

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



4 - White blood cells (WBCs)

Objectives;

Intended learning outcomes (ILOs)

After reviewing the PowerPoint presentation and the associated learning resources, the student should be able to:

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.

Leucocytes are the mobile units of the body's protective system.

Count: 4,000-11,000 WBC's/mm³ blood.

Mechanisms of action: Phagocytosis and formation of antibodies and sensitized lymphocytes.

Erythrocytes	Leukocytes					Platelets
	Polymorphonuclear granulocytes			Monocytes	Lymphocytes	
	Neutrophils	Eosinophils	Basophils			
						

Classification of White Blood Cells (WBCs)

Granulocytes

- Polymorphonuclear leukocytes (PMNs; because of multiple nuclei)
 - Neutrophils (10-16 μm , 2-5 lobes of Nucleus)
 - Eosinophils (12-18 μm , bilobed, coarse red granules)
 - Basophils (10-14 μm , rarely segmented nucleus hidden by large round bluish granules)

Agranulocytes

- Lymphocytes(Round Nucleus, Small [5-8 μm] & large [9-15 μm])
 - T lymphocyte
 - B lymphocyte
 - Natural killer cells (NKC's)
- Monocytes (15-20 μm , Kidney shaped nucleus). The monocytes make macrophage system

Granulocytes



Neutrophil



Eosinophil

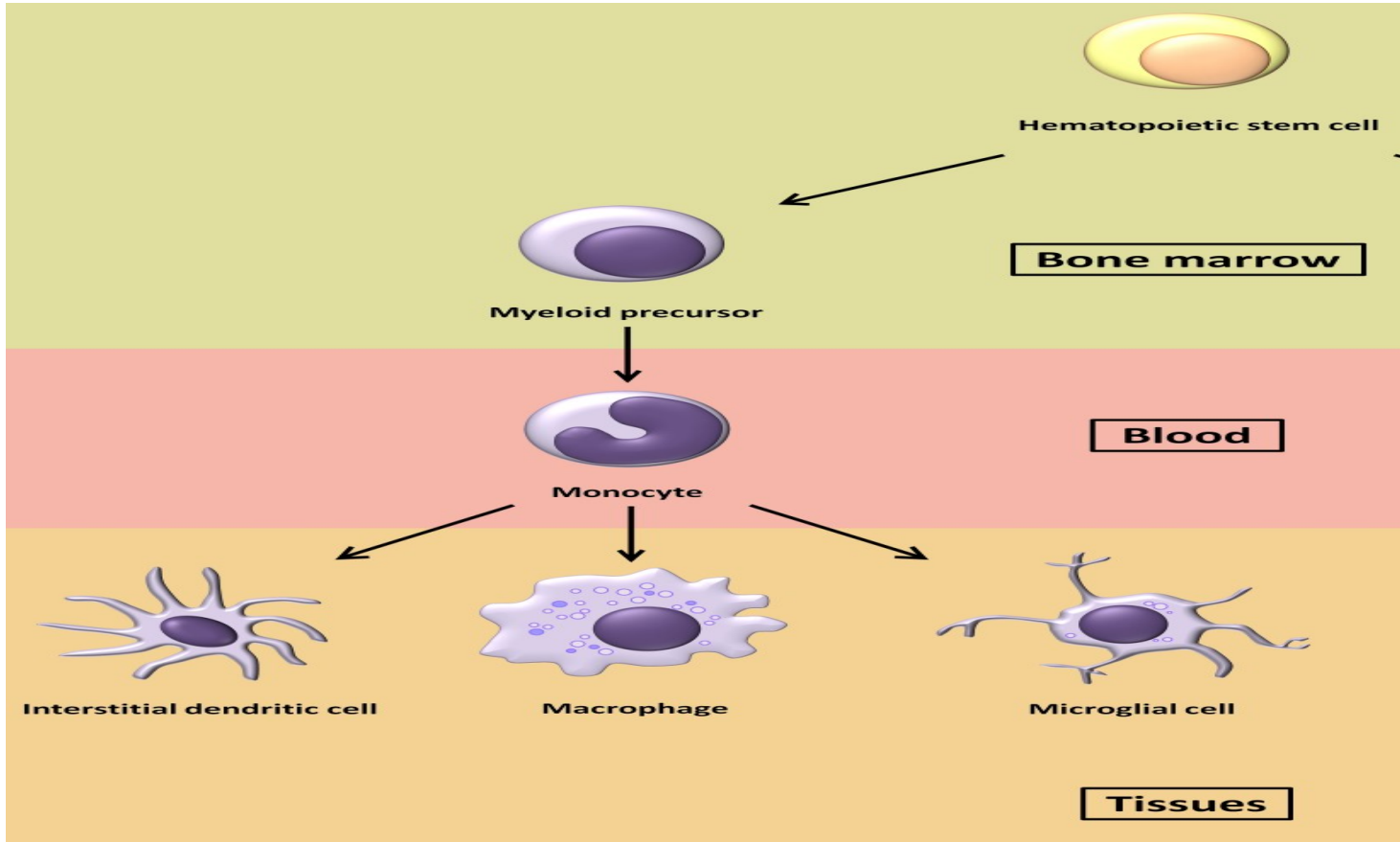


Basophil

WBCs Concentrations (Normal Counts) and Life Span

Life Span	Percentage of Total WBCs	Approximate Normal Range ($/\mu\text{L}$)	Cells
		4000 - 11000	Total WBCs
4 – 8 hours in blood and 4 – 5 days in tissues where they are needed	60 –70% (62%)	3000 - 6000	Neutrophils
	1 – 4% (2.3%)	150 - 300	Eosinophils
	0.4% (0.4%)	0 - 100	Basophils
Weeks - months	20 – 40% (30%)	1500 - 4000	Lymphocytes
10 - 20 hours in blood before getting into the tissues where they	2 – 8% (5.3%)	300 - 600	Monocytes (Macrophages)

Monocytes-macrophage system



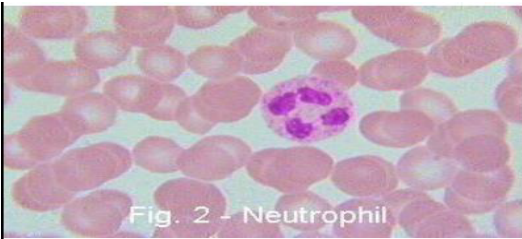


Fig. 2 - Neutrophil

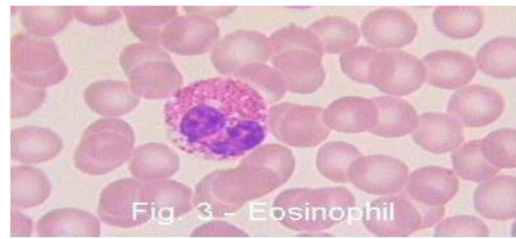


Fig. 3 - Eosinophil

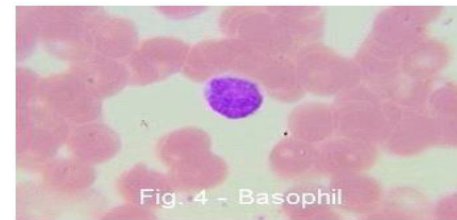


Fig. 4 - Basophil

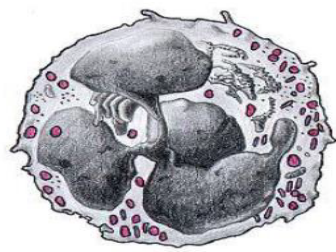


Fig. 8 - Neutrophil

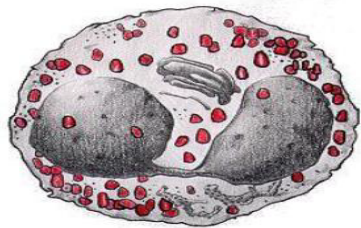


Fig. 9 - Eosinophil

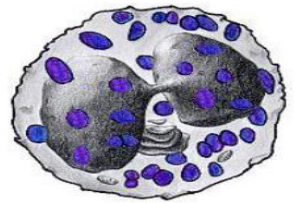


fig. 10 - Basophil



Fig. 6 - Monocyte

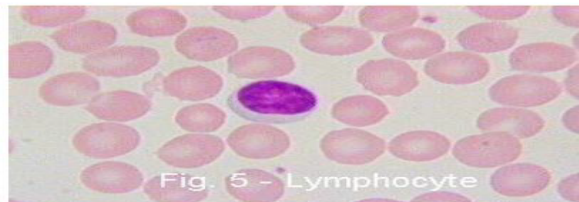


Fig. 5 - Lymphocyte

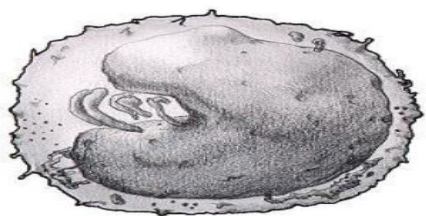


Fig. 12 - Monocyte

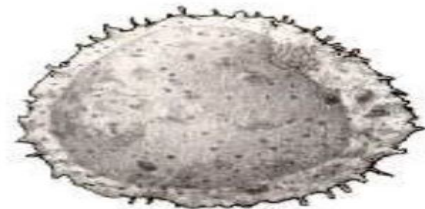
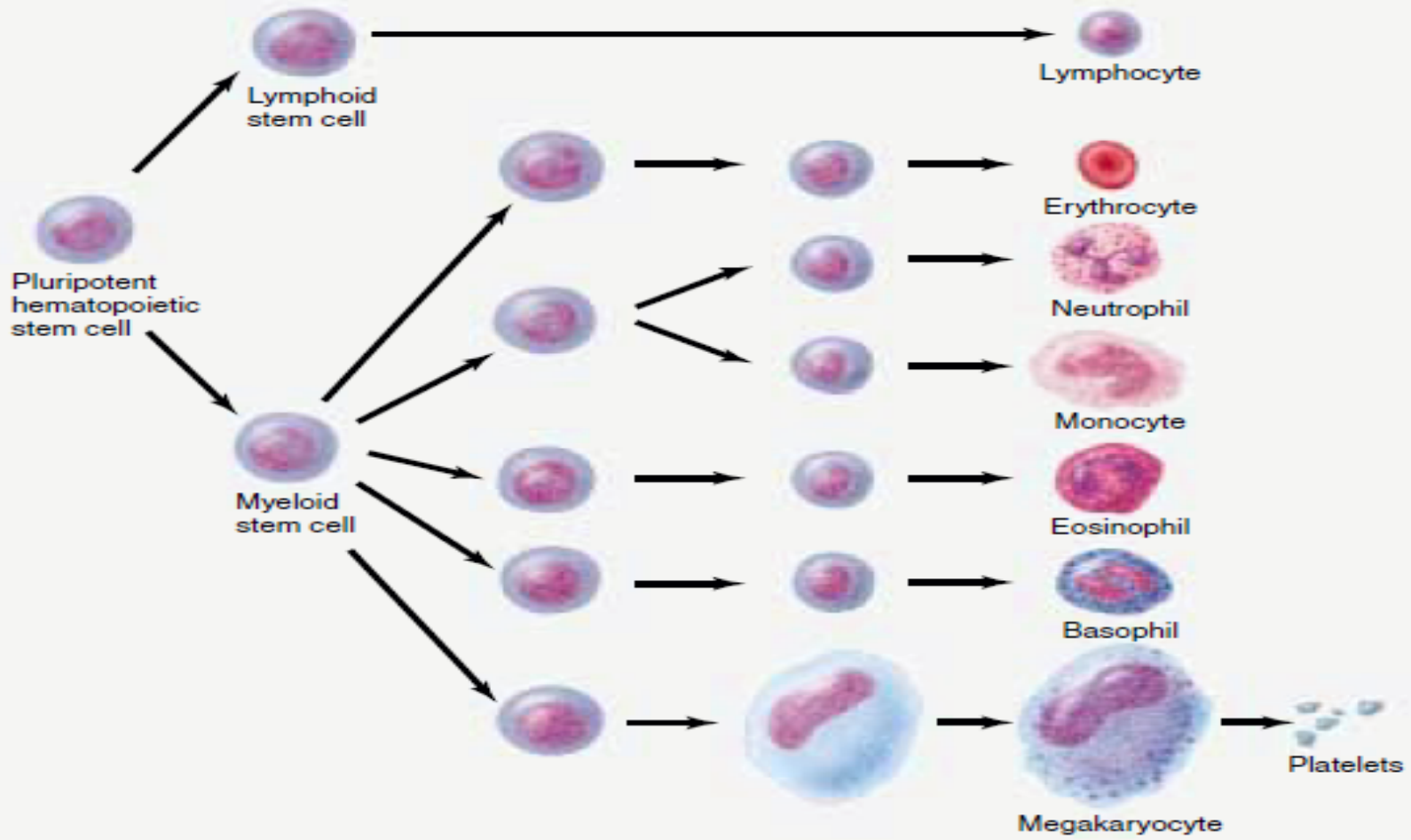
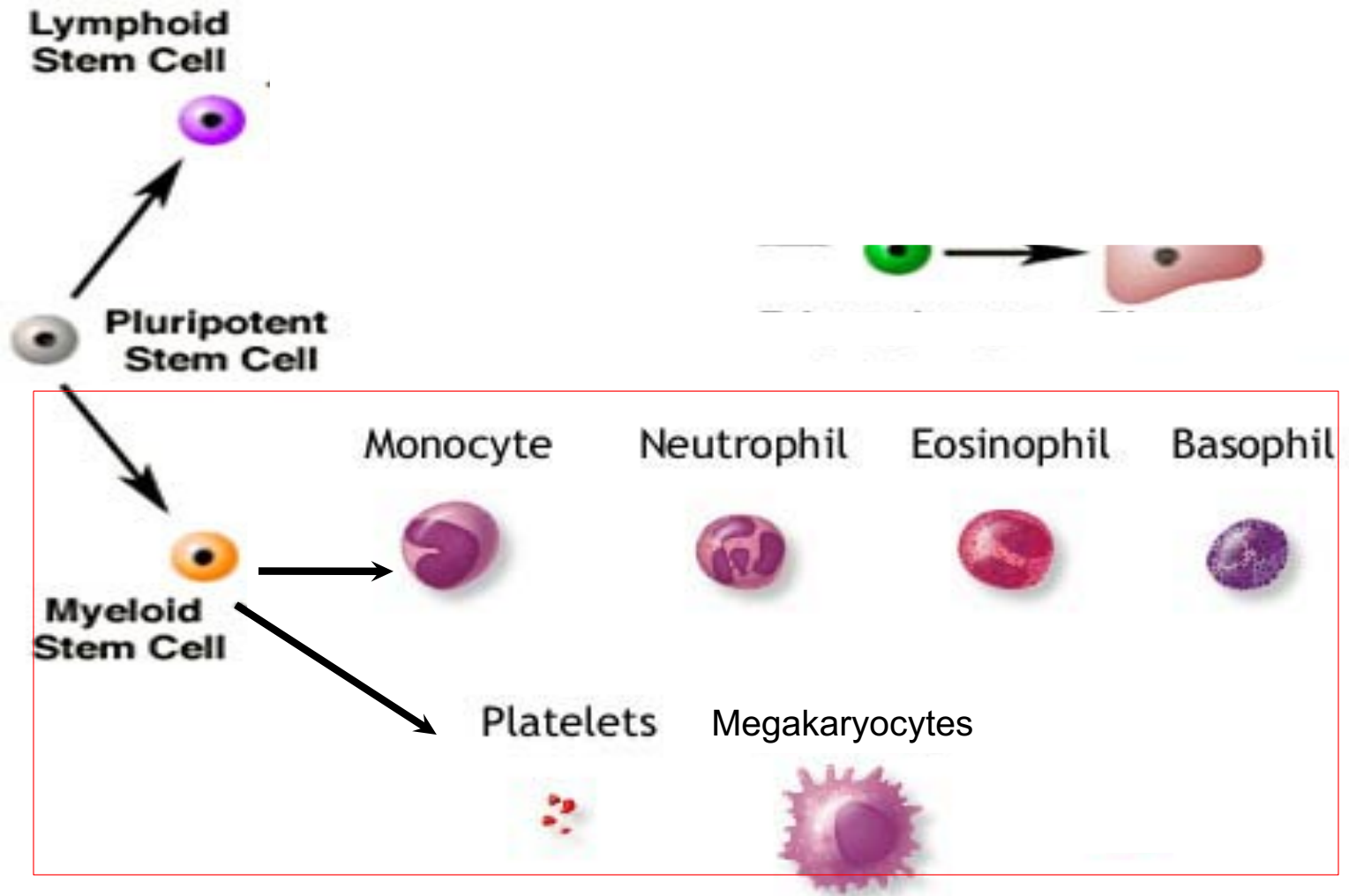


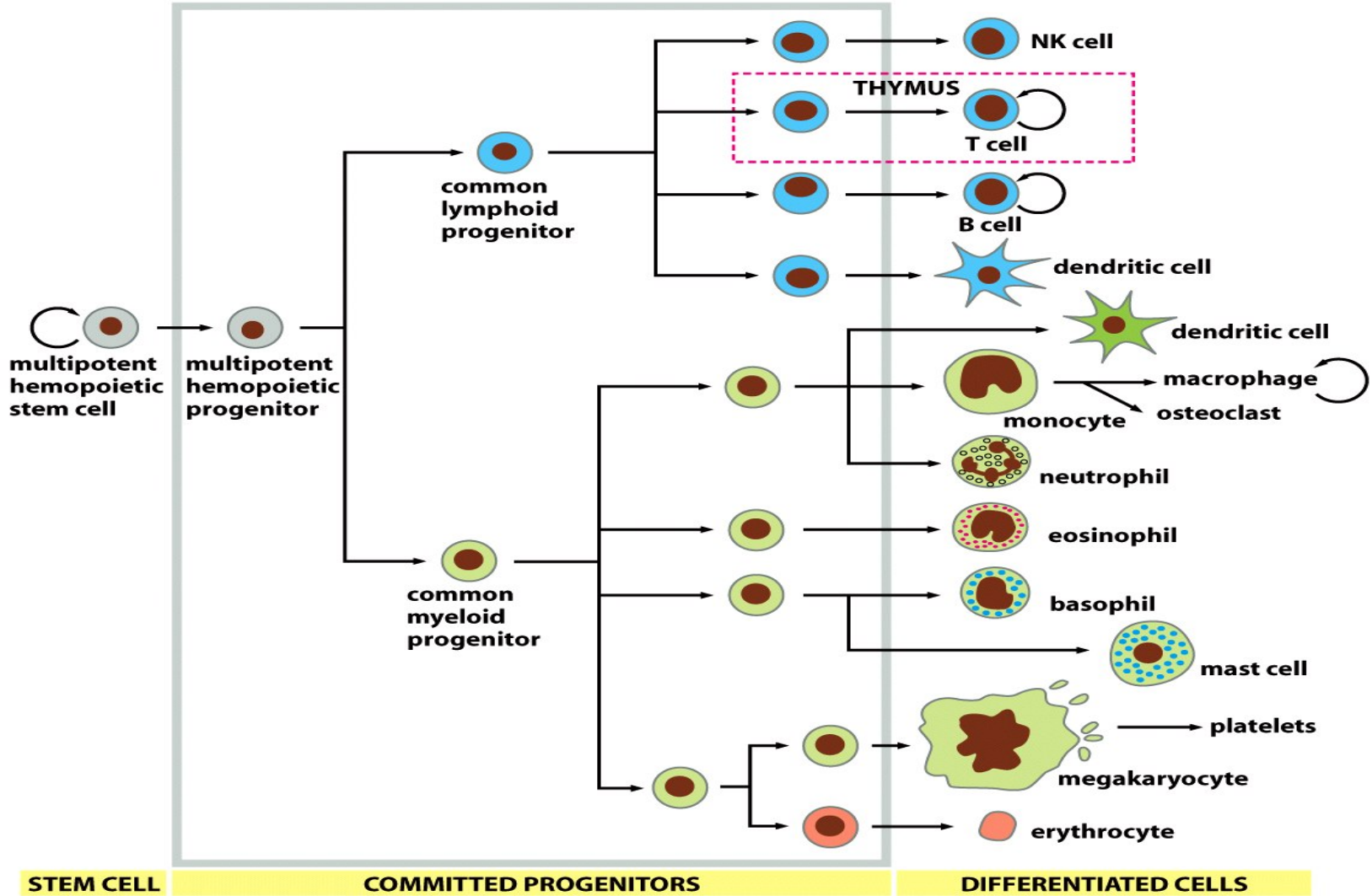
Fig. 11 - Lymphocyte

Leukopoiesis





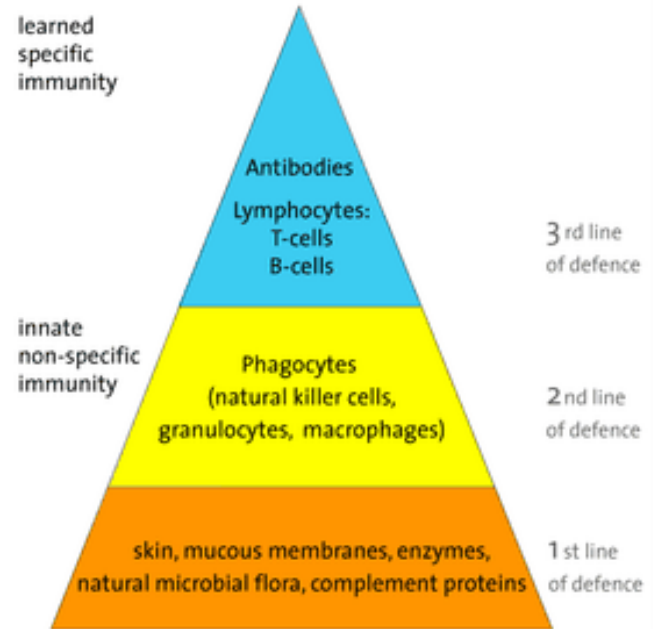
Cells of the Immune System



Immune System

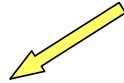
- The immune system is a system of barriers, cells, tissues and organs that work to fight invaders.
- Another important component of the immune system is the complement system. Which is system composed of a group of circulating proteins with multiple immune functions.
- The major functions of the immune system are:
 - Differentiate self from non-self.
 - Eliminate foreign substances, cells and pathogens.

Immune System



Types of Immunity

Immune system



Innate (non-specific; natural) immunity

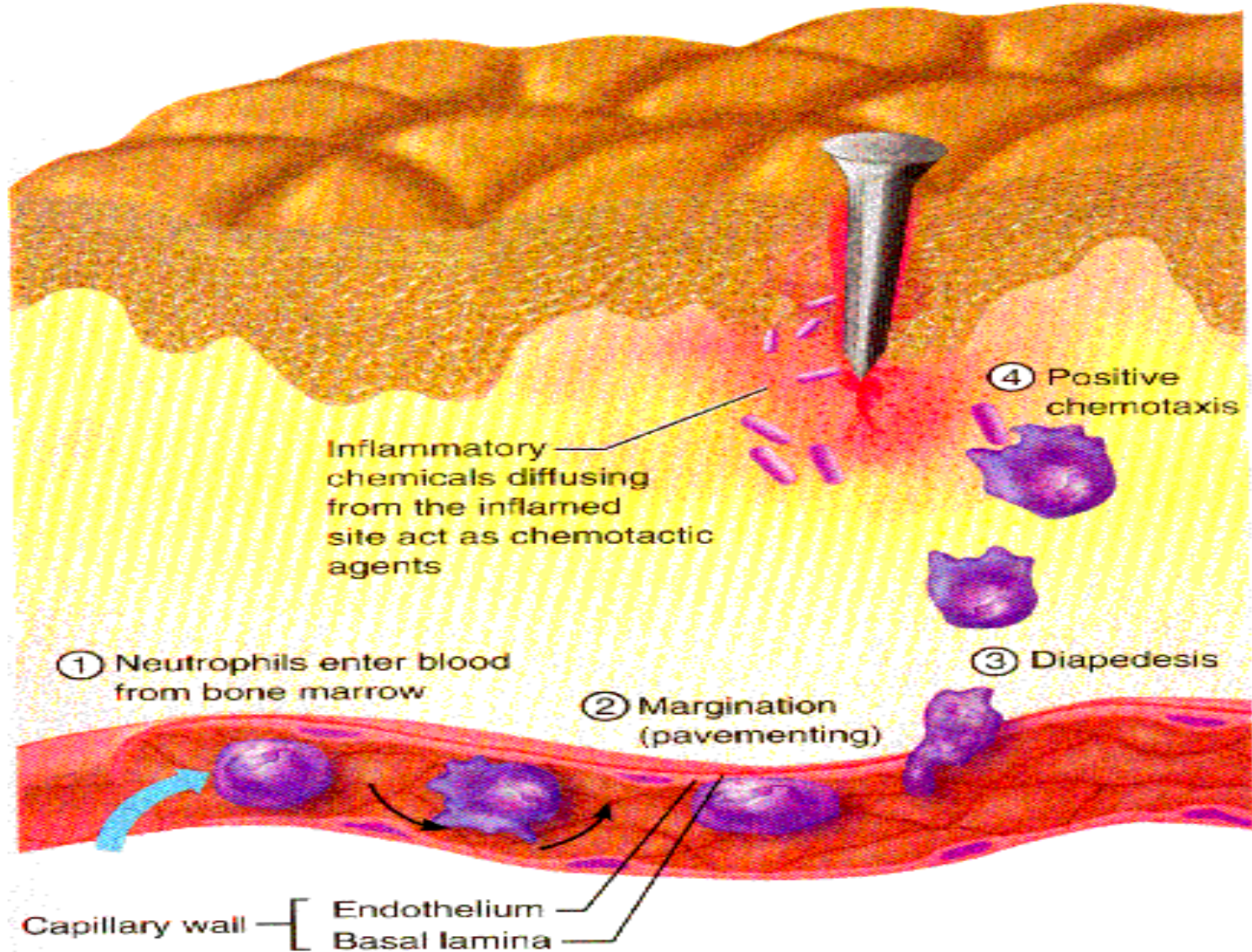
- ❑ Second line of defense
- ❑ Is present at birth
- ❑ Persists throughout life
- ❑ Can be mobilized rapidly and act quickly
- ❑ Attacks all antigens fairly equally

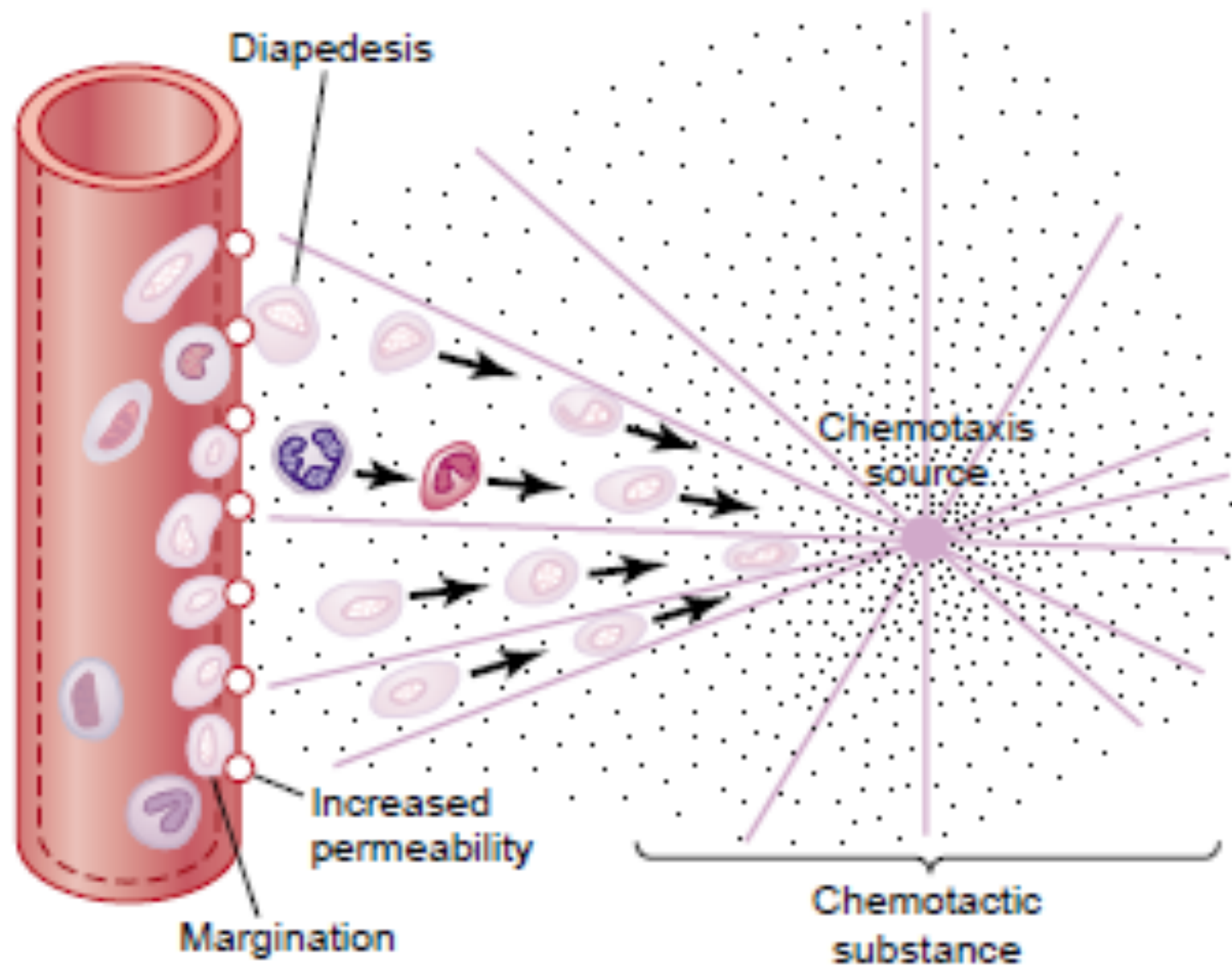
Adaptive (specific; acquired) immunity

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

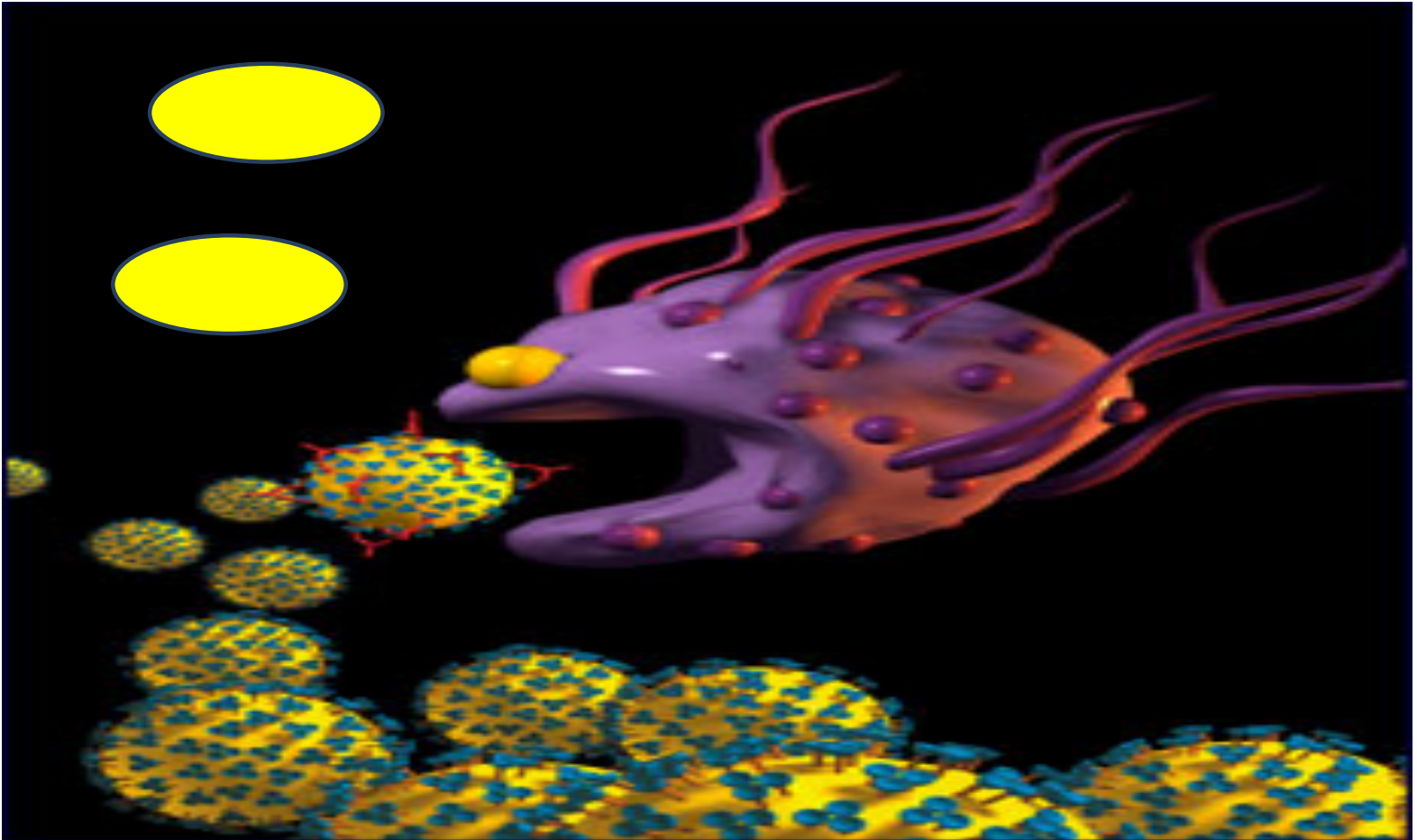
Inflammatory (immune) response







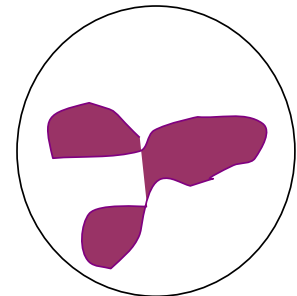
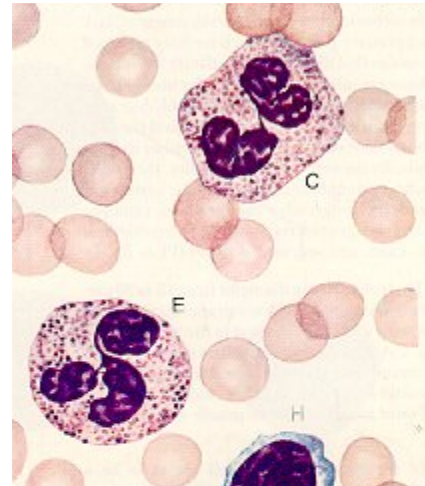
Why these bacteria look tasty?!





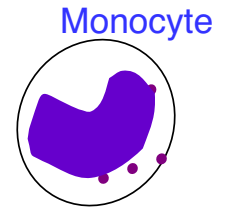
- ❑ Granulocyte
 - They constitute 60-75% of WBCs.
 - They have cytoplasmic granules.
- ❑ Polymorphonuclear.
- ❑ They contain small granules of both acidic and basic.
- ❑ They are phagocytic cells (Phagocytosis); Microphages.
- ❑ They constitute the first line of defence against bacterial infection.
- ❑ Very important at “clearing” bacterial infections.

Neutrophils

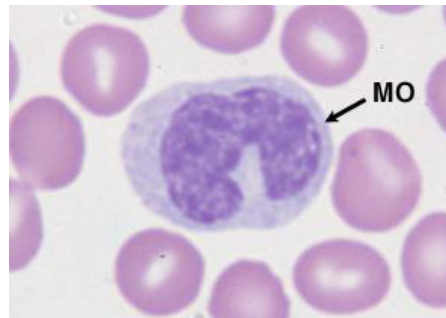


Monocytes/Macrophage

- Monocyte is a young macrophage in the blood.
- They are formed in the bone marrow: stem cell → monoblast → promonocyte → mature monocyte released into blood.
- Monocytes which leave the blood stream turn into macrophages.
- Monocytes contain agranular cytoplasm but when they enter the tissues and converted into macrophages, they swell and their cytoplasm become filled by large number of lysosomes and then they are called macrophages.
- The monocytes are big eaters
 - 15-20 μm
 - active cells 60-80 μm .
 - They have longer lifespan than neutrophils.



Macrophage
Phagocytosing
E coli

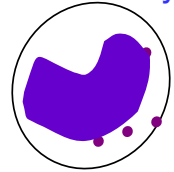


- Functions of monocytes/macrophages:
 - **Phagocytosis** and killing of microorganisms. They are more Efficient than Neutrophils (100 bacteria vs 3-20 by Neutrphil, larger particles like old RBCs & malarial parasites).

- There are tissue-specific macrophages; fixed macrophages (monocyte-macrophage system; reticulo-endothelial system)
 - Alveolar macrophage
 - Peritoneal macrophage
 - Kupfer cells in liver sinuses
 - Osteoclasts in bone
 - Microglial cells in brain
 - Histiocytes in skin and subcutaneous tissue
 - Mesengial cells in the kidneys
 - Few specialized endothelial cells in the bone marrow, spleen and lymph nodes

Monocytes/ Macrophage

Monocyte



Macrophage
Phagocytosing
E coli

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.

Defensive Properties of Neutrophils and Macrophages

Invasion of the body by bacteria triggers the inflammatory response.

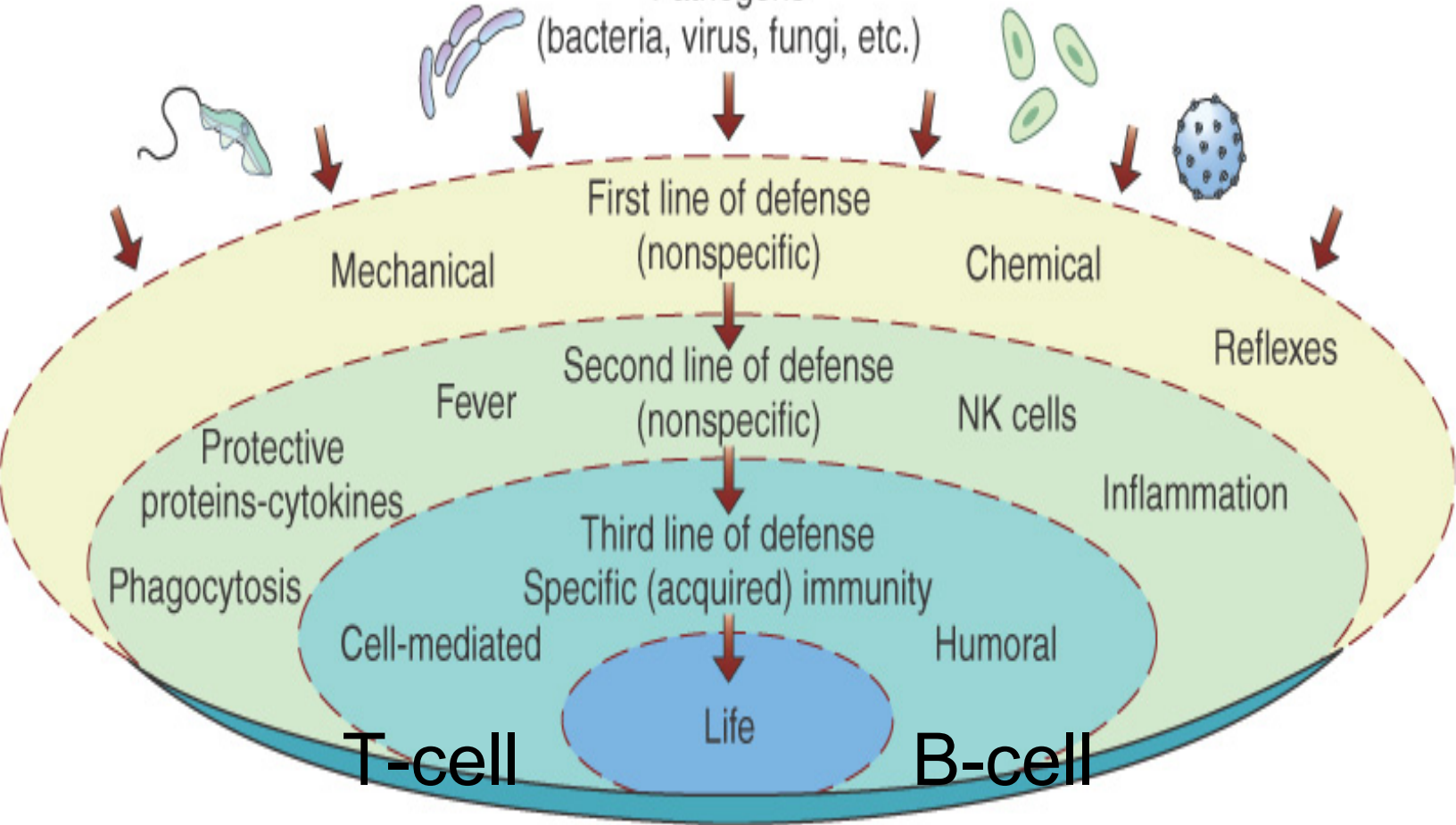
- **Margination:** The Neutrophils and monocytes aggregate and stick along the walls of blood capillary.
- **Chemotaxis:** Many different chemical substances in the tissues cause neutrophils and monocytes to move toward the source of the chemical. This phenomenon is known as chemotaxis.. The chemotactic agents include a component of the complement system (C5a); leukotrienes; and polypeptides from lymphocytes, mast cells, and basophils.
- **Diapedesis:** Neutrophils and monocytes can squeeze through the pores of the blood capillaries by diapedesis. To enter the tissue spaces
- **Ameboid movement:** Both neutrophils and macrophages can move through the tissues by ameboid motion.
- **Phagocytosis:** The most important function of the neutrophils and macrophages is phagocytosis, which means cellular ingestion of the offending agent.
- **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.





IMMUNE RESPONSE

Pathogens
(bacteria, virus, fungi, etc.)



Cellular Elements of the Innate Immune System

Lymphocytes – T and B cells

- Make up 20–40% of circulating leukocytes

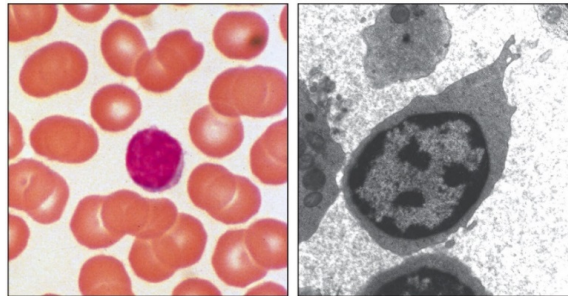


Figure 1-5 Immunobiology, 6/e. (© Garland Science 2005)

3 Classes of circulating Lymphocytes

- T cells: thymus-dependent
- B cells: thymus-independent

Lymphocytes – T and B cells

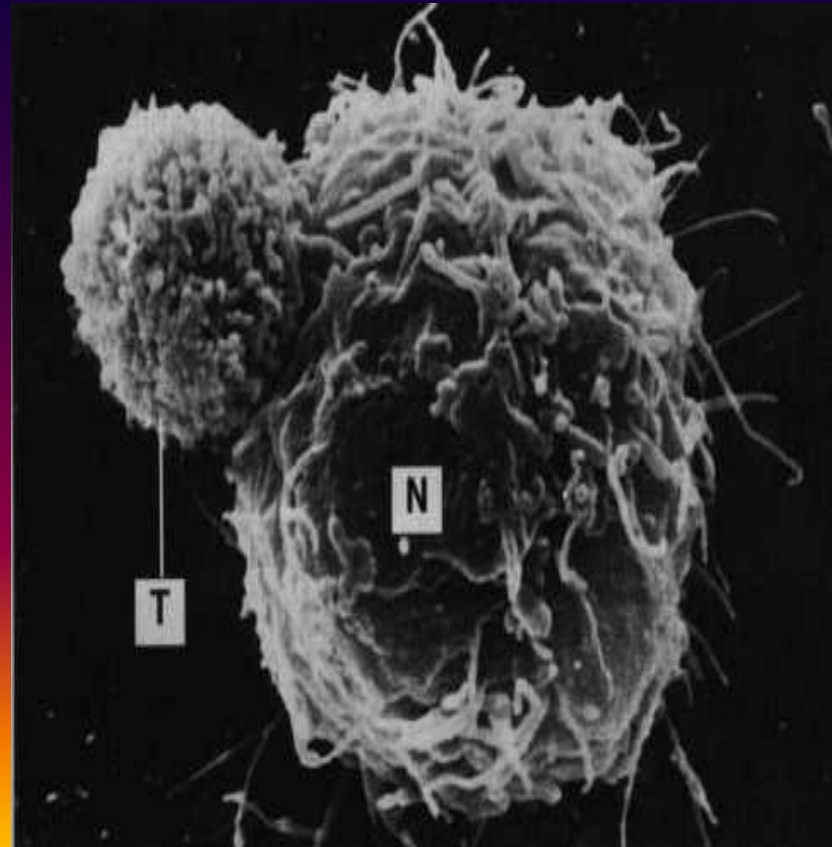
- Both types of lymphocytes are derived in the embryo from pluripotent hematopoietic stem cells that form common lymphoid progenitor cells.
- All of the lymphocytes formed end up in the lymphoid tissue, but before doing so, they are further differentiated or “preprocessed”:
 - The lymphoid progenitor cells that are destined to eventually form activated T lymphocytes first migrate to and are preprocessed in the thymus gland, and thus they are called “T” lymphocytes. They are responsible for cellular or cell-mediated immunity
 - The B lymphocytes are preprocessed in the liver during mid–fetal life and in the bone marrow in late fetal life and after birth. They are changed to plasma cells and are responsible for humeral immunity or antibody- mediated immunity.

NK cell

Natural killer cell.

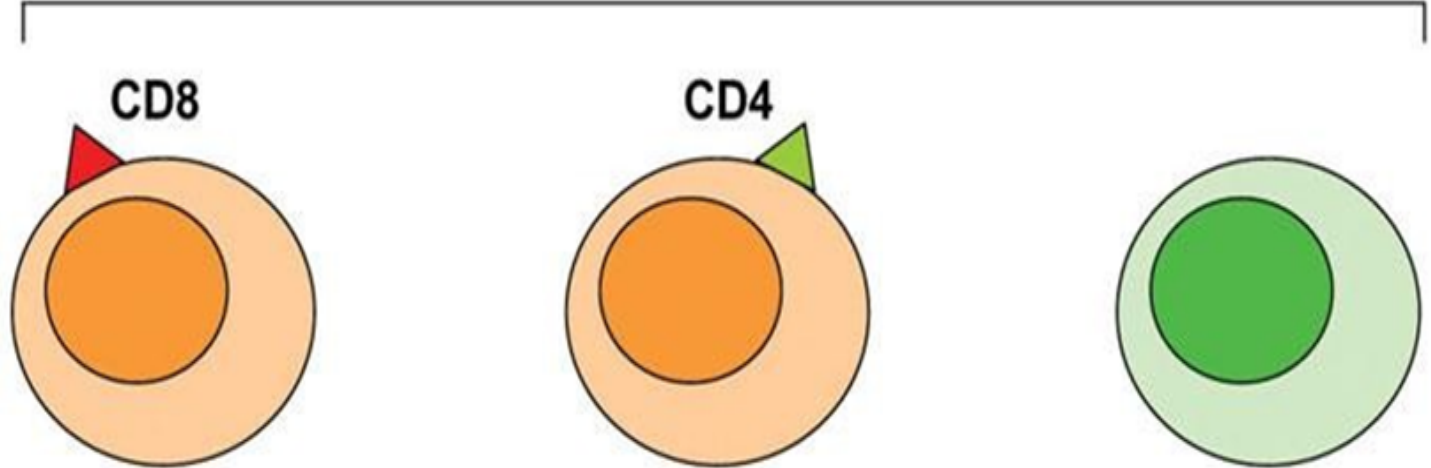
Also called Non B Non T lymphocyte.

Is a part of the non specific immune system.

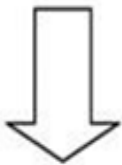


Cellular immune response	Humoral immune response	
T cells	B cells	Cells
Thymus gland	BM & liver	Processing
Tissues	Blood	Site of action
TB , viruses & fungi Tumor Tissue rejection Delayed allergy	Bacteria	Antigen
Memory, helper, cyto-toxic	Memory & plasma	Types

Lymphocytes



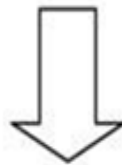
cytotoxic T cells



Kill virus-infected
and damaged cells

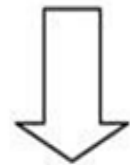
cellular immune response

helper T cells



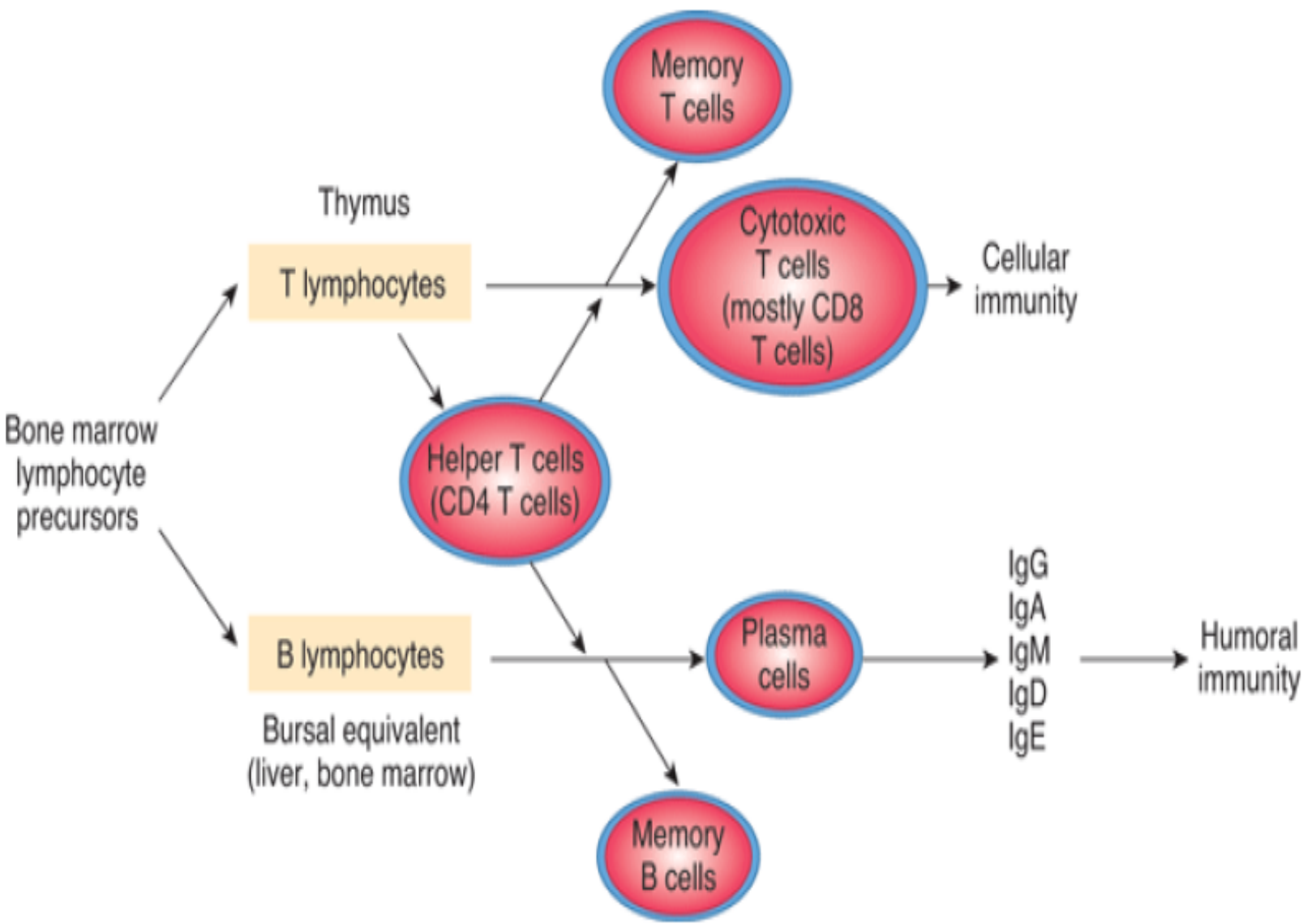
Help cytotoxic T cells
and B cells in their
immune functions

B cells



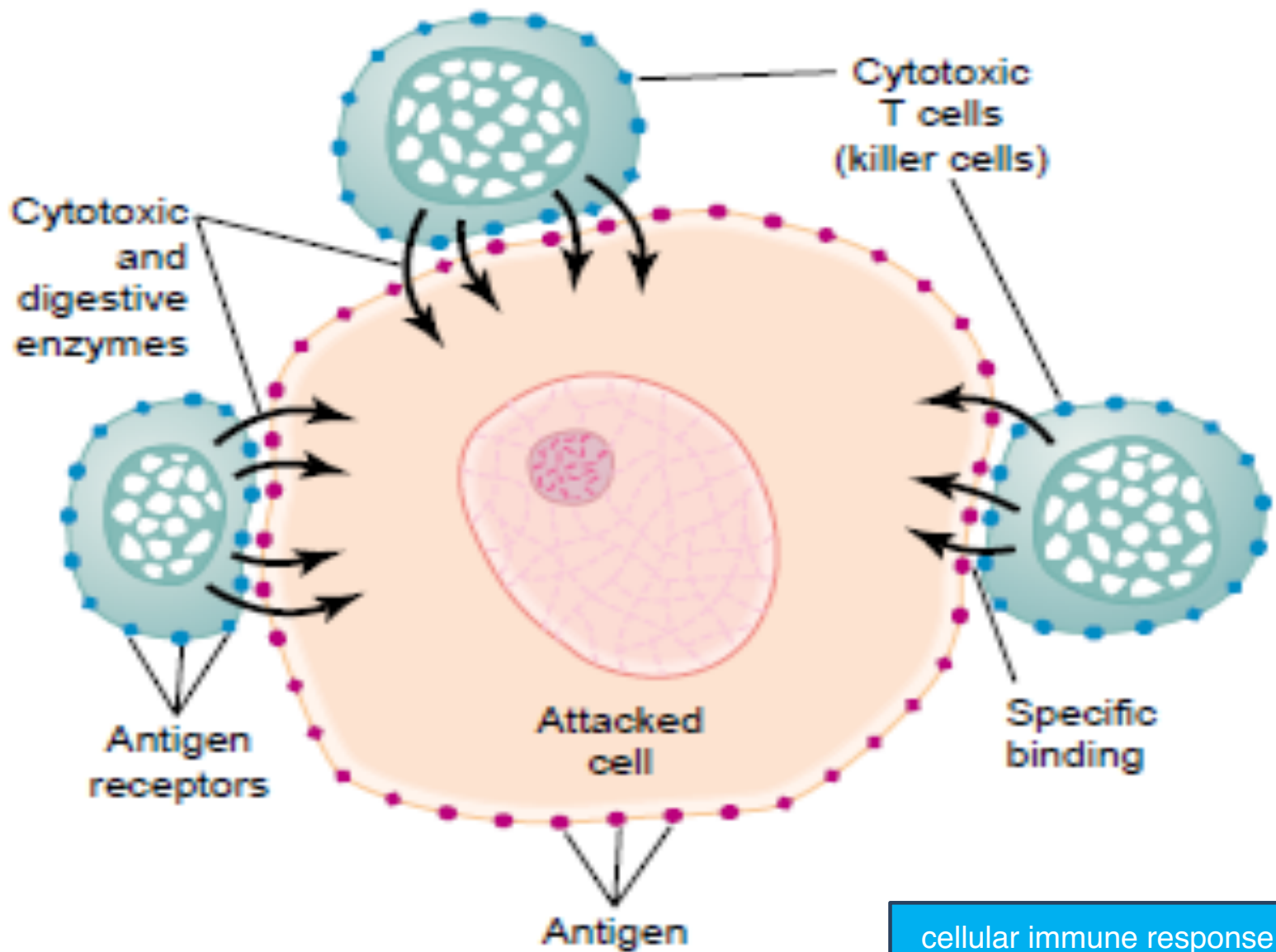
Produce antibodies

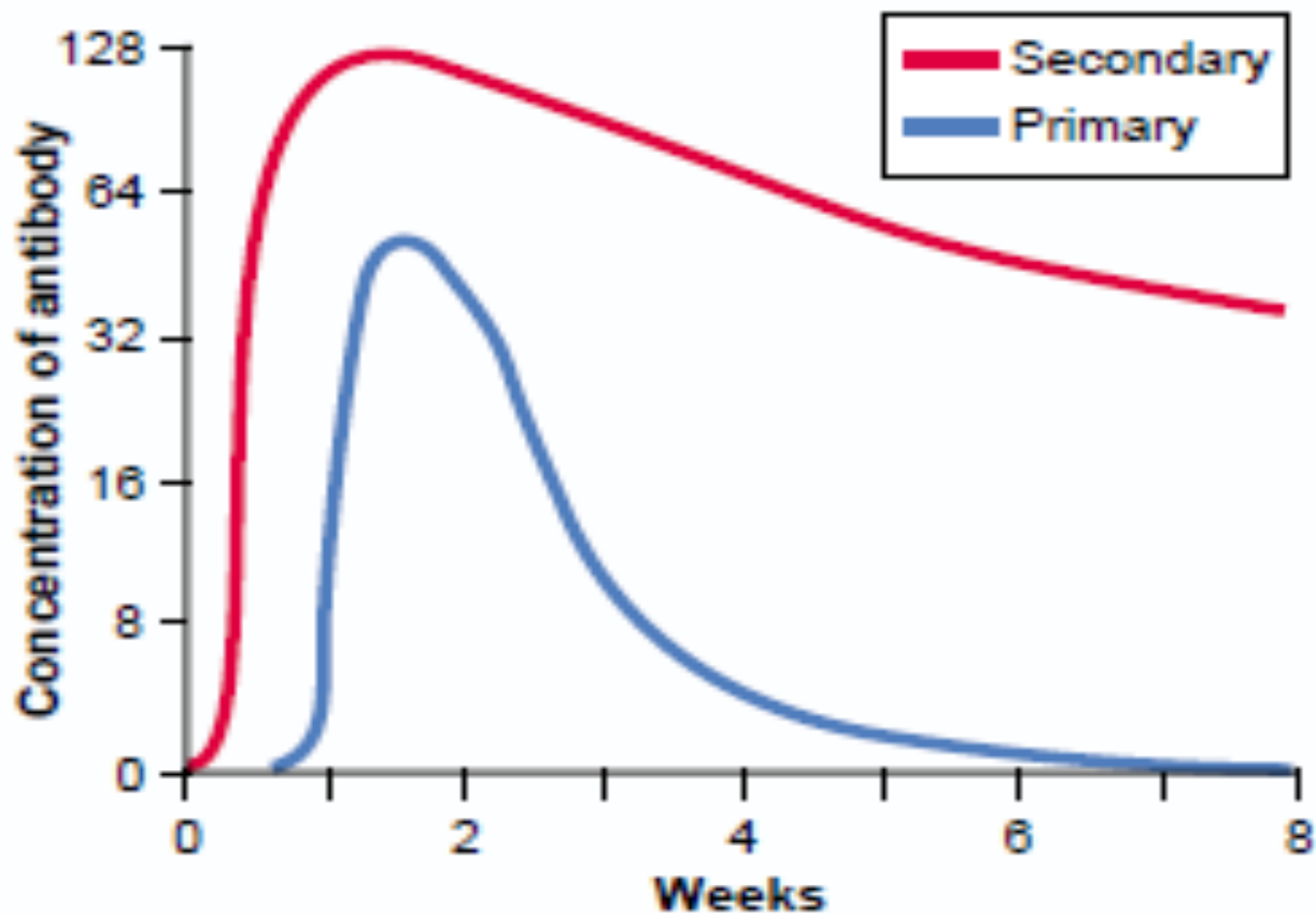
Humoral immune response



	<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"> 1) Stimulate other cells in the immune system. 2) Major regulator of all immune functions 	<ol style="list-style-type: none"> 1) Directly attack cells. 2) Defense against malignant and virus infected cells. 3) Tissue transplant rejection.
<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





Humoral immune response

Pathological Leukocytosis

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

Leukemia

- It is a malignant disease of bone marrow causing marked increase in WBCs may reach 500.000/mm³.
- Leukemia is associated with anemia and bleeding tendency (due to decrease in bone marrow area responsible for RBCs and platelet synthesis respectively).

Leukopenia

- Leukopenia (leucopenia) means a decrease in the total leucocyte count below 4.000/mm³.
- In this condition the body is not protected against infections and death may occur.
- It is caused by:
 - Bone marrow depression by radiation, drugs, and cancer chemotherapy.
 - Some bacterial infections as typhoid fever, brucellosis.
 - Some viral infections as AIDS, influenza, hepatitis.

