

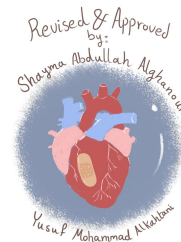


# White blood cell 1&2

Team Leaders:

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**Red: Important**

**Black: In Male & Female slides**

**Blue: In male slides**

**Pink: In female slides**

**Green: Notes & extra information**

## Objectives:

- Outline components of the immune system.
- List the types of white blood cells (**WBCs**).
- Describe the structure of the different types of WBCs.
- Outline differential WBCs count.
- Summarize the stages of formation of the different WBCs.
- State the functions the different types of WBCs.
- Describe the role of the WBCs in immune responses and defending against infection.
- Explain the process of phagocytosis.
- Recognize leukocytosis, leukopenia and leukemia.

# White Blood Cells

*\*in a nutshell*

## Originate in:

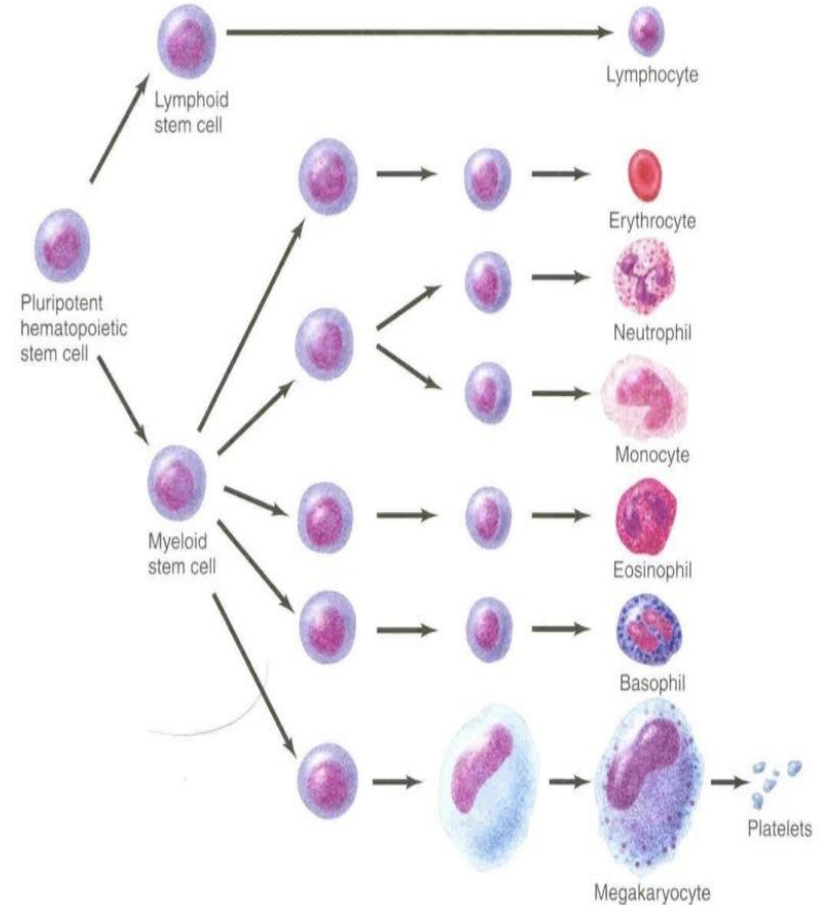
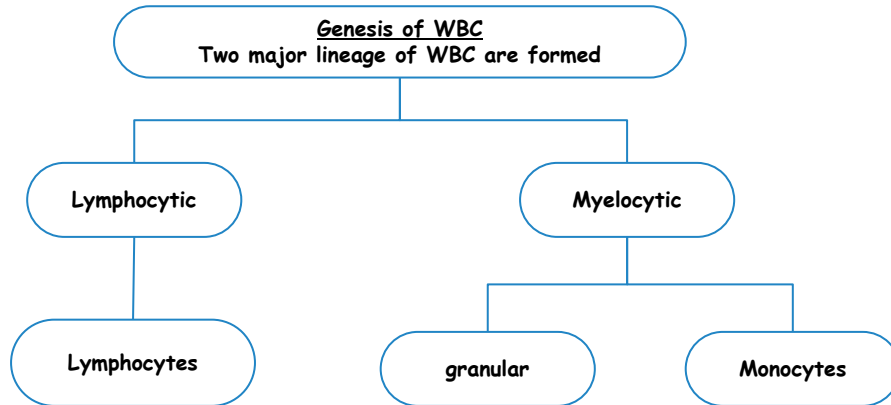
-Leukocytes are the mobile units of the body's protective system and it's formed in bone marrow & lymph tissue.

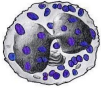

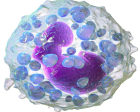
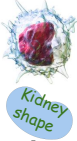
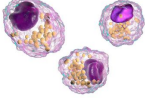
Count: 4,000-11,000 WBC's/mm<sup>3</sup> blood.

## Function:

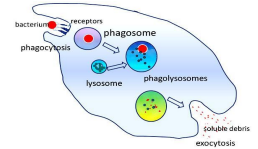
-Protection against infection by:

- 1-Phagocytosis
- 2-Secretion of antibodies
- 3-sensitized lymphocytes



Type of WBCs (5000/ml or 4000-11000/ml)		Percentage of leukocytes	Site of formation	Life span	Nucleus morphology	Shape	
<b>Granular</b> (polymorphonuclear) (PMN) They're called granulocytes -they constitute 70-75% of WBCs . -They have cytoplasmic granules . - They contain Small granules of both acidic and basic .	<u>Neutrophil</u>	62%	Bone marrow	لتسهيل الفهم تخيلوا أننا بحرب وكل واحد له دوره <b>Neutrophils (granulocytes):</b> (مدرعة صغيرة (حدها ٣٠ بكتيريا) <b>Macrophages:</b> دبابه كبيره بتجلس فترة طويلة لمدة أشهر وينقضى على عدد أكبر (١٠٠٠ بكتيريا)	lobulated, 2-5	Purple cytoplasmic granules  <small>fig. 10 - Basophil</small>	
	<u>Eosinophil</u>	2.3%	Bone marrow		4 - 8 hours in blood then 4-5 days in tissues, During infection life span only few hours because they die after ingesting bacteria.	2 lobes	Coarse red granules 
	<u>Basophil</u>	0.4%	Bone marrow		-rarely segmented nucleus & hidden by large round bluish granules (كثيره لدرجة (مانقدر نميز النواة)		
<b>Agranular</b>	<u>Monocytes/ Macrophage</u> ☞	5-3%	Bone marrow	10-20 hours then they leave blood to tissues transform into macrophage they swell and filled by large number of lysosomes, its life span goes up to months.	-Large -kidney shape (monocytes)  <small>Kidney shape</small>	 <small>SHUTTERSTOCK.COM • 120993728</small>	
	<u>Lymphocyte</u> (T-cells & B-cells & Natural killer cell)	30%	Bone marrow thymus gland & lymphoid tissues.	weeks to months according to its type.	Round	Small or Large	

Type of WBCs		Function of WBCs
<p><b>Granular</b></p> <p>They're called <b>granulocytes</b></p> <ul style="list-style-type: none"> <li>-they constitute 70-75% of WBCs .</li> <li>-They have cytoplasmic granules .</li> <li>- Polymorphonuclear .</li> <li>- They contain Small granules of both <b>acidic</b> and <b>basic</b> .</li> </ul>	<p><b>Neutrophil</b></p>	<p><b>Neutrophils</b> has the ability of engulfing bacteria or organism by a process of <b>phagocytosis</b> .</p> <ul style="list-style-type: none"> <li>-They constitute the <b>first line of defence</b> against bacterial infection .</li> <li>- Very important at "clearing" bacterial infections .</li> </ul>
	<p><b>Eosinophil</b></p>	<ul style="list-style-type: none"> <li>-attach themselves and <b>kill the parasites</b> by releasing substances as (hydrolytic enzymes, superoxide)</li> <li>-<b>Phagocytosis</b> (weak)</li> </ul> <p>High eosinophils count in:</p> <ol style="list-style-type: none"> <li>1. Allergic (asthma, rhinitis, drug reaction)</li> <li>2. Parasitic (hookworm, ascaris, bilharzia)</li> </ol>
	<p><b>Basophil</b></p>	<ul style="list-style-type: none"> <li>-secrete <b>heparin</b> (prevent clotting)</li> </ul> <p>Secrete <b>histamine, bradykinin &amp; serotonin</b> ( contribute to inflammation respond), The release of those substances cause local and vascular reactions characteristic of allergic manifestation.</p> <ul style="list-style-type: none"> <li>-Mast cells which are found in the C.T are full of basophils.</li> </ul>
<p><b>Agranular</b></p>	<p><b>Monocytes/ Macrophages</b></p> <p>( <u>Monocyte is a young macrophage in the blood</u> )</p>	<ul style="list-style-type: none"> <li>-<b>Macrophages</b> are a <u>powerful phagocytic cells</u>; first line of defense.</li> <li>- Ingest up to 100 bacteria, and larger particles as: old RBC (<b>Phagocytosis</b>)</li> <li>- Remove wastes (<b>scavenger</b>)</li> <li>-<b>anti-inflammatory</b>:</li> <li>1-directly <b>phagocytosis</b> of bacteria, dead cells.</li> <li>2- Indirectly <b>cooperating with lymphocytes</b> by recognizing foreign body (take in foreign body process it and present it to lymphocytes)</li> </ul>
	<p><b>Lymphocyte</b></p>	<p><b>T-lymphocytes:</b></p> <ol style="list-style-type: none"> <li>1-cellular (<b>cell-mediated</b>) immunity (graft rejection, delayed hypersensitivity )</li> <li>2-Antibody secretion</li> </ol> <p><b>B-lymphocytes:</b></p> <ol style="list-style-type: none"> <li>1-Humoral immunity</li> <li>2- Antibodies secretion(plasma cell)</li> </ol> <p><b>Natural killer cell NK:</b> Also called Non B Non T lymphocyte. Is a part of the non specific immune system.</p>

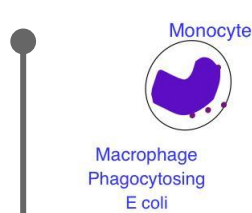
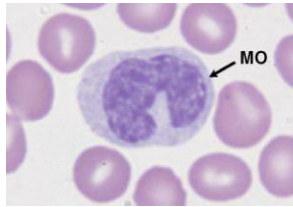


More details next slide 

# Monocytes/Macrophages

Formed in the bone marrow: stem cell → monoblast  
→ promonocyte → mature monocyte released into blood.

There are tissue-specific macrophages ; fixed Macrophages  
(monocyte-macrophage system or reticuloendothelial system)



- Alveolar macrophage
- Peritoneal macrophage
- Kupffer cells in liver sinuses
- Osteoclasts in bone
- Microglial cells in brain
- Histiocytes in skin and subcutaneous tissue
- Mesangial cells in the kidneys
- Few specialized endothelial cells in the bone marrow, spleen and lymph nodes

Found only in male slides

## Macrophage and Neutrophil Responses During Inflammation

### 1st line of defense

Tissue macrophages, barriers and complement system (circulating molecules).

### 2nd line of defense

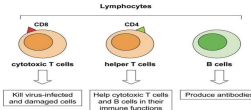
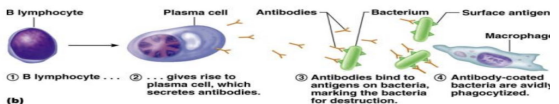
Neutrophil invasion of the inflamed area.

### 3rd line of defense

–Monocytes–macrophage invasion of inflamed area.

### 4th line of defense

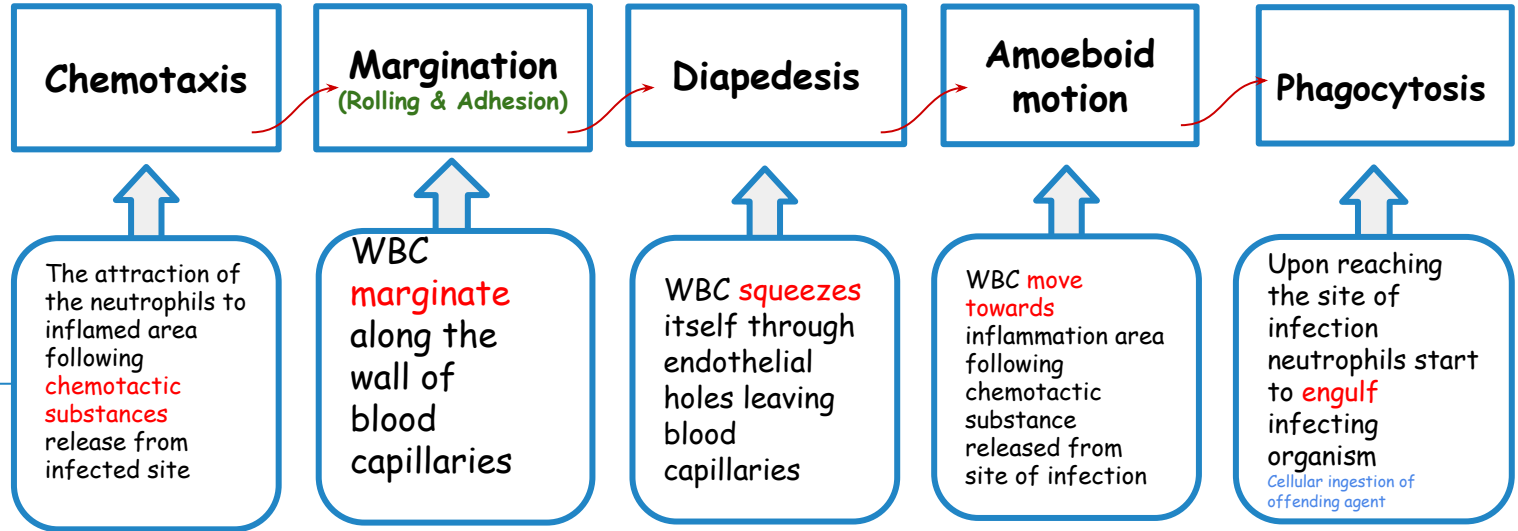
Increased production of granulocytes and monocytes by the bone marrow.

	T lymphocytes	B lymphocytes
<b>Formation</b>	<ul style="list-style-type: none"> <li>bone marrow or lymphoid tissue (Circulate between blood,tissue,lymph).</li> <li>Migrate to thymus for maturation.</li> </ul>	<ul style="list-style-type: none"> <li>bone marrow, germinal layer of lymph node, rep pulp of spleen</li> <li>preprocessed in the liver during mid-fetal life and in the bone marrow in late fetal life and after birth</li> </ul>
<b>Thymus</b>	<ul style="list-style-type: none"> <li>Thymus dependant , first migrate to and are preprocessed in the thymus gland.</li> </ul>	<ul style="list-style-type: none"> <li>Thymus independent , are preprocessed in the liver during mid-fetal life and in the bone marrow.</li> </ul>
<b>Life span</b> <small>Found only in female slides</small>	<ul style="list-style-type: none"> <li>100-300 days</li> </ul>	<ul style="list-style-type: none"> <li>2-7 days</li> </ul>
<b>Functions</b>	<ul style="list-style-type: none"> <li>cellular (cell-mediated) immunity (graft rejection,delayed hypersensitivity )</li> <li>Role in Antibody secretion</li> </ul>	<ul style="list-style-type: none"> <li>Humoral immunity</li> <li>Antibodies secretion by (plasma cell)</li> </ul>
<b>Types</b>	<ul style="list-style-type: none"> <li>Cytotoxic T cells (Tc) or killer cell (Tk)</li> <li>Helper T cell (Th)</li> <li>Memory T cells subtypes</li> <li>Suppressor T cells subtypes</li> <li>the remainder few are mainly regulatory</li> </ul> 	<ul style="list-style-type: none"> <li>There are no types but when stimulated by an antigen it is</li> </ul> 

## Steps of phagocytosis:

### Defence properties of neutrophils and macrophages:

When triggered by a bacterial invasion as an inflammatory response

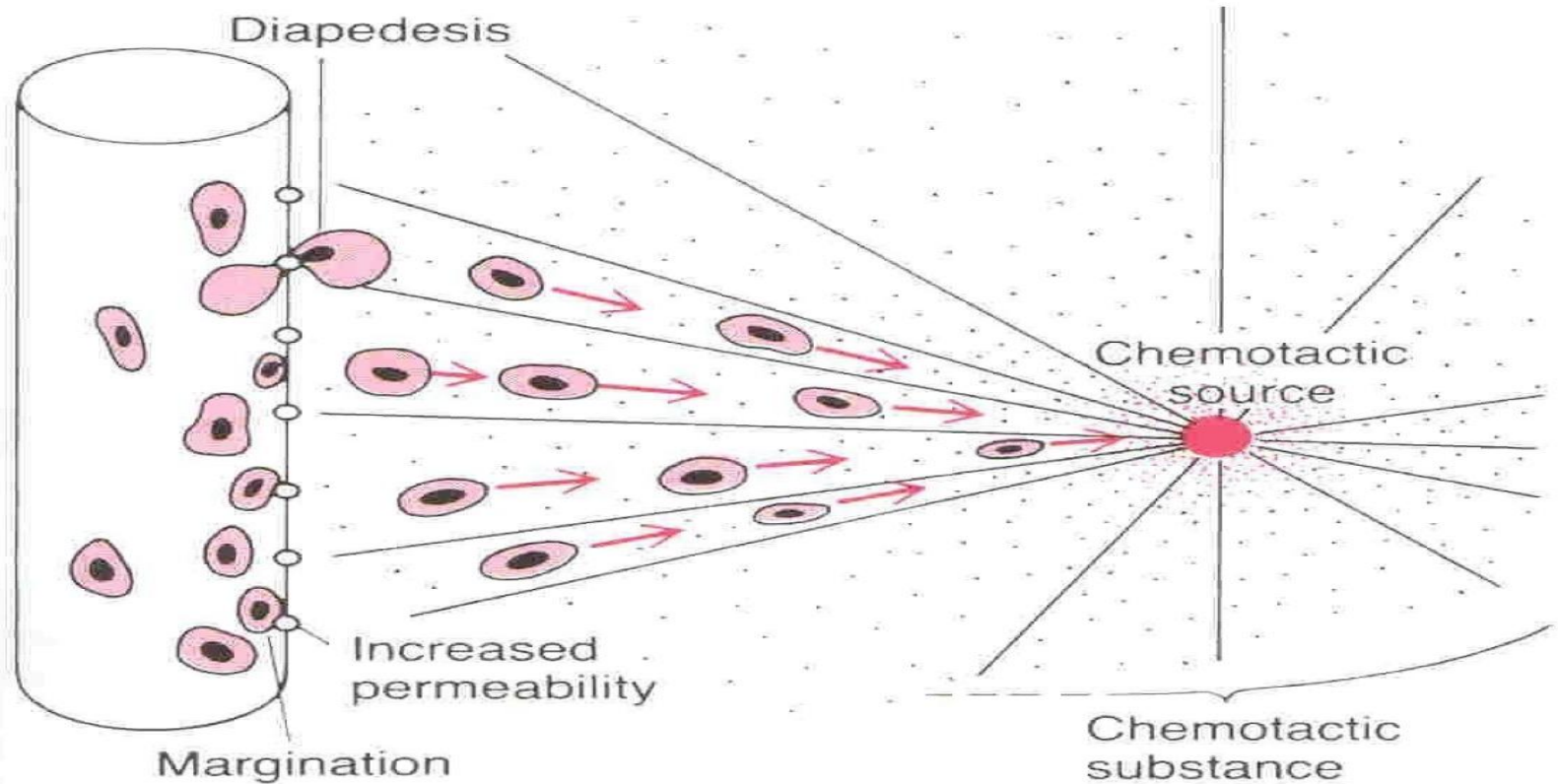


#### Chemotactic substances:

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



# Chemotaxis, Margination & Diapedesis



# Phagocytosis:

Selective process: foreign substance recognize by:

1. Rough surface
2. No protective protein coat, which prevents phagocytosis
3. Marked by certain substance e.g Complement 3 (C3) or antibodies making them ready for killing a process known as **opsonization** (it's like name tagging)

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

## Opsonization:

Some plasma factors act on the bacteria to make them "tasty" to the phagocytes (opsonization). The principal opsonins that coat the bacteria are immunoglobulins of a particular class (IgG) and complement proteins.

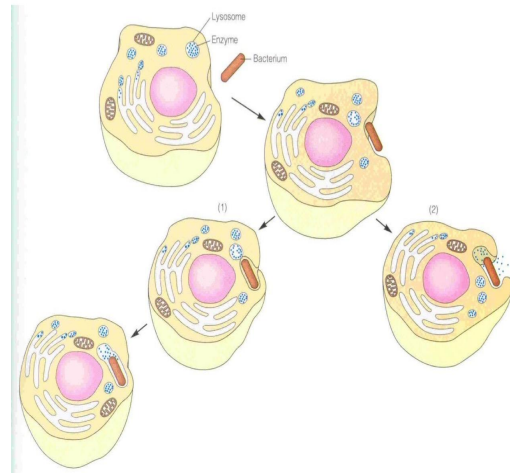
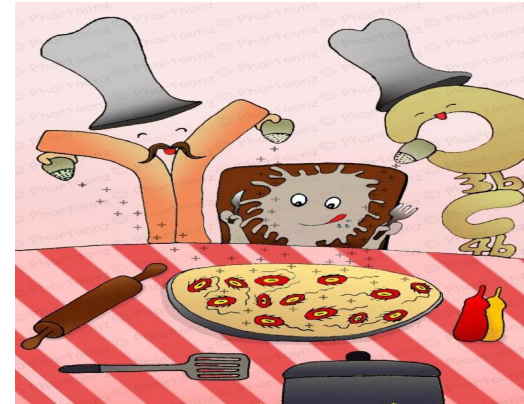


Figure 15.2

Phagocytosis by a neutrophil or macrophage. A phagocytic cell extends its pseudopodia around the object to be engulfed (such as a bacterium). (Blue dots represent lysosomal enzymes.) (1) If the pseudopodia 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 pseudopodia is complete, lysosomal enzymes are released into the infected area of tissue.



# Microbial killing:

- Digestion of organism inside the phagosome

Mechanism :

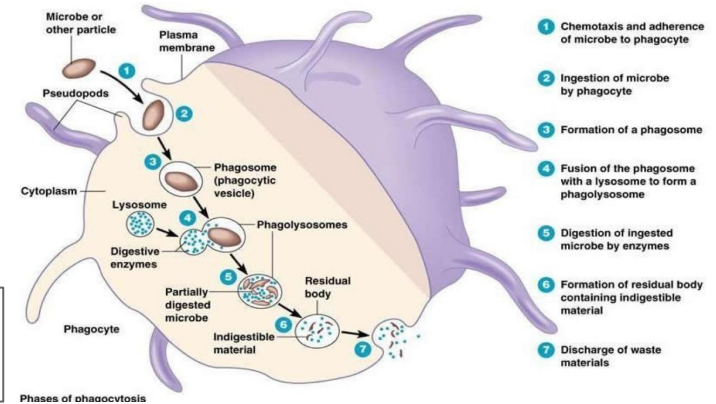
Fusion of intracellular lysosomes with phagosome vacuole

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

And, Or

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

## Microbial killing



# Reticuloendothelial system:

## **Consist of:**

- Monocytes
- Macrophages
- Endothelial cells:  
(bone marrow, spleen,  
lymph nodes)

## **Location:**

-In all tissues especially:

- 1- Skin (histiocytes)
- 2- Liver (kupffer)
- 3- Spleen
- 4- Bone marrow
- 5- Lymph nodes
- 6- Lungs

## **Functions:**

- Phagocytosis
- Break down Hb
- Storage of iron
- Immune function:  
processing antigen &  
antibodies  
production(indirect)

## Major organs

### Primary Lymphoid Organs

Bone marrow

Thymus

### Secondary (or peripheral) Lymph organs

tonsils

adenoids

spleen

Lymph nodes

Lymphatic vessels

appendix

peyer's patches

# Types of Immunity

## Immune system

### Innate (non-specific; natural) immunity

1. Second line of defense
2. Is present at birth
3. Persists throughout life
4. Can be mobilized rapidly and act quickly
5. Attacks all antigens fairly equally

Extra : Cellular Elements of the Innate Immune System Lymphocytes - T and B cells Make up 20-40% of circulating leukocytes

### Adaptive (specific; acquired) immunity

1. Third line of defense.
2. Antigen specificity. It is activated by thousands of diverse antigens.
3. Responds with the proliferation of cells and the generation of antibodies.
4. Responds slowly, being fully activated about 4 days after the immunologic threat.
5. Exhibits immunologic memory, so that repeated exposure to the same infectious agent results in improved resistance against it.

## Immune System

learned specific immunity

Antibodies  
Lymphocytes:  
T-cells  
B-cells

3<sup>rd</sup> line of defence

innate non-specific immunity

Phagocytes  
(natural killer cells,  
granulocytes, macrophages)

2<sup>nd</sup> line of defence

skin, mucous membranes, enzymes,  
natural microbial flora, complement proteins

1<sup>st</sup> line of defence

# Complement system

## Characteristics

The first part of the immune system that meets invaders such as bacteria

It is a group of proteins.

These proteins flow freely in the blood and can quickly reach the site of an invasion where they can **react directly with antigens** ( molecules that the body recognizes as foreign substances).

## Functions of complement proteins ( When activated ):

Trigger inflammation.

Attract eater cells such as macrophages to the area.

Coat intruders so that eater cells are more likely to devour (swallow and eat) them (a process called as opsonization).

Kill intruders.

# Leukocytosis

-In male slides.

- In the table we only talk about pathological Leukocytosis.

Leukocytosis is Increased number of WBC.

## Pathological:

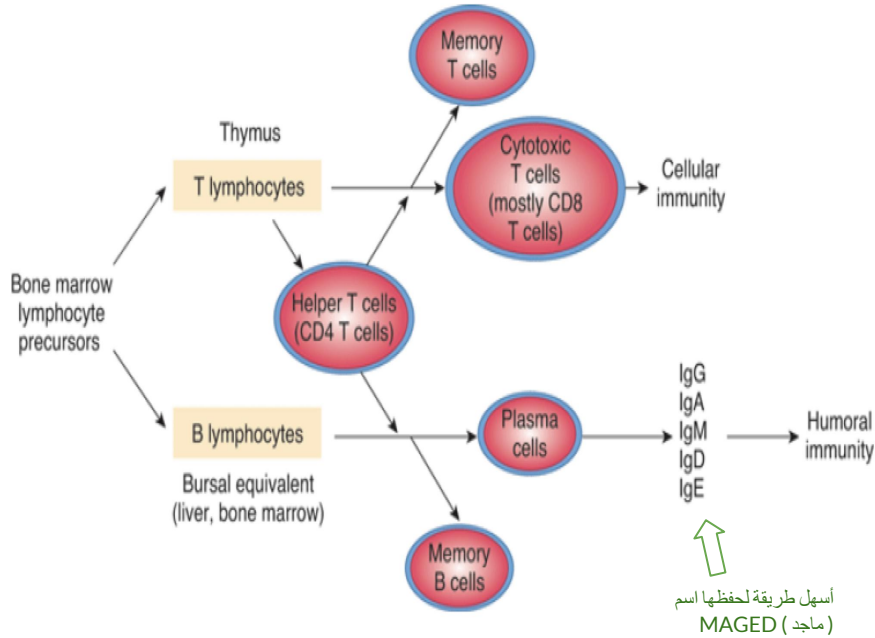
- Bacterial infection (tonsillitis, Appendicitis)
- Worm infection.
- Allergic reaction.

## Physiological:

- Diurnal morning ↓ evening ↑
- After physical exercise
- Stress or Adrenaline injection

Condition	Definition	Causes
Neutrophilia	An increase in the number of neutrophils	<ul style="list-style-type: none"> <li>❑ Infections: of all types as acute or chronic, bacterial, viral or fungal.</li> <li>❑ Inflammation as rheumatic fever</li> <li>❑ Tissue damage as trauma, burn</li> <li>❑ Malignant tumors</li> <li>❑ Smoking.</li> </ul>
Eosinophilia	an increase in the number of eosinophils	<ul style="list-style-type: none"> <li>❑ Allergic conditions as asthma, hay fever, skin allergy</li> <li>❑ Parasitic infection</li> <li>❑ Leukemia</li> </ul>
Basophilia	an increase in the number of basophils	<ul style="list-style-type: none"> <li>❑ Allergic conditions as asthma, hay fever, skin allergy</li> <li>❑ Leukemia</li> </ul>
Monocytosis	an increase in the number of monocytes	<ul style="list-style-type: none"> <li>❑ Chronic infection as in tuberculosis</li> <li>❑ Leukemia</li> </ul>
Lymphocytosis	an increase in the number of lymphocytes	<ul style="list-style-type: none"> <li>❑ Chronic bacterial and viral infections</li> <li>❑ Leukemia</li> </ul>

## Types of T-cells & B-cells



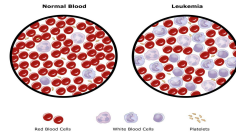
## Types of CD ( Cluster of differentiation )

	<u>CD4 cells *</u>	<u>CD8 cells</u>
<u>Number</u>	Most numerous	Less numerous
<u>Called</u>	T helper cells ( Th1 & Th2)	Cytotoxic cells
<u>Function</u>	<ol style="list-style-type: none"> <li>1) Stimulate other cells in the immune system.</li> <li>2) Major regulator of all immune functions</li> </ol>	<ol style="list-style-type: none"> <li>1) Directly attack cells.</li> <li>2) Defense against malignant and virus infected cells.</li> <li>3) Tissue transplant rejection.</li> </ol>
<u>Recognize Antigens</u>	accompanied to MHC II	Accompanied to MHC I
<u>Secretes</u>	Interleukins, Interferone	Perforins

- CD = Cluster of differentiation
- MHC = Major histocompatibility complex



# Leukemia



-Leukemia is a malignant disease of bone marrow causing marked increase in WBCs may reach  $m500.000/mm^3$ . -WBC more than 50,000

-Leukemia is associated with anemia and bleeding tendency ( due to decrease in bone marrow area responsible for RBCs and platelet synthesis respectively).

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

## Types of leukaemia:

- Myeloblast leukaemia → myeloid cells
- Lymphoblast leukaemia → lymphocytic cells

1-Acute or chronic onset

2-Accompanied with anaemia, bleeding

# Leukopenia

Leukopenia is Deficiency of the white blood cells.

**Causes:** malnutrition, typhoid fever, drugs B12 & folic acid ↓, radiation.

-Leukopenia (leucopenia) means a decrease in the total leucocyte count below  $4.000/mm^3$ .

-In this condition the body is not protected against infections and death may occur.

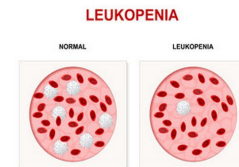
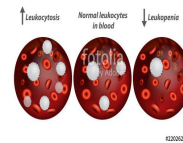
**It is caused by:**

1-Bone marrow depression by radiation, drugs, and cancer chemotherapy.

2-Some bacterial infections as typhoid fever, brucellosis.

3-Some viral infections as AIDS, influenza, hepatitis.

4- Decreased B12 and folic acid and malnutrition



# QUIZ!

## MCQs

Q1: Life span of granulocytes is :

A) Weeks to months

B) 10 - 20 hours

C) 4 - 8 hours

D) Month

Q2: the attraction of neutrophils to inflamed area is :

A) Margination

B) ameoboid movement

C) Diapedesis

D) Chemotaxis

Q3: type of WBC has 2 lobe nucleus

A) Neutrophil

B) Eosinophil

C) basophil

D) lymphocytes

Q4 :Which of the following is a Function Reticuloendothelial system:

A) Break down Hb

B) Secrete Heparin

C) Granular

D) Secrete Histamine

## SAQ

Q1: Leukocytosis is Increased number of WBCs by 2 ways .

Q2: Functions of complement proteins ( When activated ) .

MCQs key answer :  
1) C  
2) D  
3) B  
4) A

SAQ answer key :  
1) 1 - Physiological  
2) 2 - Pathological  
1) 1. Trigger inflammation.  
2. Attract eater cells such as macrophages to the area. And others ..

# Thank You

## Team members:

- ▷ أحمد الخياط
- ▷ ماجد العسكر
- ▷ مشعل الثنيان
- ▷ عبد العزيز الربيعة
- ▷ باسل فقيها
- ▷ محمد بيارى
- ▷ محمد السلطان
- ▷ عبد الرحمن الدويش
- ▷ مرشد الحربي
- ▷ منيب الخطيب
- ▷ **نايف الشهري**
- ▷ **ليصل العمري**
- ▷ عبد العزيز الغليقة
- ▷ عبد العزيز السحيم

- ▷ حصة العليان
- ▷ شذى الظهير
- ▷ سمو الزير
- ▷ **بورا الشثري**
- ▷ سارة القحطاني
- ▷ ريناد الحميدي
- ▷ ياسمين القرني
- ▷ **يارا الزهراني**
- ▷ لمى الأحمدى
- ▷ آلاء السلمي
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