Lymphocytic**: lymphocytes

مُطالِبين فيها

Pluripotent stem cells can potentially produce any cell or tissue the body needs to repair itself. This property is called pluripotency.

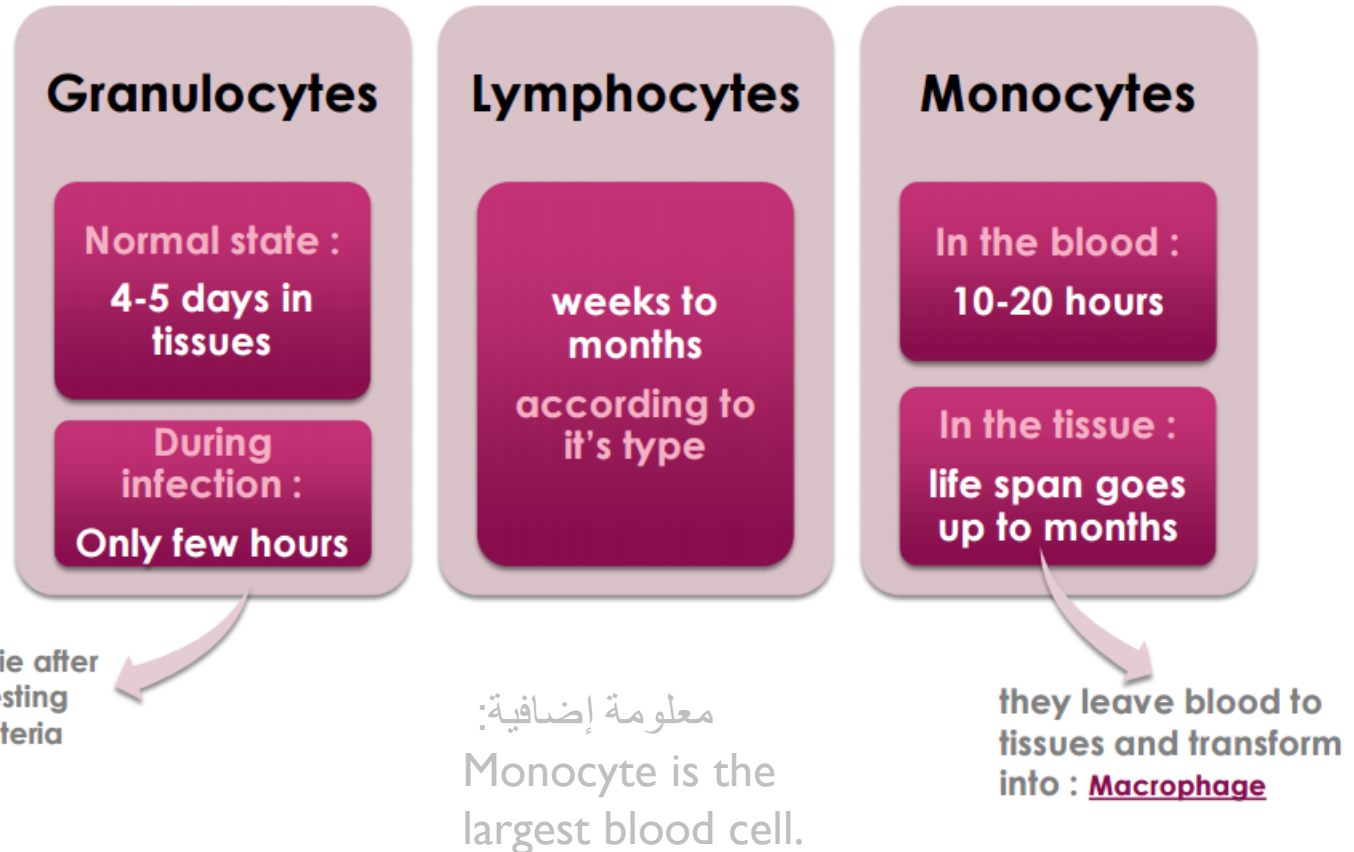


Sites of WBC Formation:

- Granulocytes: bone marrow
- Monocytes : bone marrow
- Lymphocytes : bone marrow AND thymus & lymphoid tissues

Life span of WBCs (Teamwork 435)

Note from the male slides:
Life span of neutrophil: 6-8 hours



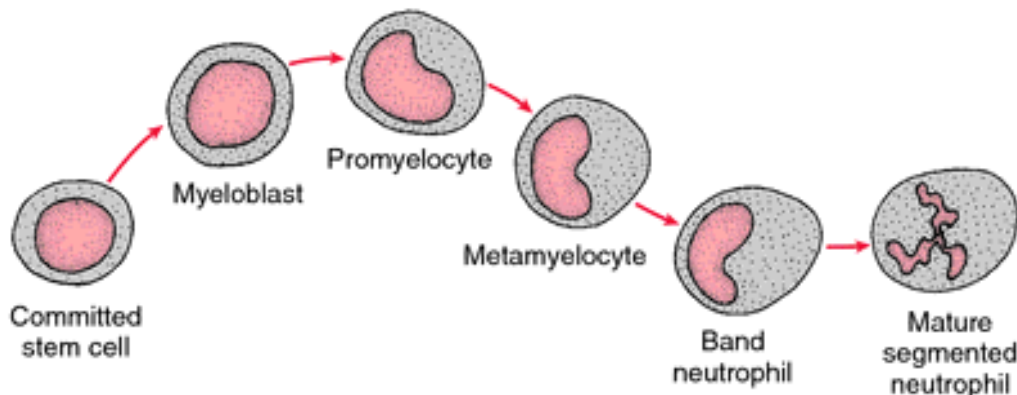
Formation and Maturation of Neutrophils

(Formed in Bone Marrow)

1. Stem cells →
2. Myelo-blast →
3. Pro-myelo-cytes →
4. Neutrophil myelocytes →
5. Young neutrophil meta-myelocytes →
6. Band neutrophil →
7. Polymorphnuclear neutrophil (Mature Neutrophils released to blood)

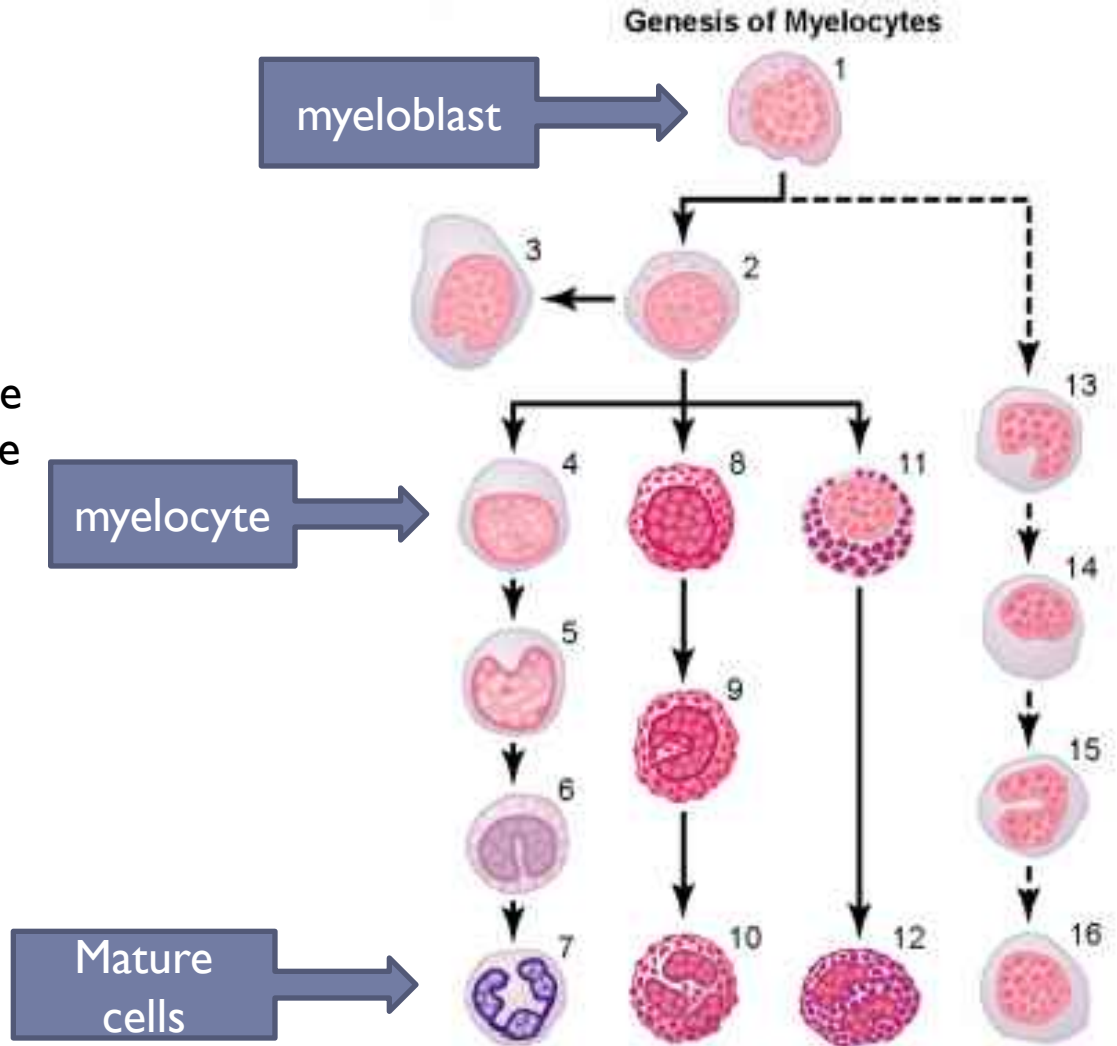
بالاحمر اللي قالت عليها
الدكتور ه انها معنا (حفظاً)
الباقي فهم فقط

Polymorphnuclear
neutrophil
هي نفسها neutrophil



Formation and Maturation of Neutrophils

- 1-myeloblast
- 2-promyelocyte
- 3-megakaryocyte
- 4-neutrophil myelocyte
- 5-young neutrophil metamyelocyte
- 6-"band" neutrophil metamyelocyte
- 7-polymorphonuclear neutrophil
- 8-eosinophil myelocyte
- 9-eosinophil metamyelocyte
- 10-polymorphonuclear eosinophil
- 11-basophil myelocyte
- 12-polymorphonuclear basophil
- 13-16-stages of monocyte formation.



Formation and Maturation of WBC

Granular			AGranular	
Myelocytic				Lymphocytic
Neutrophils	Eosinophils	Basophils	Monocytes	Lymphocytes
Stem cells	Stem cells	Stem cells	Stem cell	Stem cell
Myeloblast	Myeloblast	Myeloblast	monoblast	lymphoblast
Promyelocytes	Promyelocytes	Promyelocytes	promonocyte	intermediate pyronophilic blast cell
Neutrophil myelocytes	Eosinophil myelocytes	Basophil myelocytes		
Young neutrophil meta-myelocytes	Eosinophil meta-myelocytes			
Band neutrophil				
Polymorphnuclear neutrophil (Mature Neutrphils released to blood)	polymorphnuclear eosinophil (Mature Eosinophil released to blood)	Polymorphnuclear Basophil (Mature Basophils released to blood)	mature monocytes released into blood	lymphocytes

Notice in granular: stem → blast → pro-myelocyte → myelocyte → meta (unavailable in basophil) → band (only in neutrpohil)

-Read and understand the following image:

(c) Bone marrow consists of blood cells in different stages of development and supporting tissue known as the **stroma** (mattress).

Mature blood cells squeeze through the endothelium to reach the circulation.

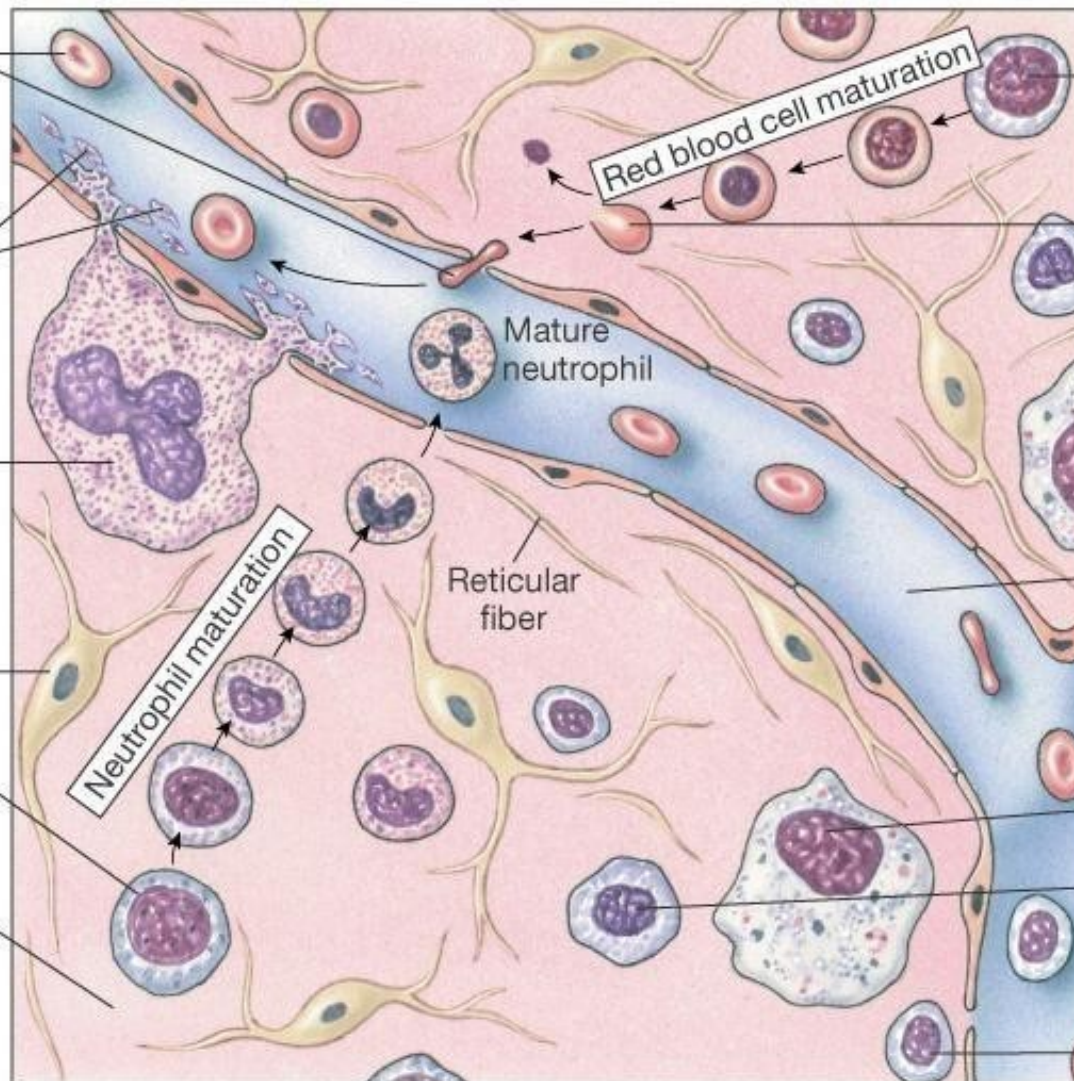
Platelets

Fragments of megakaryocyte break off to become platelets.

Reticular cell

Stem cell

The stroma is composed of fibroblast-like reticular cells, collagenous fibers, and extracellular matrix.



Stem cell

Reticulocyte expelling nucleus

Venous sinus

Macrophage

Monocyte

Lymphocyte

Neutrophil Granules

▶ Primary Granules

▶ (Also called Non Specific, Azurophilic, lysosomes) [33%]:

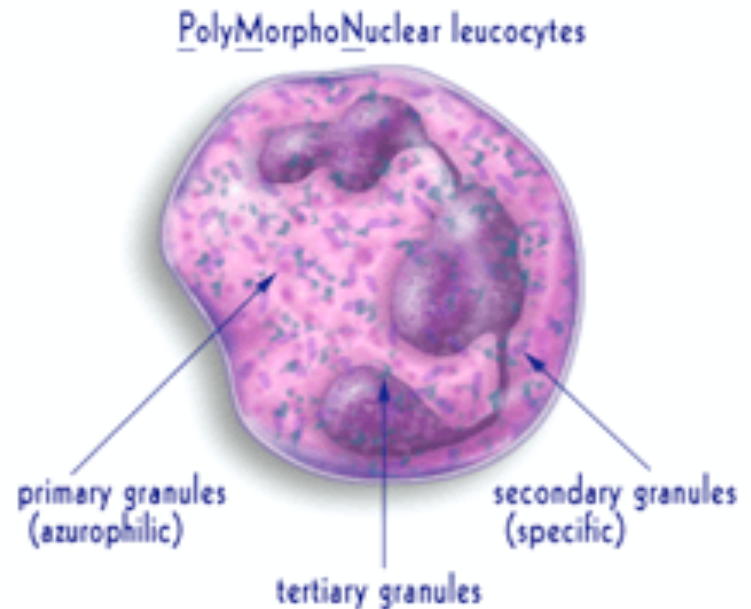
Acid hydrolases, MPO, HOCl, **Defensins**

▶ Secondary Granules (Specific) [67%]:

▶ Lysozyme, Lactoferrin, Alkaline Phosphatase, Gelatinase, Bacteriostatic & Bactericidal products.

▶ **Tertiary Granules** (help to digest tissues) Collagenase, Hyaluronidase and Gelatinase.

Glycogen granules: for anaerobic glycolysis.



Neutrophil Pools:

Bone Marrow, circulating pool (within blood) and Marginated Pool (of neutrophils adherent to endothelium)

Neutrophil function



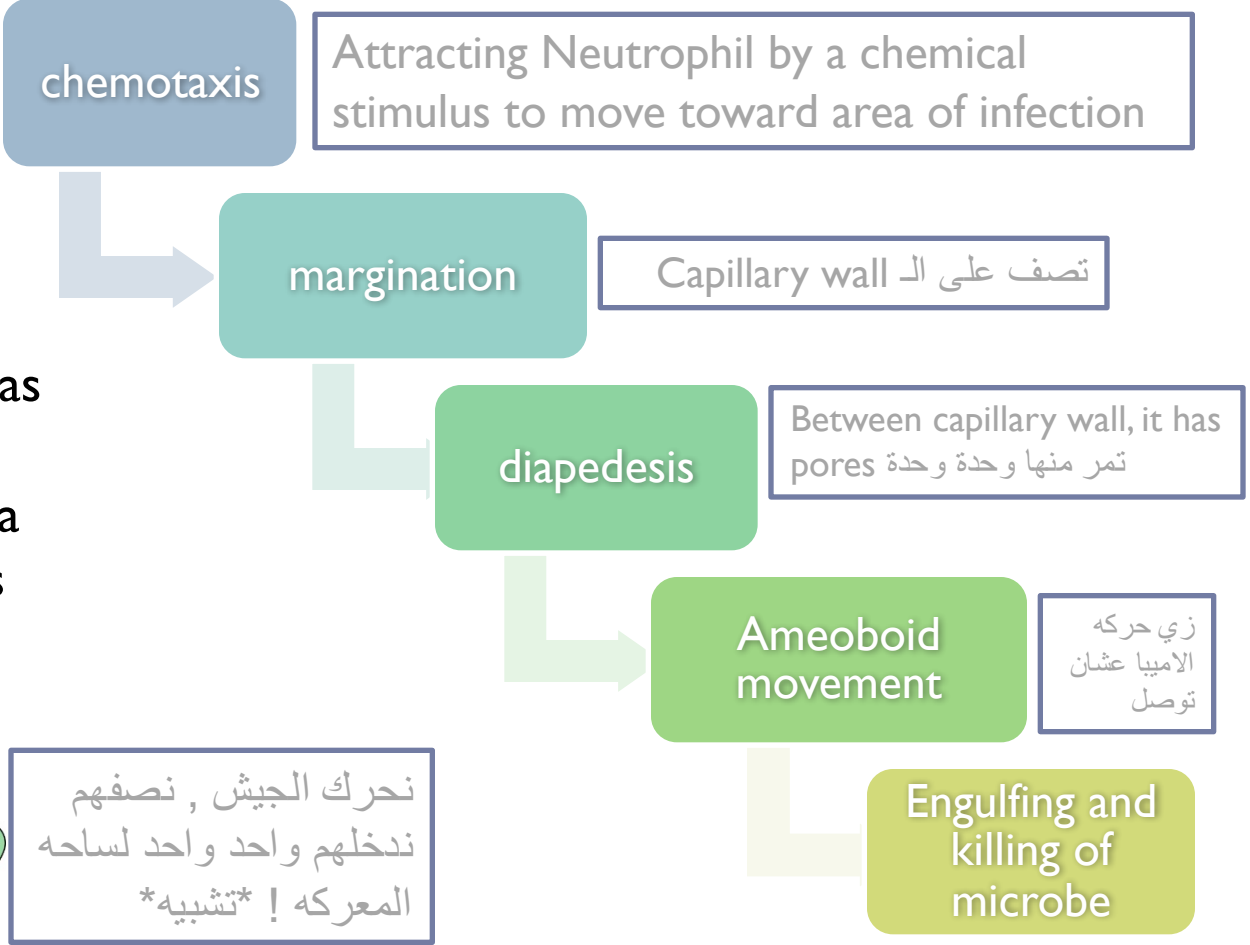
Monocyte => دبابه كبيره
تاكل اكثر

Neutrophil => دبابه
صغيره تاكل اقل



جميع الـ WBCs وليس فقط الـ Neutrophil

Defense against infection: Neutrophil has the ability of engulfing bacteria or organism by a process of phagocytosis



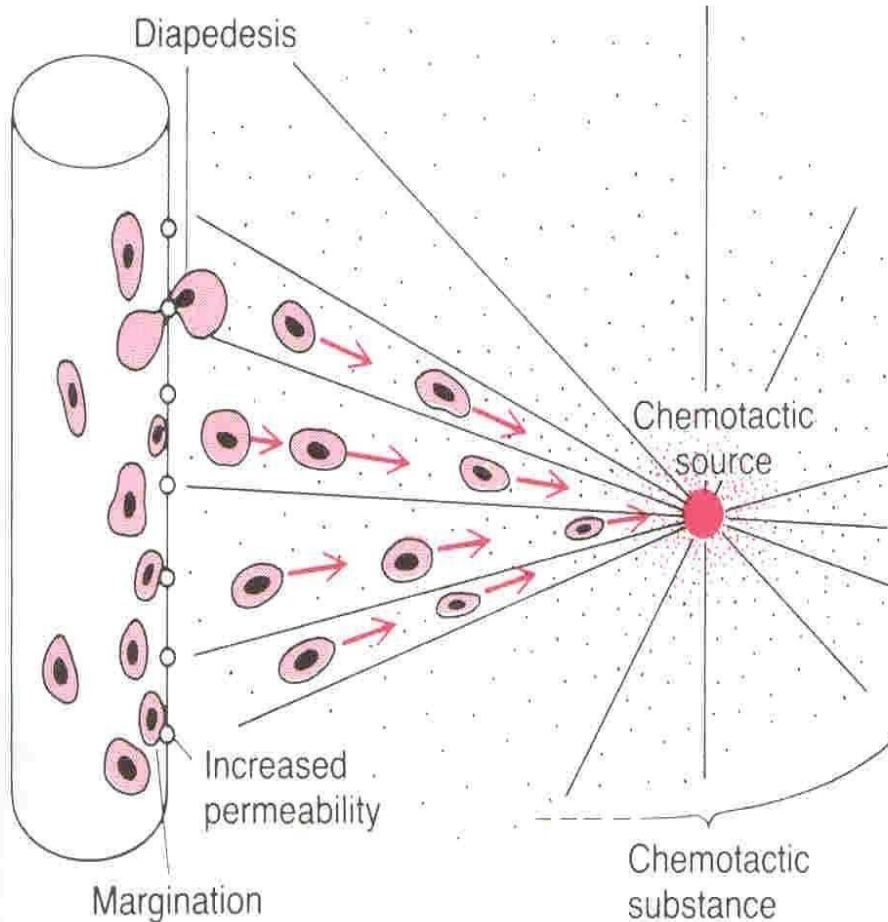
نحرك الجيش , نصفهم ندخلهم واحد واحد لساحه المعركه ! *تشبيهه*

Responses During Inflammation

Macrophage and Neutrophil

- ▶ **1st line of defense – Tissue macrophages & Physical Barriers**
- ▶ **2nd line of defense – Neutrophil Invasion of the inflamed area**
- ▶ **3rd line of defense – Monocytes –macrophage invasion of inflamed area**
- ▶ **4th line of defense – Increased production of granulocytes and Monocytes by Bone marrow**

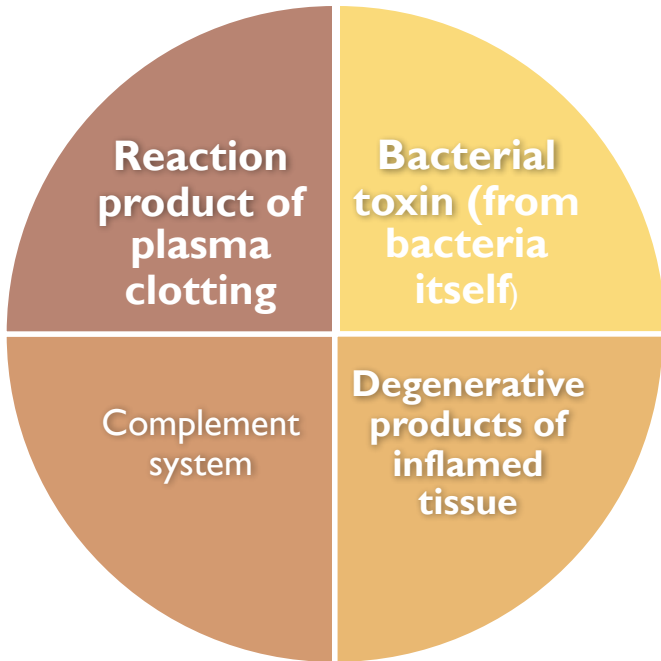
Chemotaxis, Margination and Diapedesis



عندما يكون هنالك جسم غريب داخل الجسم
كيف تحاربه الـ **Neutrophils**?
الجسم الغريب أو المنطقة المصابة تفرز
مواد كيميائية لجذب الـ Neutrophil نحو
هذه تسمى بالـ Chemotaxis
الآن تم إبلاغ الـ عن وجود الإصابة ومكانها
المحدد وهنا تبدأ المعركة!
تبدأ الـ Neutrophils بجلب جنودها
WBC وتجعلها تصطف على الـ wall
Vessel ثم تبدأ تدخل بالدور واحدة تلو
الأخرى من خلال ثقوب هذه العملية تسمى
Diapedesis وبعدها تصل إلى المنطقة
المصابة ويحصل الابتلاع.

Chemotaxis

The attraction of the neutrophils to inflamed area following chemotactic substances release from infected site:



مثل ما قلنا الـ Chemotaxis هي اللي تجذب الـ Neutrophils

“infected area release substances to attract neutrophils”

بالنسبة للنقطة الثانية فهي تعني أنه عندما حصل التهاب للنسيج بدأ بالتكسر و التحلل وإفراز مواد وهذه المواد هي اللي تصبح chemotaxis

Margination & Diapedesis

Margination: WBC marginate along the wall of blood capillaries

diapedesis: WBC squeezes itself through endothelial holes leaving blood capillaries

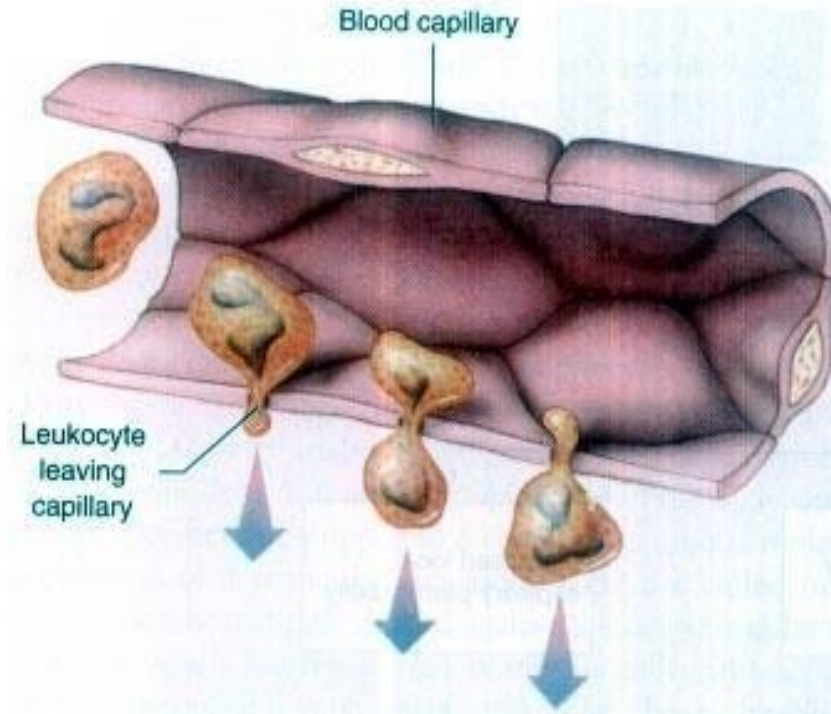
WBC move by amoeboid motion towards inflammation area following chemotactic substance released from site of infection

Upon reaching the site of infection neutrophils start to engulf infecting organism

Margination: accumulation and adhesion of leukocytes to the epithelial cells of blood vessel walls at the site of injury in the early stages of inflammation
Diapedesis: is the movement of leukocytes out of the circulatory system and towards the site of tissue damage or infection.

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CHAPTER 12



phagocytosis => process عملية الابتلاع

pseudopodia => الاقدام الكاذبه

phagosome => الحويصله اللي تكونت بعد الـ Phagocytosis

Phagocytosis

Selective process: foreign substances are recognized by:

- ★ 1. Rough surface
- ★ 2. No protective protein coat, which prevents phagocytosis
- ★ 3. Marked by certain substance

e.g **opsonization:** complement 3 or anti bodies **mark** foreign substances & making them ready for killing as a way to identify it to the phagocyte.

- ★ Neutrophils encircle the bacteria with **pseudo-podia** أقدام كاذبة
- ★ And engulf it inside into a vacuole (phagosome), takes 3-20 bacteria

▶ 20Minute video showing the process of Opsonization: <https://m.youtube.com/watch?v=6SiqO20ySQc>

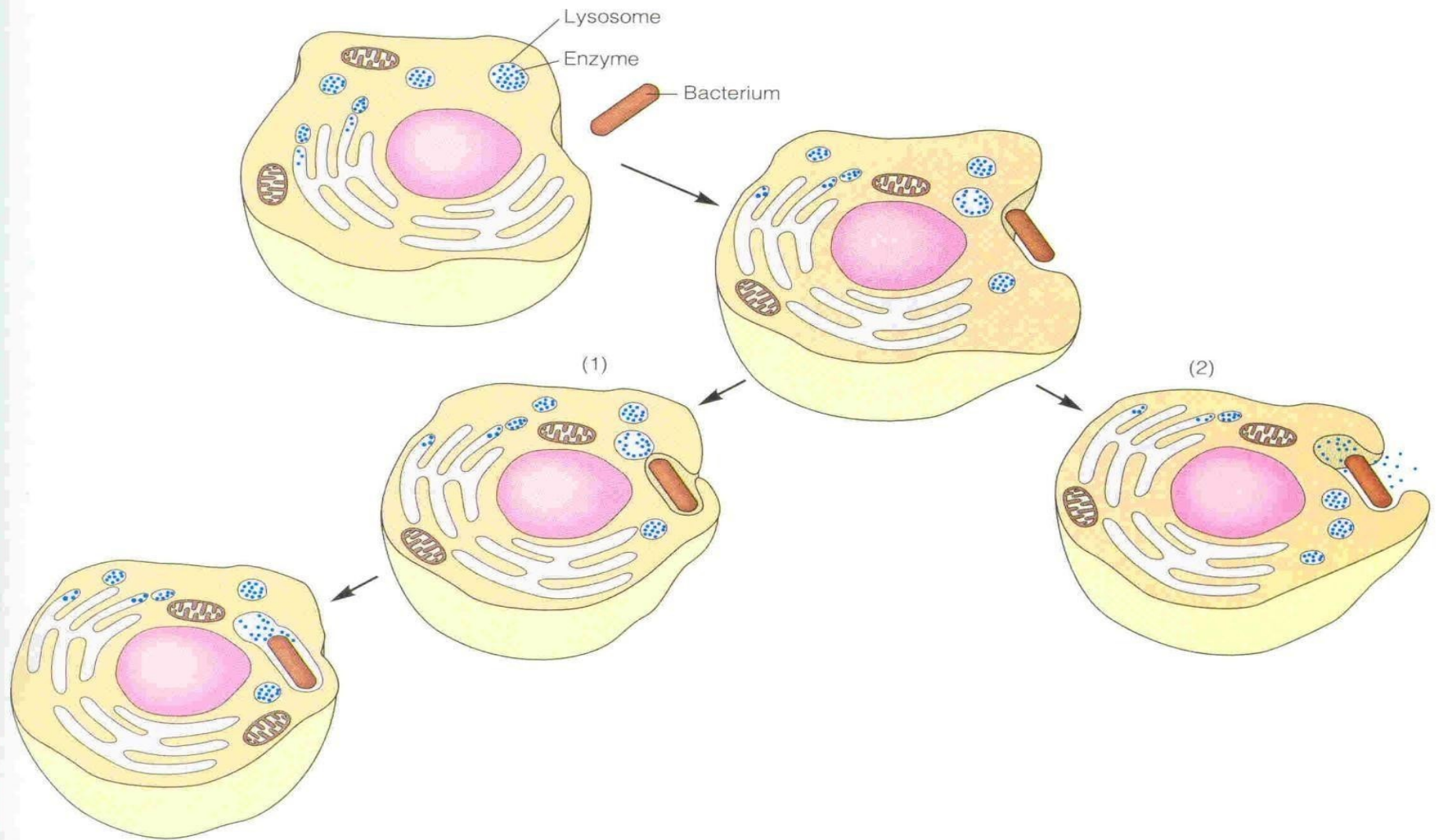


Figure 15.2

Phagocytosis by a neutrophil or macrophage. A phagocytic cell extends its pseudopods around the object to be engulfed (such as a bacterium). (Blue dots represent lysosomal enzymes.) (1) If the pseudopods fuse to form a complete food vacuole, lysosomal enzymes are restricted to the organelle formed by the lysosome and food vacuole. (2) If the lysosome fuses with the vacuole before fusion of the pseudopods is complete, lysosomal enzymes are released into the infected area of tissue.

Microbial killing (قراءة)

Digestion of organism inside the phagosome (vacuole داخلها البكتيريا)

1

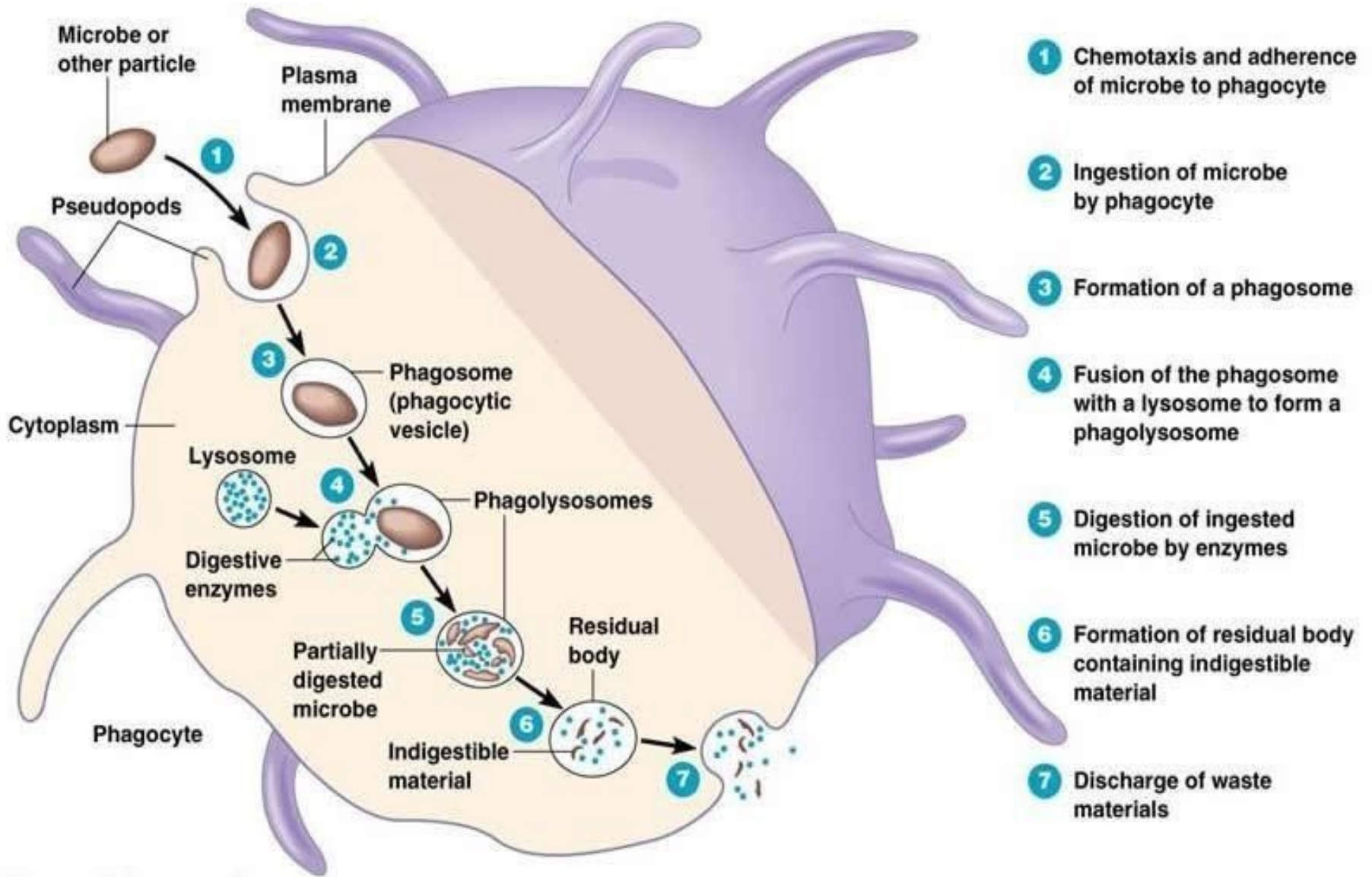
- **Fusion** of intracellular lysosomes + phagosome vacuole

2

- Lysosomes discharge its proteolytic enzymes such as myeloperoxidase, catalase into the vacuole, killing and digesting the engulfed bacteria

3

- Release of bactericidal such as **superoxide**, **hydrogen peroxide** to kill the bacteria



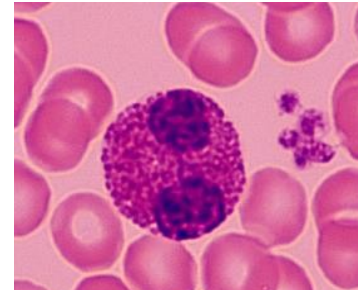
Phases of phagocytosis



EOSINOPHILS

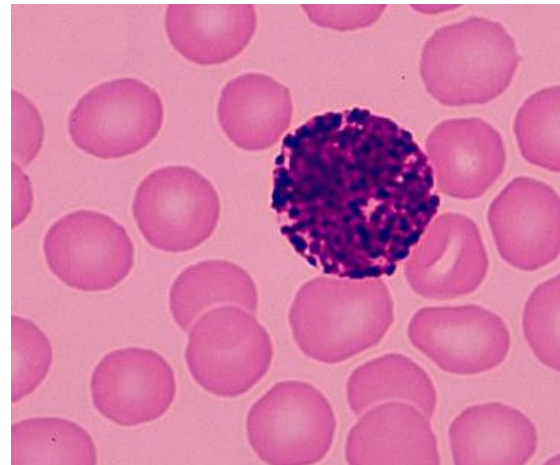
(only found in males' slides)

- ▶ **Weak phagocytes**
- ▶ **Exhibit Chemotaxis**
- ▶ **Attach themselves to the parasite:**
 - ▶ (1) by releasing hydrolytic enzymes from their granules (modified lysosomes)
 - ▶ (2) release highly reactive forms of oxygen
 - ▶ (3) release **major basic protein** (a highly larvacidal polypeptide)
- ▶ **Produced in large numbers during: PARASITIC INFECTIONS**
- ▶ **Examples of parastici infection: schistosomiasis, hook worm, Ascaris and**
- ▶ **in ALLERGIES eg; asthma & Rhinitis**
- ▶ **DRUG REACTIONS and SKIN ALLERGIES.**
- ▶ **Neutralizes** allergic products such as histamine, 5-HT, Ag-Ab complex, bradykinin (allergic disease of skin & lungs)



BASOPHILS

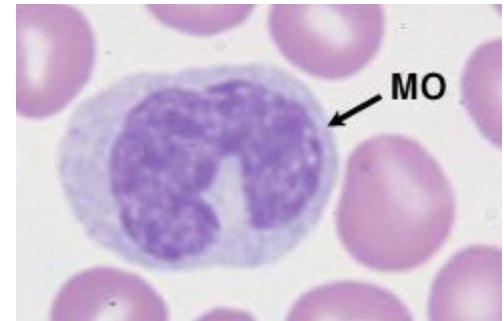
- ▶ Both mast cells and basophils **liberate** (secrete): heparin (anticoagulant),
- ▶ bradykinin, Serotonin (5HT), histamine (contribute to inflammation response)
- ▶ slow-reacting substance of anaphylaxis (a mixture of three leukotrienes) and a number of lysosomal enzymes.
- ▶ **Increased in allergic reactions: immediate-type hypersensitivity (allergic) reactions**
- ▶ The release of those substances cause local and vascular reactions characteristic of allergic manifestation.



MONOCYTES

(only found in males' slides)

- ▶ More efficient than Neutrophils (can phagocytize 100 bacteria vs 3- 20 by Neutrophil)
 - ▶ Can engulf larger particles (like RBCs & malarial parasites)
 - ▶ Life span: 10-20 hours
 - ▶ Two types: Mobile & Fixed
 - ▶ Lysosomes contain **lipases** unlike Neutrophil.
 - ▶ Acts as Antigen Presenting Cells
-
- ▶ After staying 10-20 hours in circulation, they leave the blood to tissues transforming into larger cells, **macrophages**.
 - ▶ Macrophage life span is up to a few months.

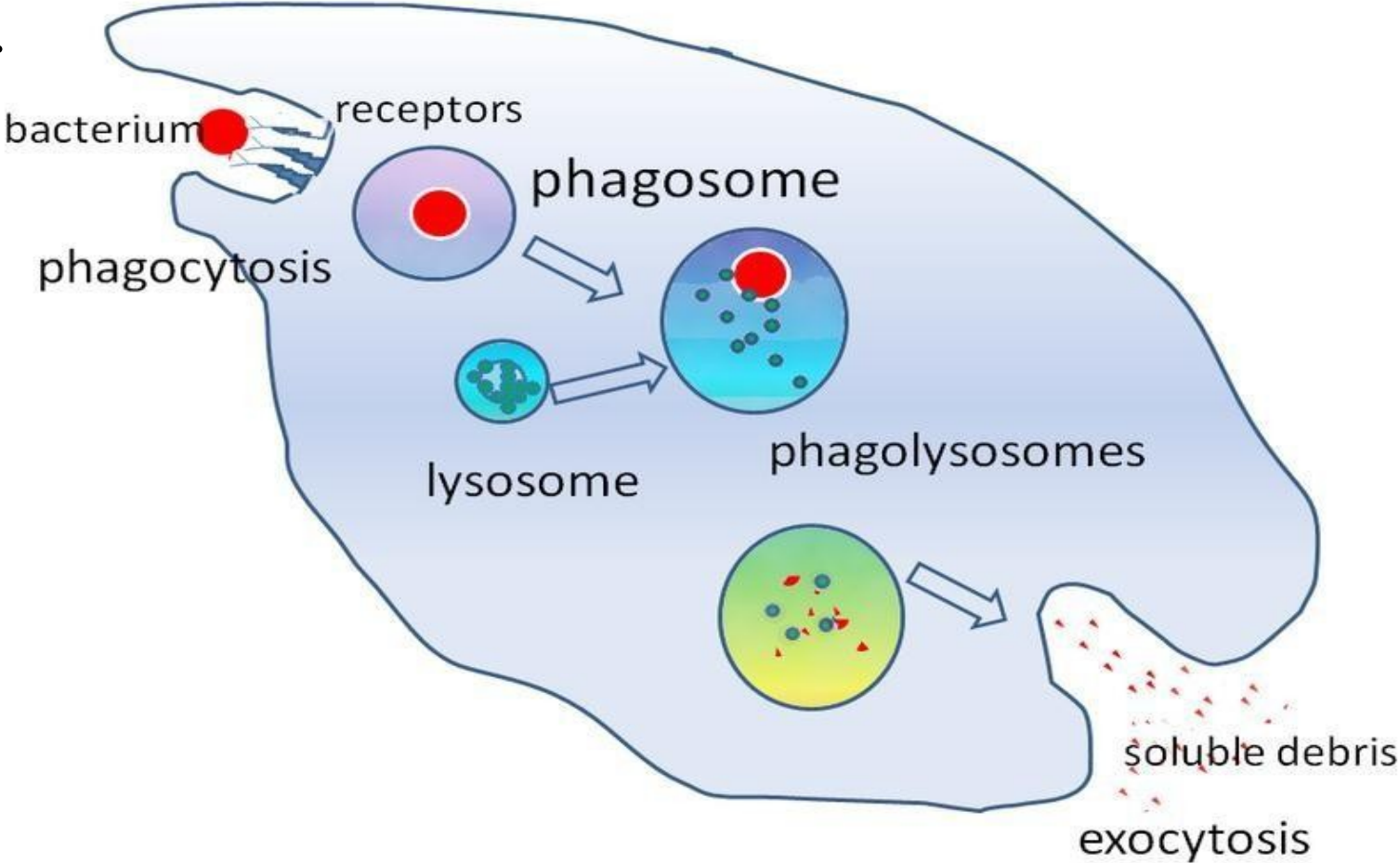


Function of Monocytes and Macrophages

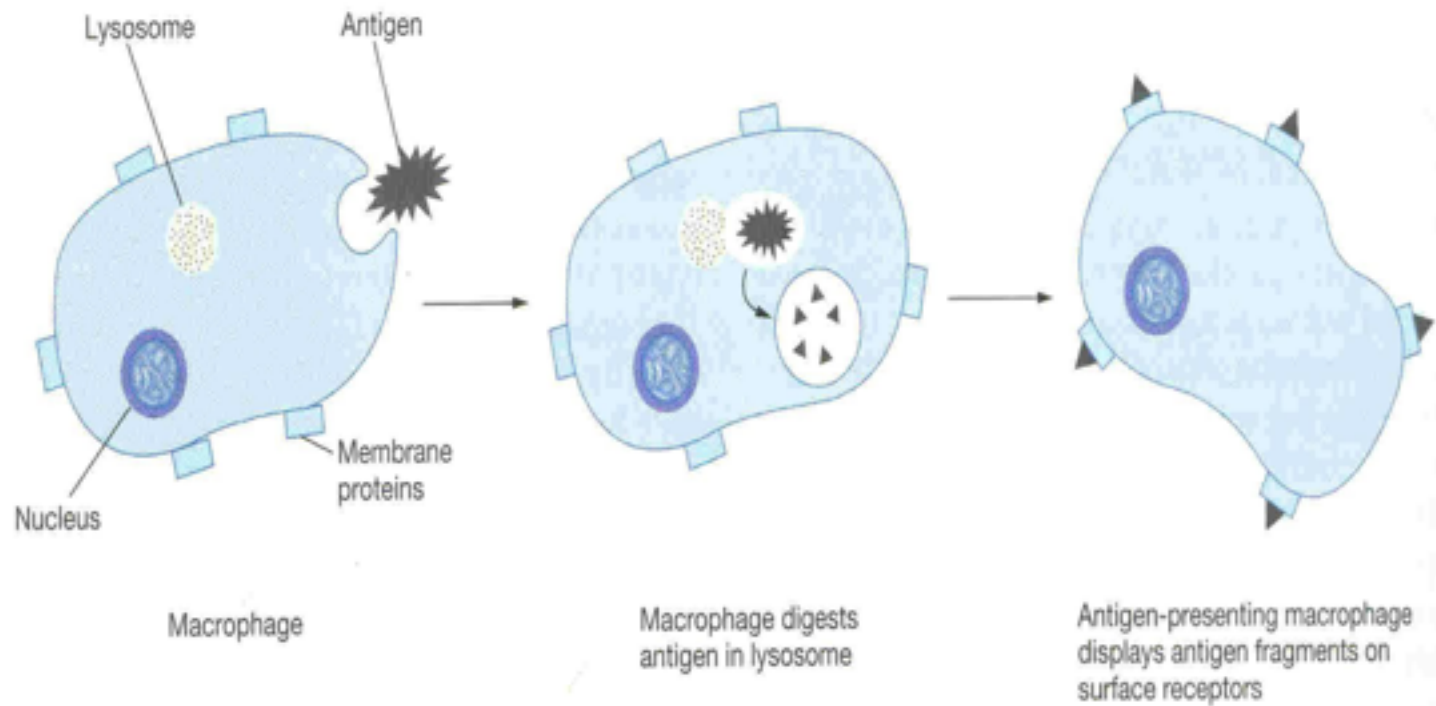
(only found in females' slides)

- Macrophages are a powerful phagocytic cells; first line of defense
 - Ingest up to 100 bacteria,
 - Ingest larger particles as old RBC
 - Get rid of waste and survive
- Functions: anti-inflammatory
 - **Directly**: phagocytosis of bacteria, dead cells
 - **Indirectly** cooperating with lymphocytes by recognizing foreign body (take in foreign body process it and present it to lymphocytes)

Direct anti Inflammatory



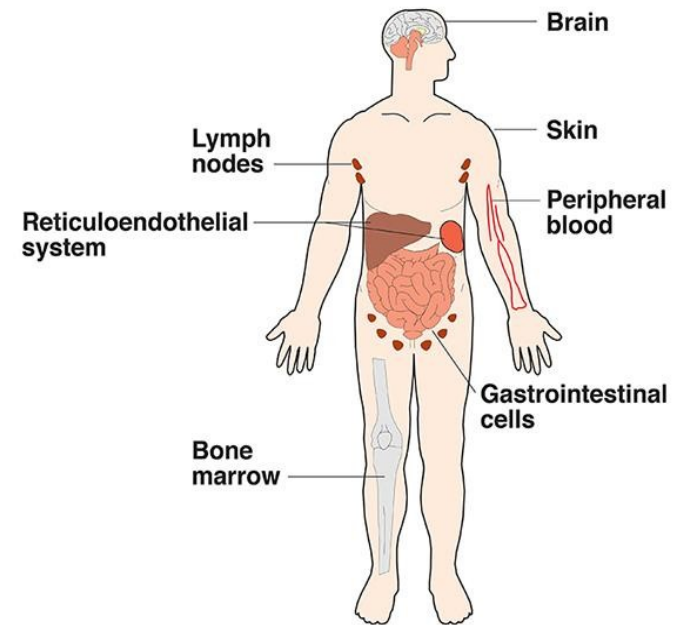
Indirect anti-inflammatory



Reticulo-endothelial System

Monocytes/Macrophage System

- ▶ Consists of Monocytes, Macrophages, and endothelial cells (found in spleen, bone marrow, lymph nodes)
- ▶ Monocytes → enter the tissues → transform themselves into macrophages
- ▶ This system of phagocytes is called: **Monocyte-Macrophage Cell System**
- ▶ It is found in various places in the body:
 - ▶ 1.Skin and subcutaneous tissues (**Histiocytes**)
 - ▶ 2.Lymph Nodes
 - ▶ 3.Alveolar macrophages
 - ▶ 4.Liver sinuses (**Kupffer Cells**)
 - ▶ 5. Lung
 - ▶ 6. Spleen
 - ▶ 7. Bone marrow
 - ▶ 8.Microglia in Brain
 - ▶ 9.Kidneys (**Mesangial Cells**)
 - ▶ 10.Bone (**Osteoclasts**)



PMNs (Antimicrobial system)

(only found in males' slides)

RESPIRATORY BURST

- O₂ Free Radicals (O⁻², H₂O₂, -OH)
- NADPH-oxidase
- Myeloperoxidase
- Cl⁻ → HOCl: Hypochlorous acid “very toxic”

REACTIVE OXYGEN METABOLITES

Superoxide anion: O₂⁻



Hydrogen peroxide: H₂O₂



Hydroxyl radical: OH[·]



Hypochlorous acid: HOCl



Myeloperoxidase = MPO

Lymphocytes Formation and Maturation

▶ Formed in :

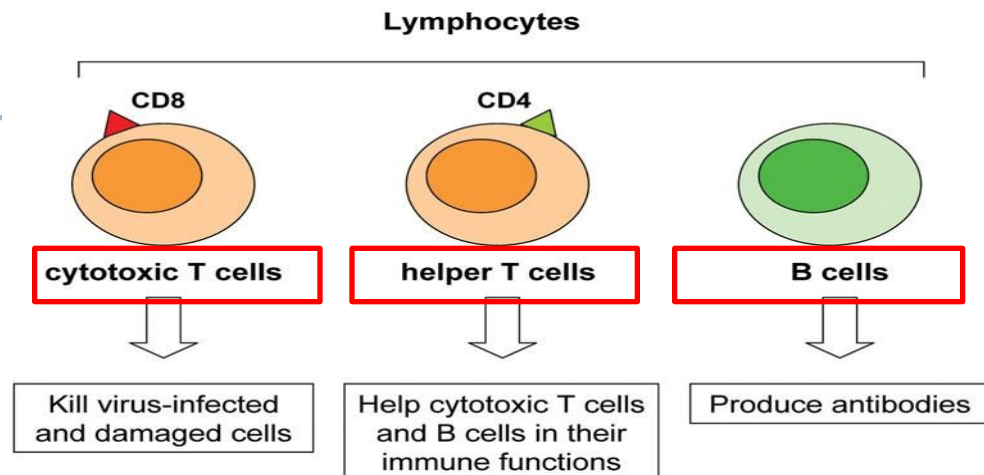
- stem cells of bone marrow
- Thymus
- lymphoid tissues.

▶ Life Span :

- Range from weeks to months according to its type.(T or B)

▶ It has 2 types:

1. T Lymphocytes: (thymus-dependent)
2. B Lymphocytes: (thymus-independent)



T & B lymphocyte

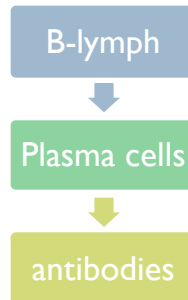
T-Lymphocytes (Thymus dependent)

- ▶ **Formed in:**
 - bone marrow or lymphoid tissue migrate to **thymus** for maturation
- ▶ **Life spans :** 100-130 days. (long period)
- ▶ **Circulate between :**
 - blood , tissue lymph
- ▶ **Types:**
 - T-helper
 - T-cytotoxic
 - Natural killer
- ▶ **Functions :**
 - **Cellular immunity** (graft rejection delayed hypersensitivity)
 - Role in antibody secretion.

على سبيل المثال :
-1- لما تحدث عملية نقل للكلية
أو أي عضو والجسم رفض هذا
العضو وتصير مضاعفات من
التي رفض العضو ؟ الـ
Lymphocytes-T
delayed -2
(hypersensitivity)
مثال عليها : جرعة
منشطة بعد التعقيم

B- Lymphocytes (thymus-**in**dependents)

- ▶ **First discovered in Bird Bursa**
(من هنا جائت التسمية) (حويصلات)
- ▶ **Formed in:**
 - Bone marrow , germinal layer of lymph node , red pulp of spleen
- ▶ **Life spans :** 2-7 days.
- ▶ **Circulate between :**
 - blood , tissue lymph
- ▶ **Transforms into :**
 - large **plasma cell** (produce antibody)
- ▶ **Functions :**
 - Humoral immunity. (*not Hormonal !*)
 - Stimulated by **antigen transforming**



Abnormality of WBC numbers

Leucocytosis

- ▶ **Increased WBC**
- ▶ **Physiologic or pathological causes**
- ▶ **Physiologic :**
 - Diurnal (morning : more) (evening: less)
 - After physical exercise
 - Stress or Adrenaline injection Disease
- ▶ **Pathologic :**
 - Bacterial infection (tonsillitis, Appendicitis)
 - Worm infection

Leucopenia

- ▶ **decreased WBC**
- ▶ **Causes:**
 - malnutrition.
 - Drugs
 - Radiation
 - Typhoid fever.
 - Decrease B12 & folic acid

Paradox: assuming that fever means high white blood cells

Leukemia

▶ Definition :

- Cancer of **white blood cells** due to chromosomal abnormality

▶ Caused by :

- chemicals,
- Radiation
- viruses.

▶ **WBC more than 50×10^3**

(ارتفاع في عدد كريات الدم البيضاء الغير طبيعية)

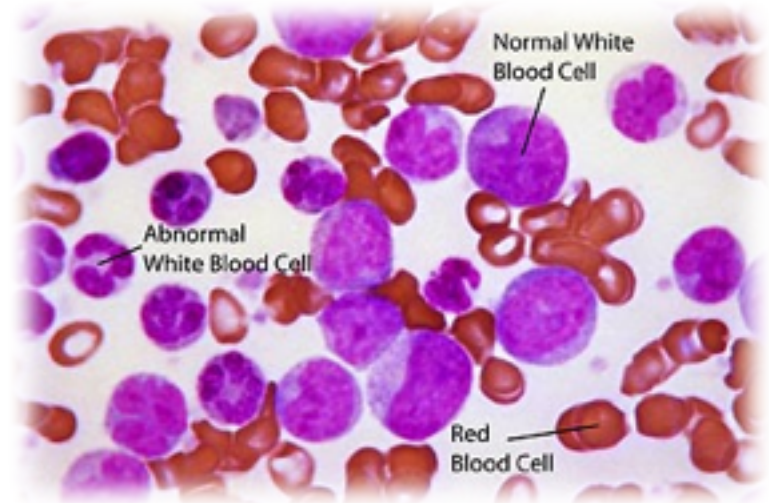
▶ Types of leukemia :

- Myeloblast leukemia → myeloid cells
- Lymphoblast leukemia → lymphocyte cells

▶ Acute or chronic onset

▶ Accompanied with :

- Anemia
- Bleeding



Lymphoid
Myloid :
Have different causes
and age groups

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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