PHYSIOLOGY Team 433

Lecture 9:
White blood cells

Mojahed Otayf
Khalid Al Nasser

Awatif Alenazi
Aisha Al radadi

Color Index

Blue = Main Topic
Violet = sup topic
Red = important
Orange = Explanation

White &Black = Addition

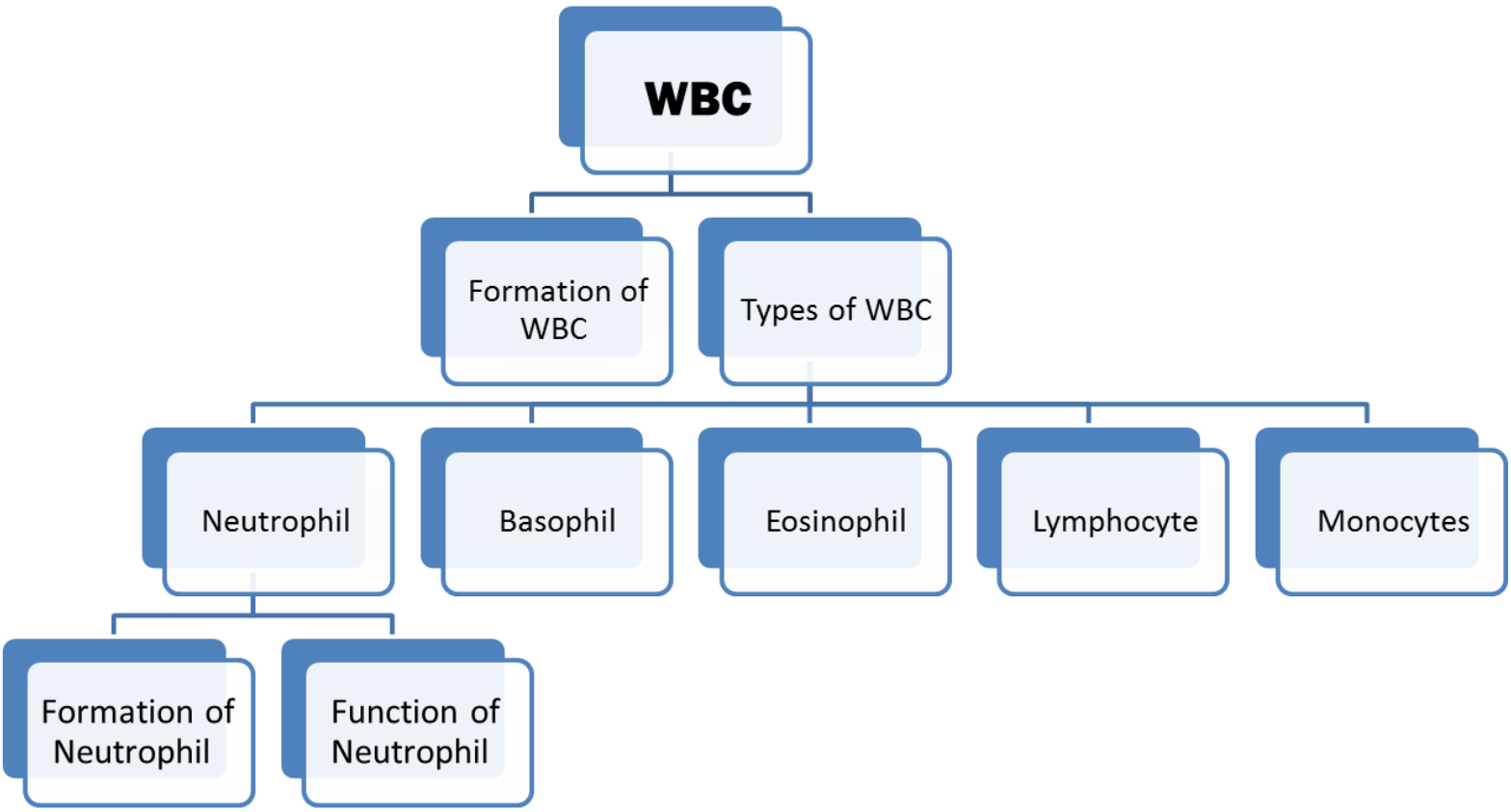
Contact us: PHT433@gmail.com

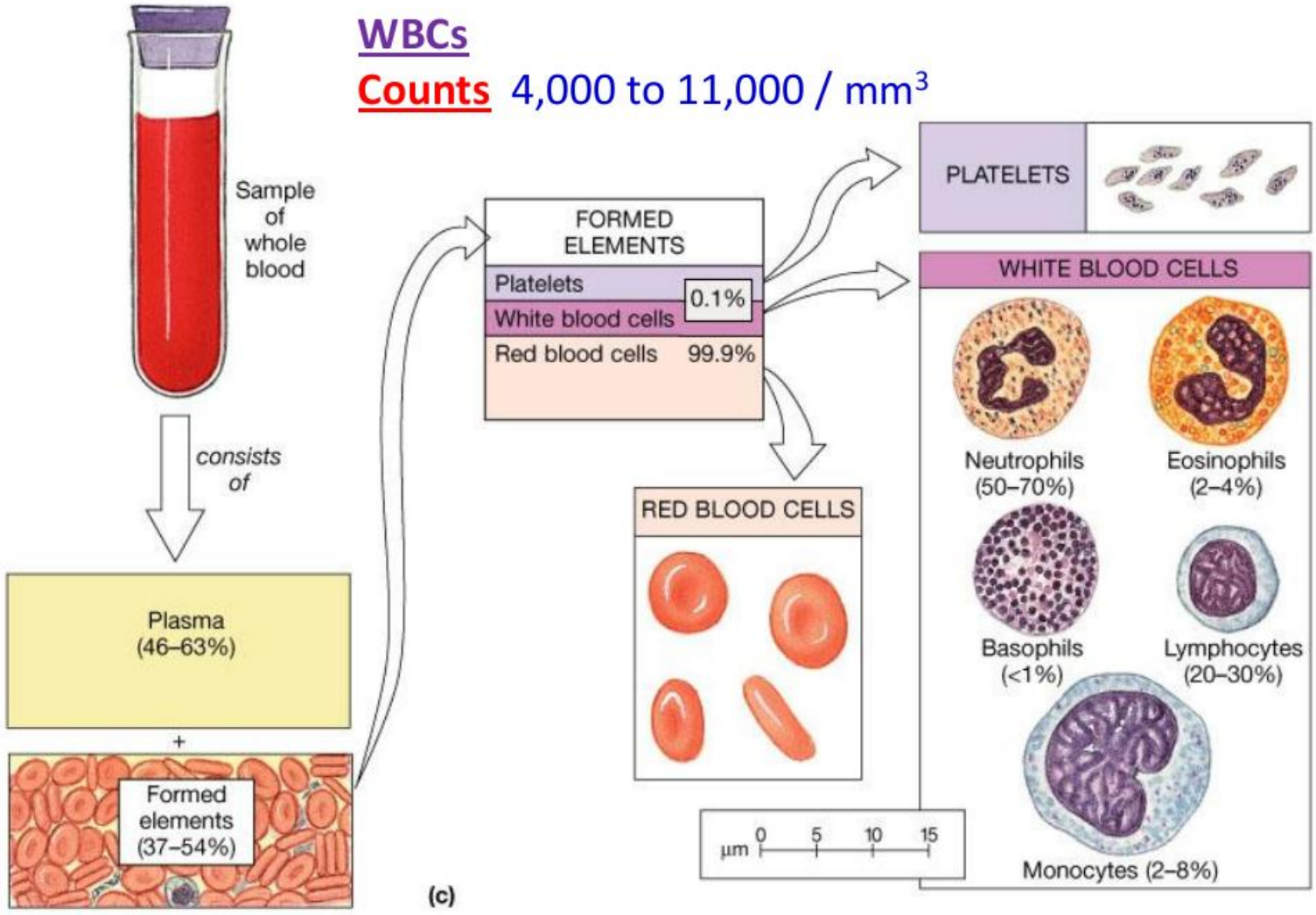
Objectives:

At the end of this session, the students should be able to:

- ✓ Formation of WBC.
- ✓ Types of WBC.
- ✓ Genesis, sites of formation and life span of WBC.
- ✓ Neutrophils formation, maturation and function.
- ✓ Phagocytosis.

Mind map

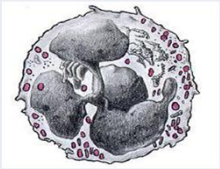
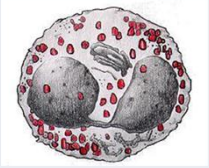
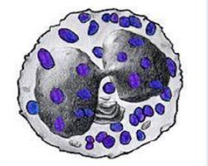




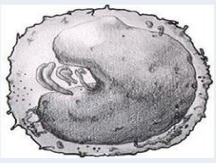
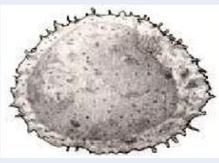
White blood cells called by another name which is (Leukocytes)

❖ Types of WBC's (According to cell morphology and cytoplasmic staining (hematoxylin and eosin) :

1. Granular (polymorphnuclear PMN) محببة

type	Neutrophil	Eosinophil	Basophil
size	10-16um	12-18um	10 -14um
shape	lobulated nucleus 2-5, purple cytoplasmic granules 	2 lobe nucleus, coarse red granules 	rarely segmented nucleus, nucleus hidden by large round bluish cytoplasmic granules. 
Percentage of total WBC	62%	2.3%	**0.4%**

2. Agranular غير محببة

type	Monocytes	Lymphocyte
size	15-20 um	– small size(5-8um) – large size(9-15um)
shape	kidney shape nucleus. 	round nucleus. 
Percentage of total WBC	5.3%	30%

❖ Function and important notes about WBC's :

1- Neutrophils

Main function is phagocytosis

2- Eosinophils

High eosinophil count (eosinophilia):

- **Parasitic (hook worm, ascaris, bilharzia) infection.**
- **Allergy (asthma, rhinitis, drug reaction).**
- **Allergic skin diseases**

Eosinophils attach themselves to the parasites by way of special surface molecules and release substances that kill many of the parasites (by releasing hydrolytic enzymes from their granules)

3- Basophil

- They are very similar functionally to mast cell.
- Release histamine → inflammation (redness, swelling, and pain)
- Release heparin → anticoagulant (prevent clotting)

4- Monocyte

These cells are the largest of all WBCs

5- Lymphocyte

These cells are the smallest of all WBCs

Genesis of White blood cells

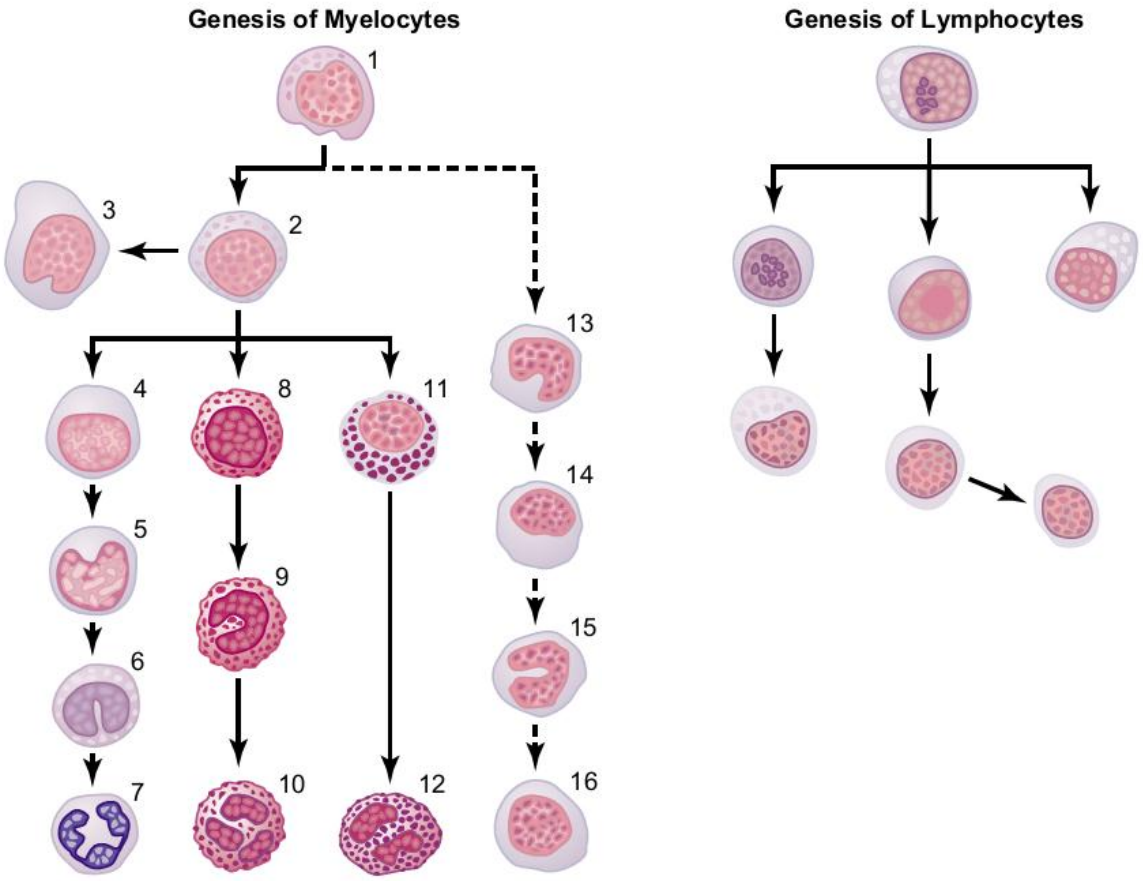


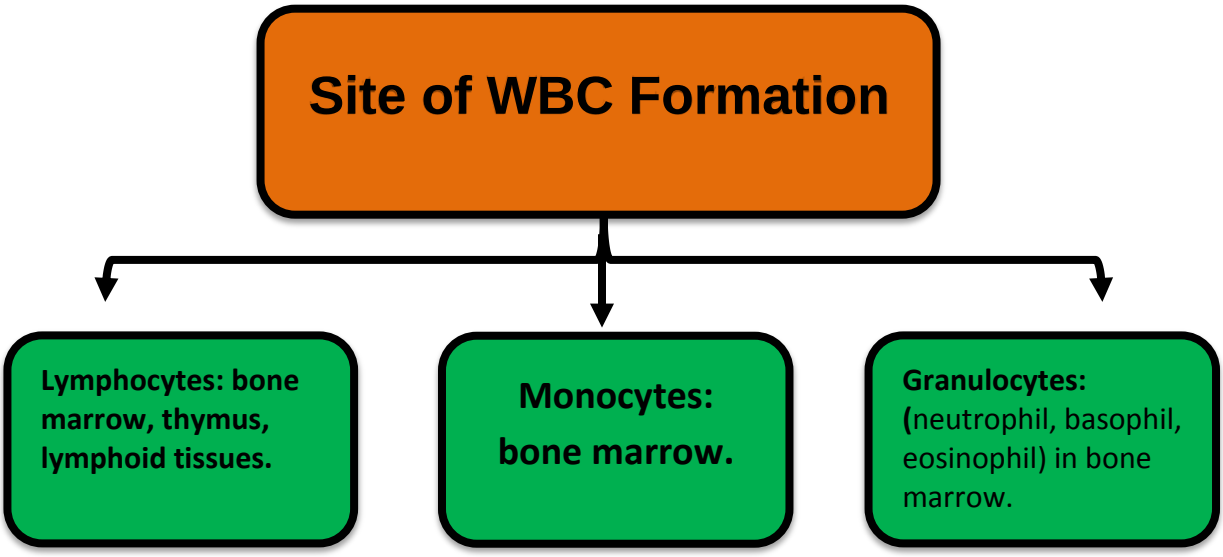
Figure 33–1

Genesis of white blood cells. The different cells of the myelocyte series are 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.

Two major lineage of WBC

Myelocytic
1- granular
2-monocytes

Lymphocytic
lymphocytes



Life Span of WBC's

Granulocyte

- **4 to 8 hrs (transit time) in blood circulation.**
- **4-5 days in tissues, During infection life span only few hours,**
- **Because they die after ingesting bacteria.**

Monocyte

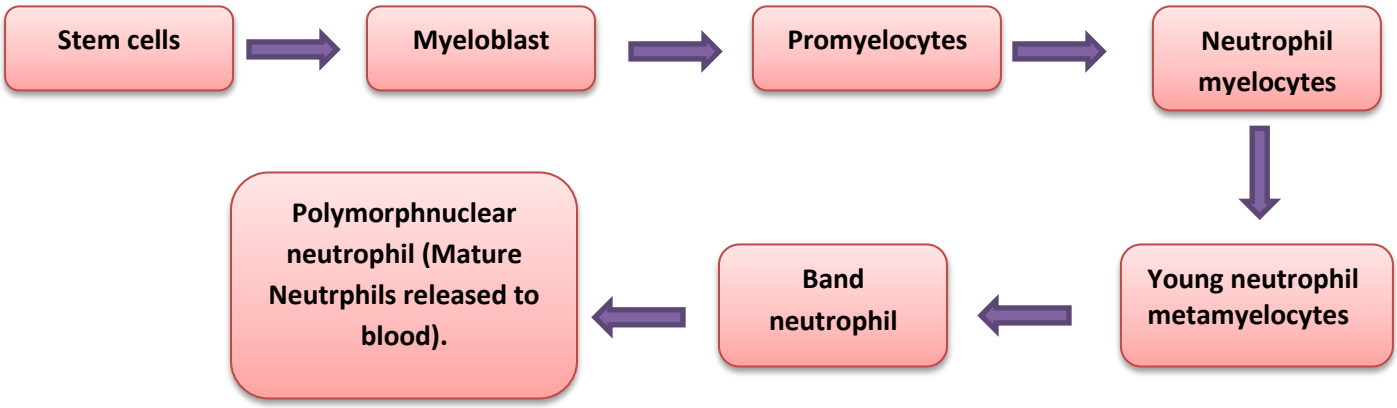
10-20- hours then they leave blood to tissues transform into macrophage, its life span goes up to months.

Lymphocyte

Weeks to months according to its type

NEUTROPHILLS

Formation and Maturation of Neutrohils : Formed in Bone Marrow

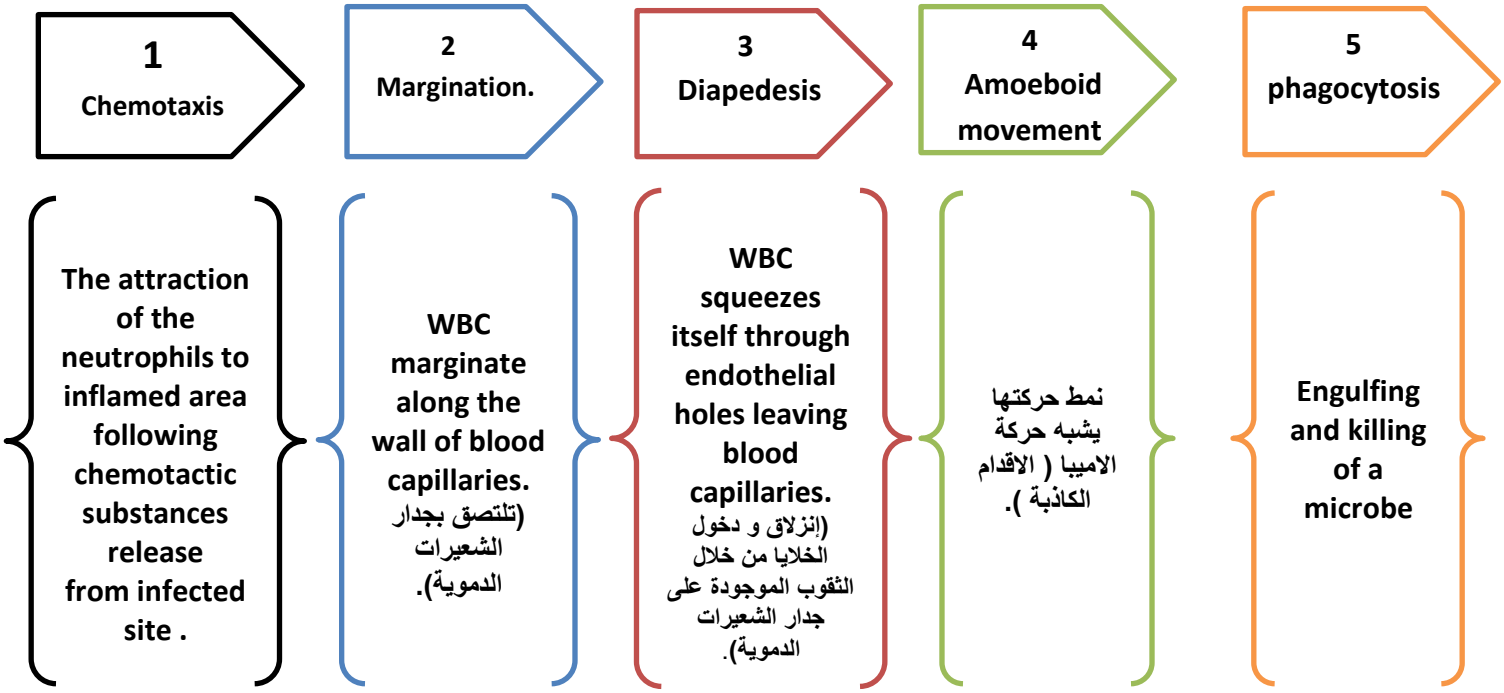


Neutrophil Function:

Defense against infection:

Neutrophil has the ability of engulfing (ابتلاع) bacteria or organism by a process of phagocytosis (البلعمة).

Steps of Phagocytosis:

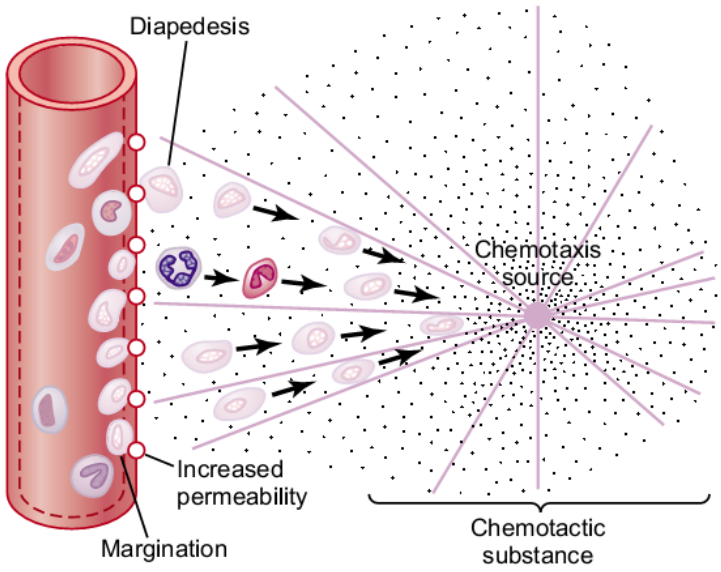


Chemotaxis: The attraction of the neutrophils to inflamed area following chemotactic substances release from infected site.

Chemotactic substances

(مواد تؤدي إلى انجذاب الخلايا البيضاء)

- Bacterial toxin
- Degenerative products of inflamed tissue
- Complement system
- Reaction product of plasma clotting



Margination & Diapedesis:

1- WBC marginate along the wall of blood capillaries.
2- WBC squeezes itself through endothelial holes leaving blood capillaries (Diapedesis).
3- WBC move by amoeboid motion towards inflammation area following chemotactic Substance released from site of infection.
4- Upon reaching the site of infection neutrophils start to engulf infecting organism.

Phagocytosis:

Selective process, Foreign substance recognize by:
(كيف تستطيع الخلايا التعرف على الجسم الغريب؟)

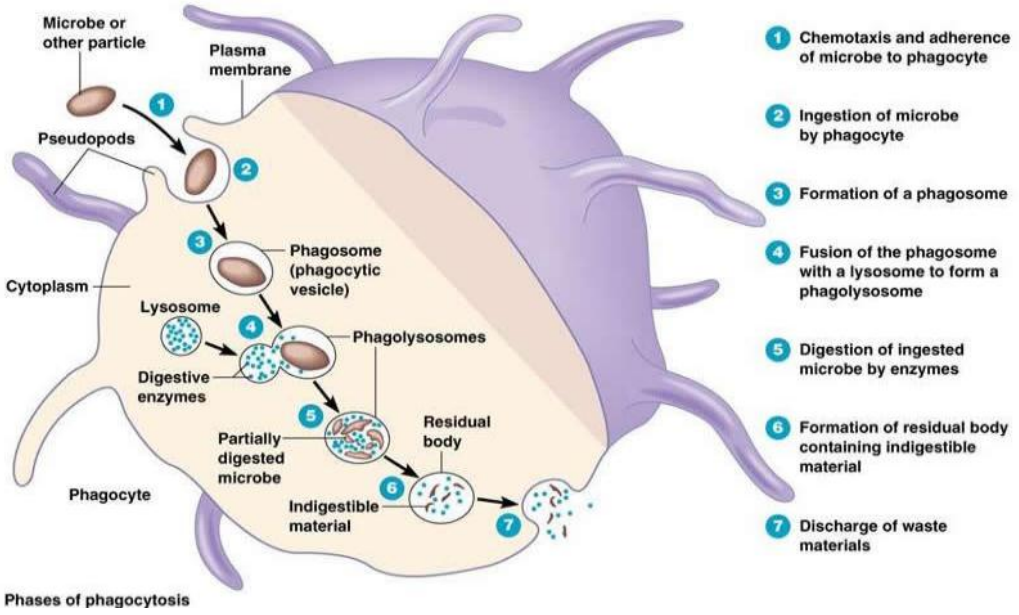
- **Rough surface**
- **No protective protein coat: which prevents phagocytosis**
- **Marked by certain substance: e.g Complement 3 or antibodies making them ready for killing a process known as opsonization**

Neutrophils encircled the bacteria with pseudopodia الاقدام الكاذبة , and engulf it inside into a vacuole (phagosome), takes 3-20 bacteria.

Microbial killing:

- **Digestion of organism inside the phagosom.**
- **Fusion of intracellular lysosomes with phagosome vacuole.**
- **Lysosomes discharge its proteolytic enzymes such as myeloperoxidase, catalase into the vacuole, killing and digesting the engulfed bacteria. And/ or (outside)**
- **Release of bactericidal such as superoxide, hydrogen peroxide to kill the bacteria.**

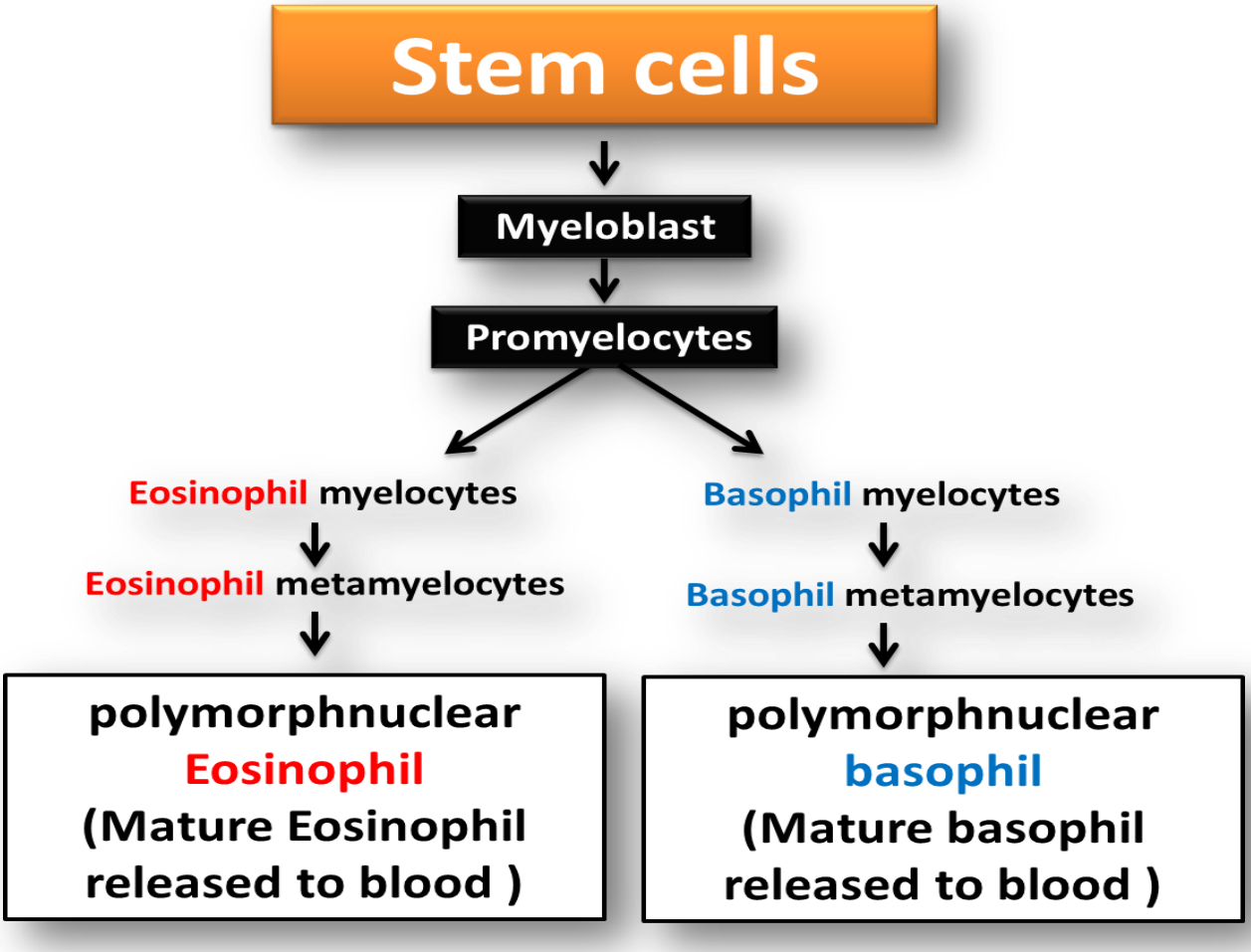
فيه منه نوعين : نوع يتم داخل الخلية بعد ما تمم عملية الـ Phagocytosis وتحصل في phagocytic cells و النوع الاخر خارج الخلية عن طريق افراز الانزيمات القاتلة مثل الـ Eosinophil .

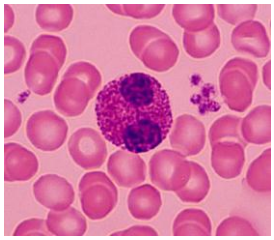


Eosinophils and Basophils

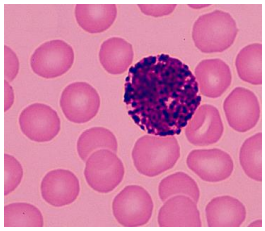
(granular WBC)

Formation and Maturation: Formed in Bone Marrow.





Red granules



Blue granules

Function of Eosinophils

Phagocytosis: attach themselves to parasites and releases substances (hydrolytic enzymes, Superoxide) to kill it.

High eosinophil count:

Parasitic(طفيليات) (hook worm, ascaris, bilharzia).
Allergic(حساسية) (asthma, rhinitis, drug reaction).

Function of Basophils

Similar to mast cells both secrets:

1- Heparin to prevent clotting.

2- Histamine , bradykinin & serotonin to inflammation response.

The release of those substances cause local and vascular reactions characteristic of allergic manifestation.

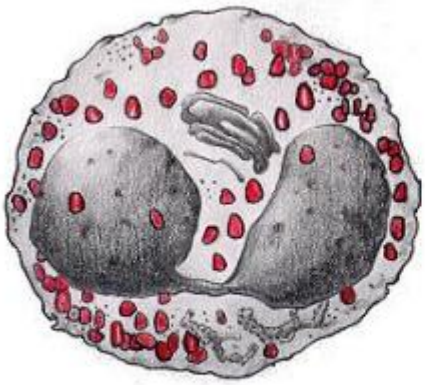


Fig. 9 - Eosinophil

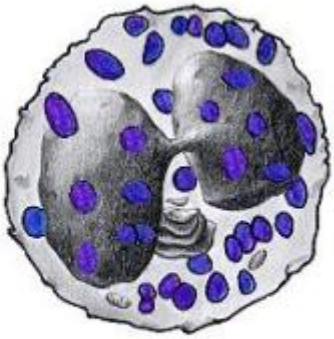
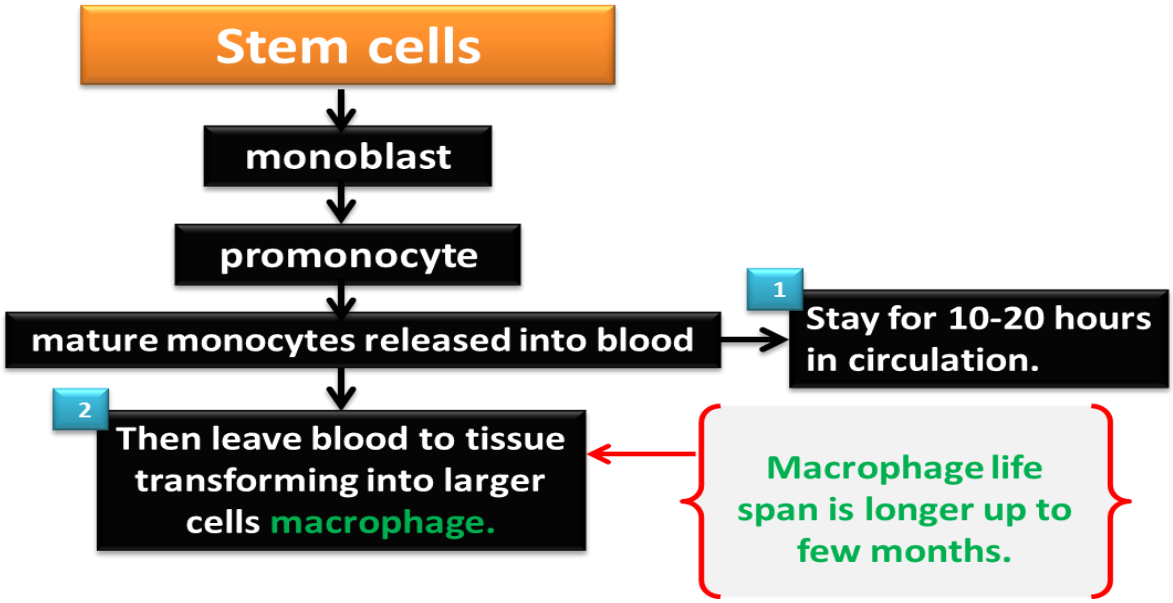


fig. 10 - Basophil

MONOCYTES AND MACROPHAGES:

(A granular WBC)

Formation: Formed in Bone Marrow.



Function of monocytes and Macrophages

Macrophages are powerful phagocytic cells, first line of defense.

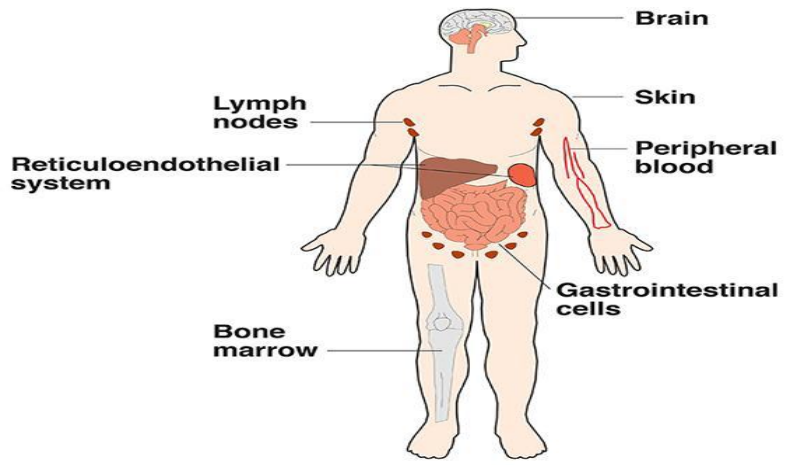
- **Ingest up to 100 bacteria.**
- **Ingest larger particles as old RBC.**
- **Get rid of waste and survive.**

Functions: anti-inflammatory.

1. **Directly: phagocytosis of bacteria, dead cells.**
2. **Indirectly: cooperating with lymphocytes by recognizing foreign body (take in foreign body process it and present it to lymphocytes).**

Reticuloendothelial system(RES):

(عبارة عن خلايا موجودة في أنحاء الجسم تؤدي نفس الوظيفة)



CONSIST OF:

1. **Monocytes.** 2. **Macrophage.**

3. **Endothelial cells** تبطن الأوعية الدموية **(bone marrow, spleen, lymph node).**

Located in all tissues especially; skin(histocytes), liver (kupffer), spleen, bone marrow, lymph nodes, lung.

FUNCTIONS OF (RES) :

- ✓ **Phagocytosis: Bacterial, dead cells foreign particles.**
- ✓ **breakdown of Hb.**
- ✓ **immune function: processing antigen and antibodies production (indirest).**
- ✓ **storage of iron.**

LYMPHOCYTES:

Formation:

Formed in Bone Marrow, thymus and lymphoid tissues.

Stem cells
(Bone Marrow, thymus and lymphoid tissues)
↓
lymphoblast
↓
intermediate pyronophilic blast cell
↓
lymphocytes ← Life Span Of Lymphocytes range from weeks to months according to its type

Function of lymphocytes is Immunity.

Types of lymphocytes:

1. thymus dependent(T- lymphocytes).
2. thymus independent(B- lymphocytes). ← First discovered in bird bursa.

B- lymphocyte (shorter life span).

T- lymphocyte (longer life span).

1. T- lymphocytes:

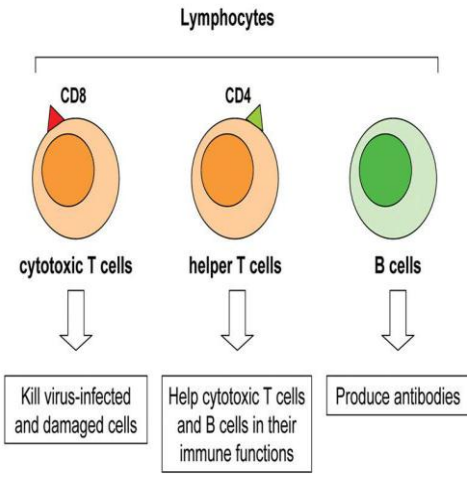
- ✓ Formed in bone marrow or lymphoid tissue, migrate to thymus for maturation.
- ✓ Life spans 100-130 days.
- ✓ Circulate between blood, tissues and lymph.
- ✓ Types of T- lymphocytes:
  - T-helper.
  - T- cytotoxic.
  - Natural killer.
- ✓ Functions :
  - Cellular immunity (graft rejection delyed hypersensitivity).
  - Role in antibody secretion.

2. B- lymphocytes:

B- lymphocyte + antigen=plasma cell

- ✓ Formed in: Bone marrow, germinal layer of lymph node, red pulp of spleen.
- ✓ Life span 2-7 days.
- ✓ It transforms into large plasma cell (produce antibody).
- ✓ Function: Humoral immunity.
- ✓ Stimulated by antigen transforming.

	T-lymphocytes	B-lymphocytes
formation	Bone marrow or lymphoid tissue, migrate to thymus for maturation.	Bone marrow, germinal layer of lymph node, red pulp of spleen.
life span	100-130 days	2-7 days



Leukocytosis: Increased WBC.

- ✓ **Physiological (normal):**
- **Diurnal ↓ morning ↑ evening.**
- **After physical exercise.**
- **Stress or Adrenaline injection.**
- ✓ **Disease:**
- **Bacterial infection (tonsillitis,التهاب اللوزتين Appendicitis التهاب الزائدة).**
- **Worm infection.**

Leukopenia: decreased WBC.

Causes:

1. Malnutrition.
2. typhoid fever.
3. drugs.
4. Deficient vit B12 & folic acid.
5. Radiation.

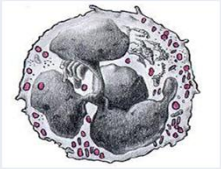
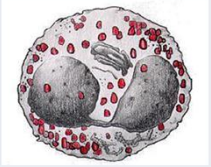
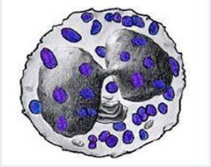
Leukaemia: Cancer of white cells due to chromosomal abnormality caused by chemicals, radiation, and viruses.

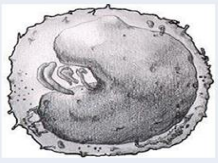
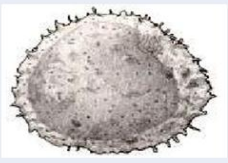
- ✓ **WBC more than $50x10^3$.**
- ✓ **Types of leukaemia:**
  - **Myeloblast leukaemia → myeloid cells.**
  - **Lymphoblast leukaemia → lymphocytic cells.**

- ✓ **Acute or chronic onset.**
- ✓ **Accompanied with anemia, bleeding.**

Summary

- **WBC's Classified into Granular and Agranular leukocytes**
- **The normal count of WBC's is 4000 – 11000 / mm^3**
- **Steps of Dfeense of neutrophils are (Chemotaxis,Margination,Diapadsis,Amobied movement and phagocytosis)**

type	Neutrophil	Eosinophil	Basophil
size	10-16um	12-18um	10 -14um
shape	lobulated nucleus 2-5, **purple** cytoplasmic granules 	2 lobe nucleus, coarse **red** granules 	rarely segmented nucleus, nucleus hidden by large round **bluish** cytoplasmic granules. 
Percentage of total WBC	62%	2.3%	**0.4%**

type	Monocytes	Lymphocyte
size	15-20 um	– small size(5-8um) – large size(9-15um)
shape	kidney shape nucleus. 	round nucleus. 
Percentage of total WBC	5.3%	30%

Site of WBC Formation

- **Lymphocytes: bone marrow, thymus, lymphoid tissues.**
- **Monocytes: bone marrow.**
- **Granulocytes:** (neutrophil, basophil, eosinophil) in bone marrow.

	T-lymphocytes	B- lymphocytes
formation	**Bone marrow or lymphoid tissue, migrate to thymus for maturation.**	**Bone marrow, germinal layer of lymph node, red pulp of spleen.**
life span	**100-130 days**	**2-7 days**

Abnormal Conditions Of Leukocytes

- **Leukopenia**
  Decrease in number of WBC
- **Leukocytosis**
  Increase in number of WBC
- **Leukemia**
  Cancer of white cells due to chromosomal abnormality

How White Blood Cells Are Formed?

https://www.youtube.com/watch?v=tDTLC2swhlQ

How White blood cells Works?

https://www.youtube.com/watch?v=0TvTyj5FAaQ

Multiple Choice Questions

Q1: Which of the following is granular leukocyte?

A- Lymphocyte
B- Basophil
C- Neutrophil
D- Both B + C

Q2: The least abundant leukocyte is?

A- Monocyte
B- Basophil
C- Eosinophil
D- Neutrophil

Q3: Which of the following has a similar function of mast cells?

A- Lymphocyte
B- Basophil
C- Eosinophil
D- None of them

Q4: The Largest L Smallest leukocytes are?

A- Neutrophil/basophil
B- Lymphocyte/Monocyte
C- Monocyte/Lymphocyte
D- Basophil/Neutrophil

Q5: The site of monocyte formation is?

A- Thymes
B- Lymphoid tissue
C- Bone morrow
D- All of them

Q6: The first event of neutrophil to defense is?

A- Chemotaxis
B- Diapedesis
C- Phagocytosis
D- Margination

1-D 2-B 3-B 4-C 5-C 6-A