
بسم الله الرحمن الرحيم

5 - 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/mm^3 blood.

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

Erythrocytes	Leukocytes					Platelets
	Polymorphonuclear granulocytes			Monocytes	Lymphocytes	
	Neutrophils	Eosinophils	Basophils			
						

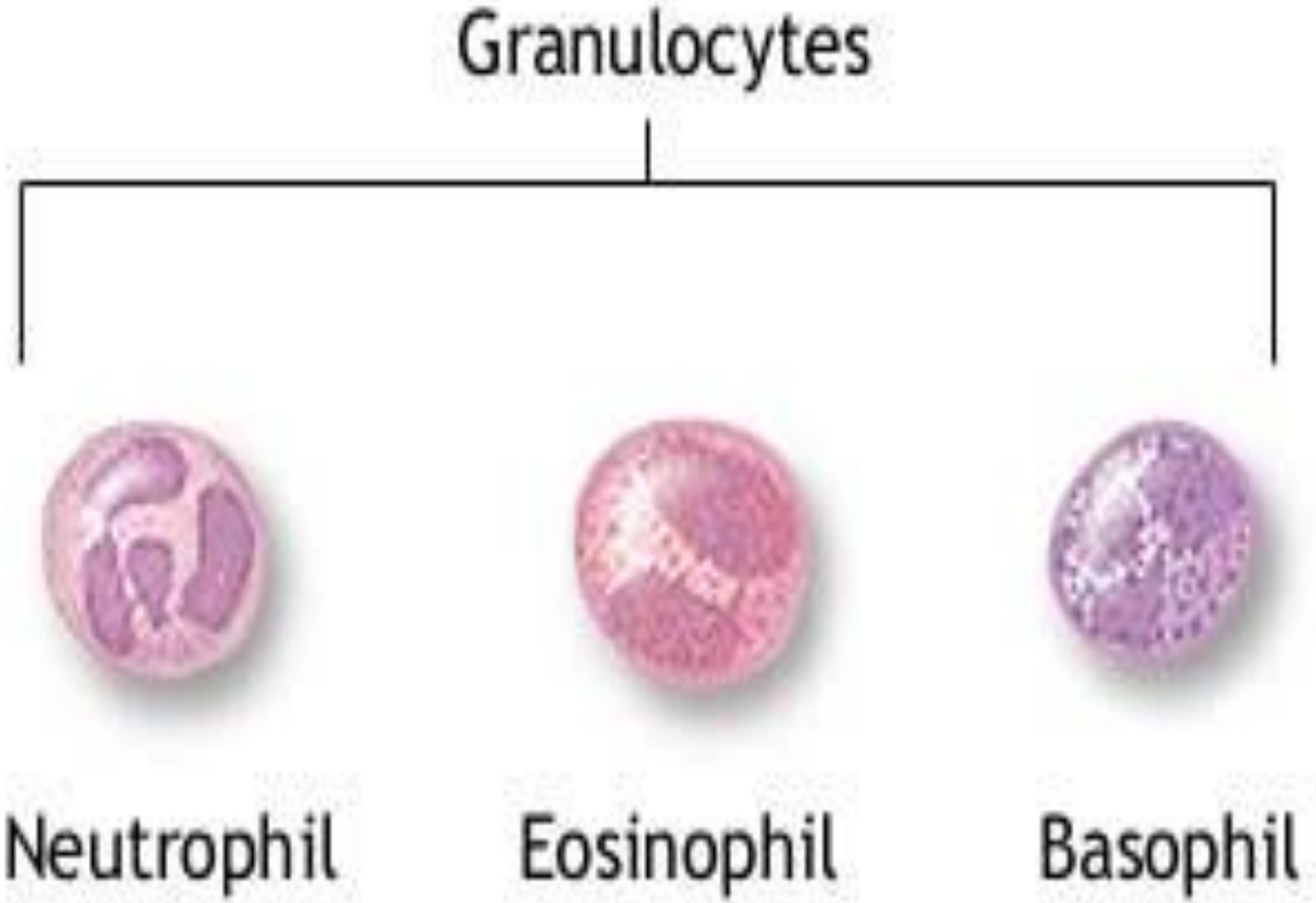
Classification of White Blood Cells (WBCs)

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

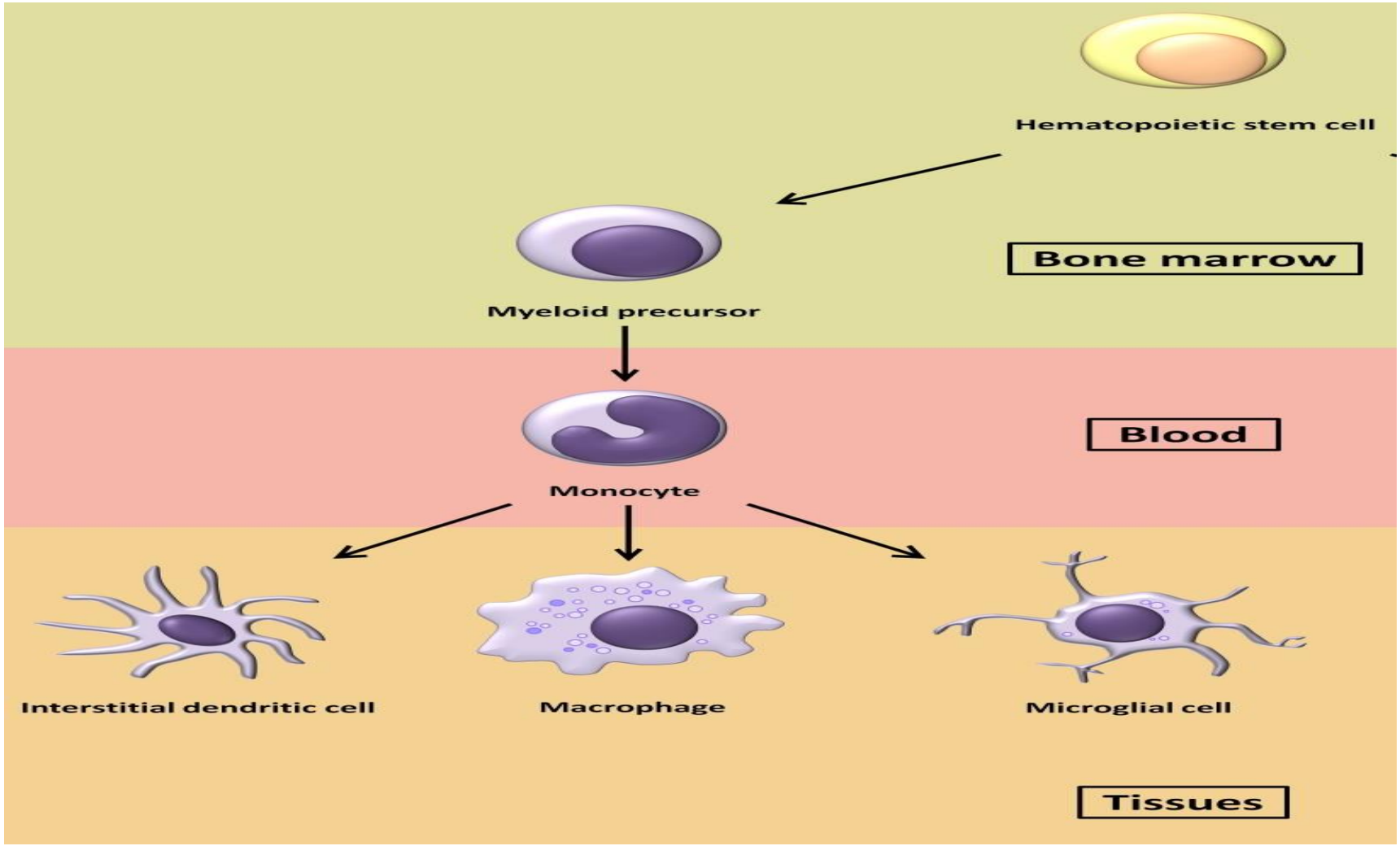
- **Lymphocytes(Round Nucleus, Small [5-8 µm] & large [9-15 µm])**
  - **T lymphocyte**
  - **B lymphocyte**
  - **Natural killer cells (NKCs)**
- **Monocytes (15-20 µm, Kidney shaped nucleus). The monocytes make macrophage system**

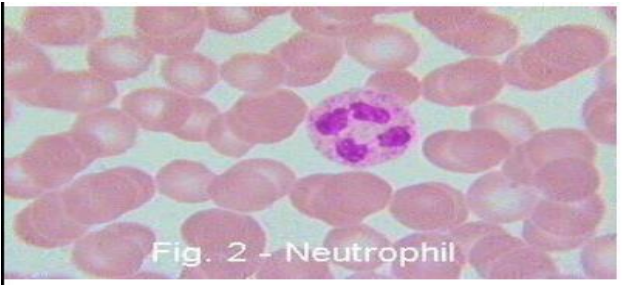

Granulocytes
Neutrophil
Eosinophil
Basophil

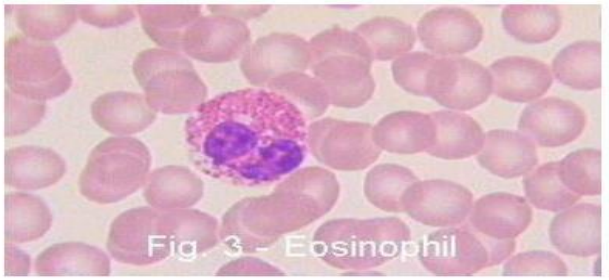
WBCs Concentrations (Normal Counts) and Life Span

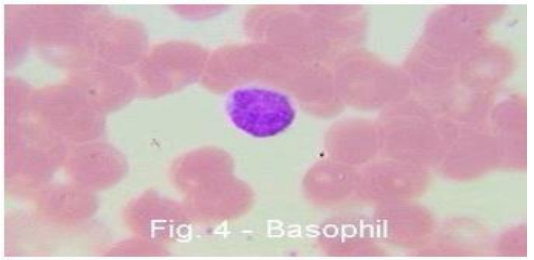
Cells	Approximate Normal Range (/µL)	Percentage of Total WBCs	Life Span
Total WBCs	4000 - 11000		
Neutrophils	3000 - 6000	60 –70% (62%)	4 – 8 hours in blood and 4 – 5 days in tissues where they are needed
Eosinophils	150 - 300	1 – 4% (2.3%)	
Basophils	0 - 100	0.4% (0.4%)	
Lymphocytes	1500 - 4000	20 –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

Monocytes-macrophage system









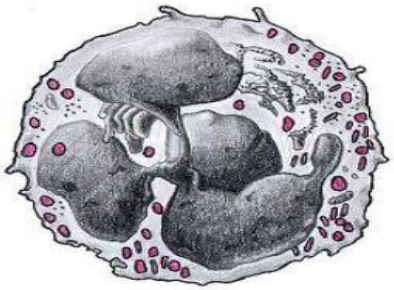


Fig. 8 - Neutrophil

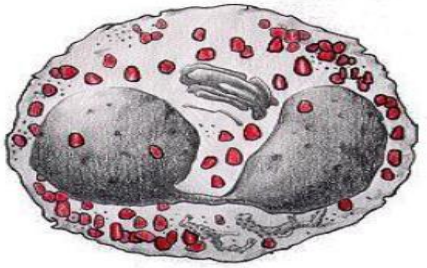


Fig. 9 - Eosinophil

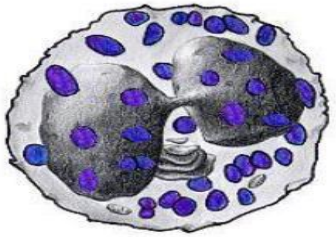
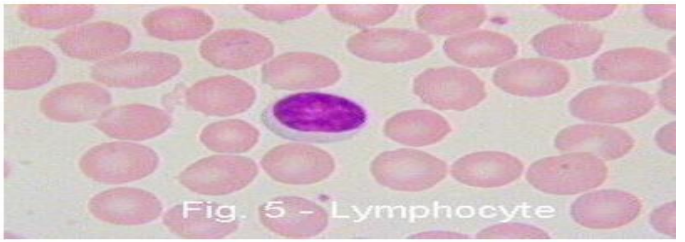


fig. 10 - Basophil



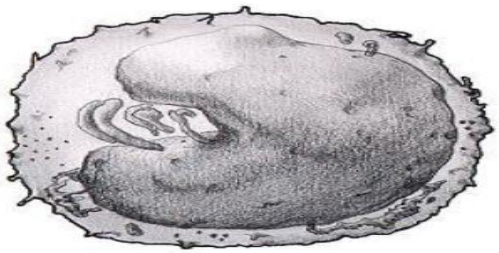


Fig. 12 - Monocyte

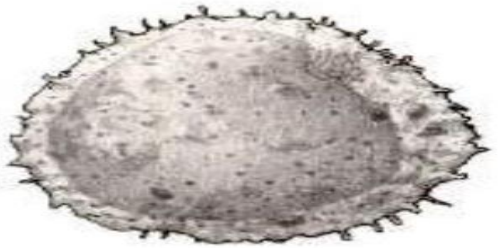
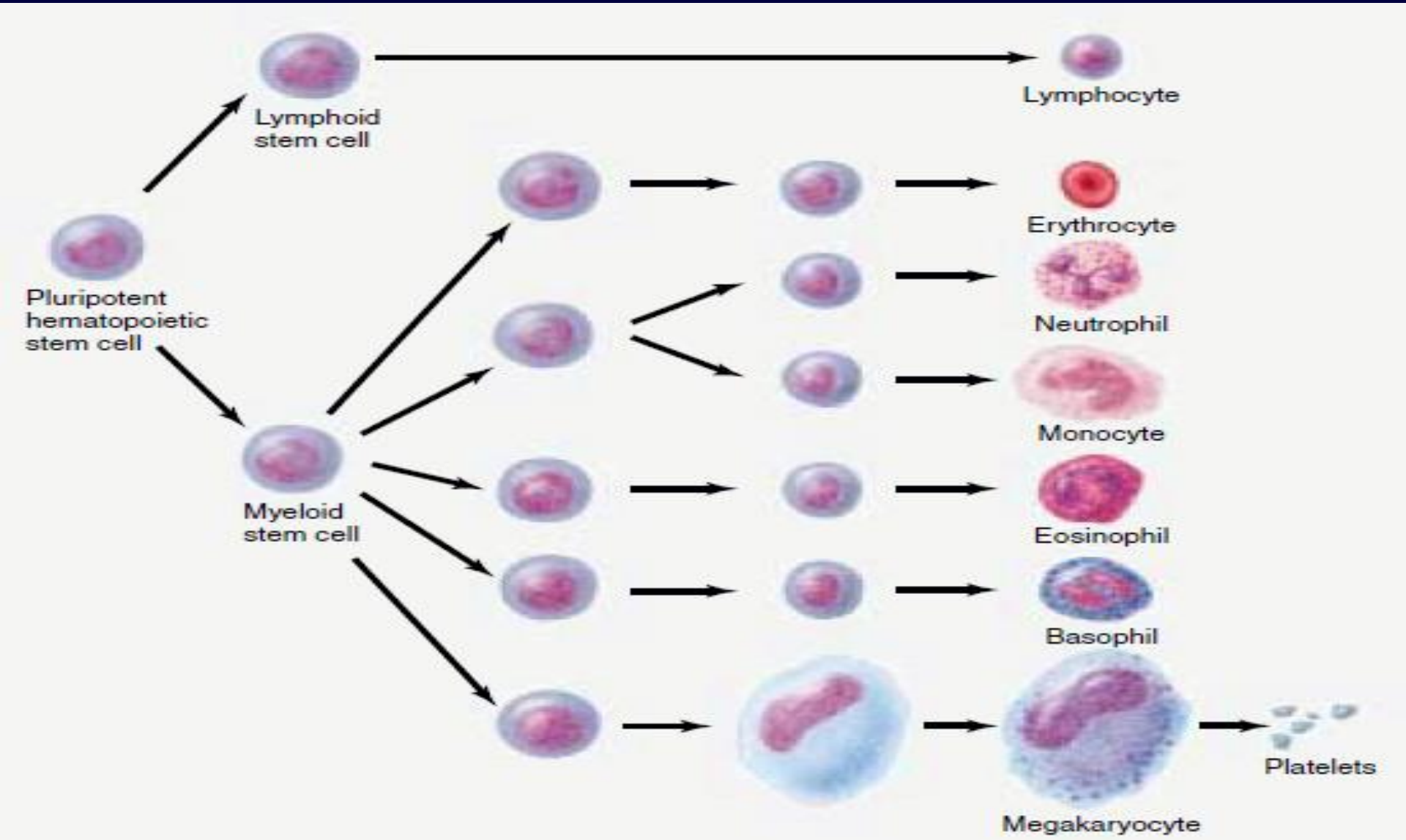
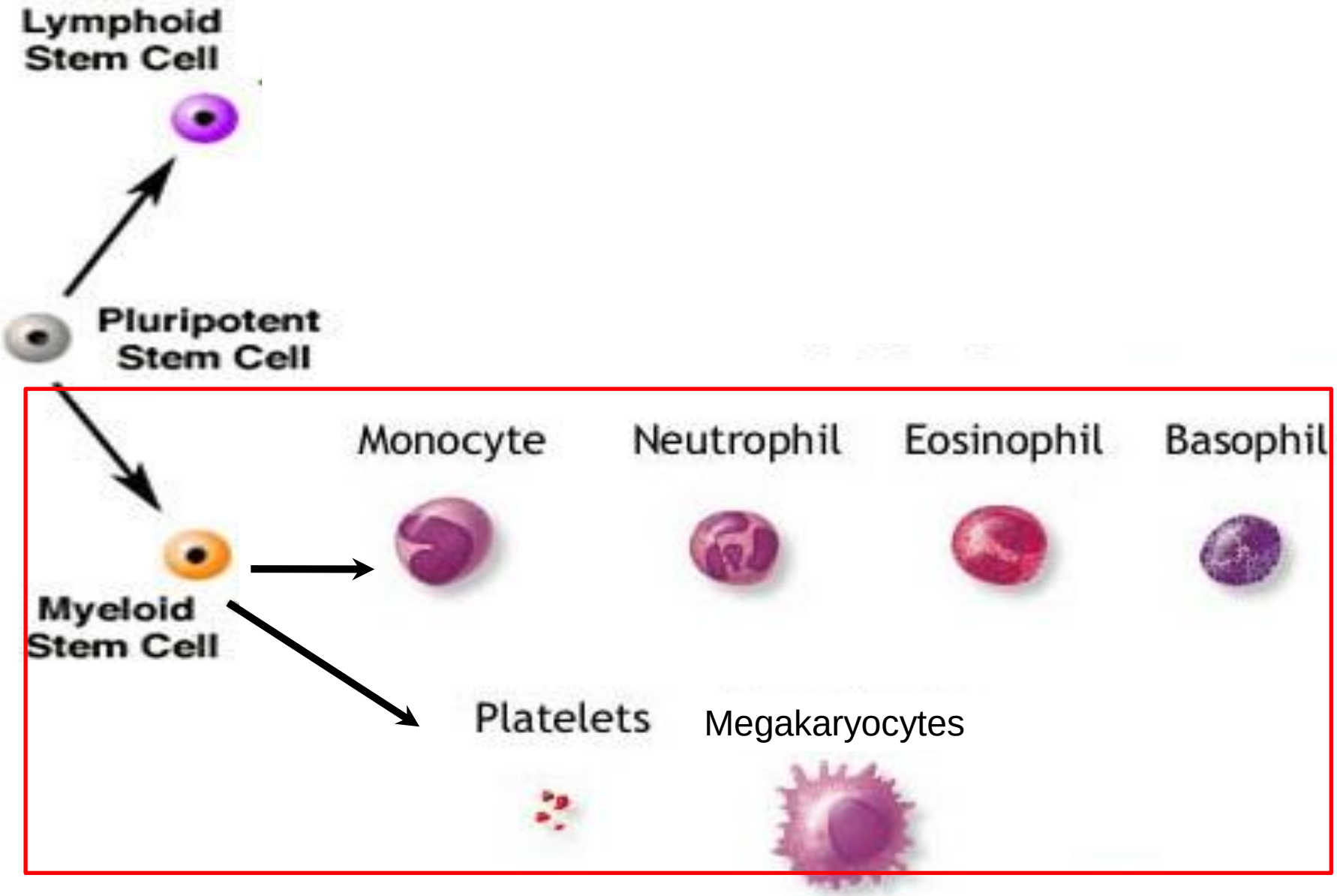


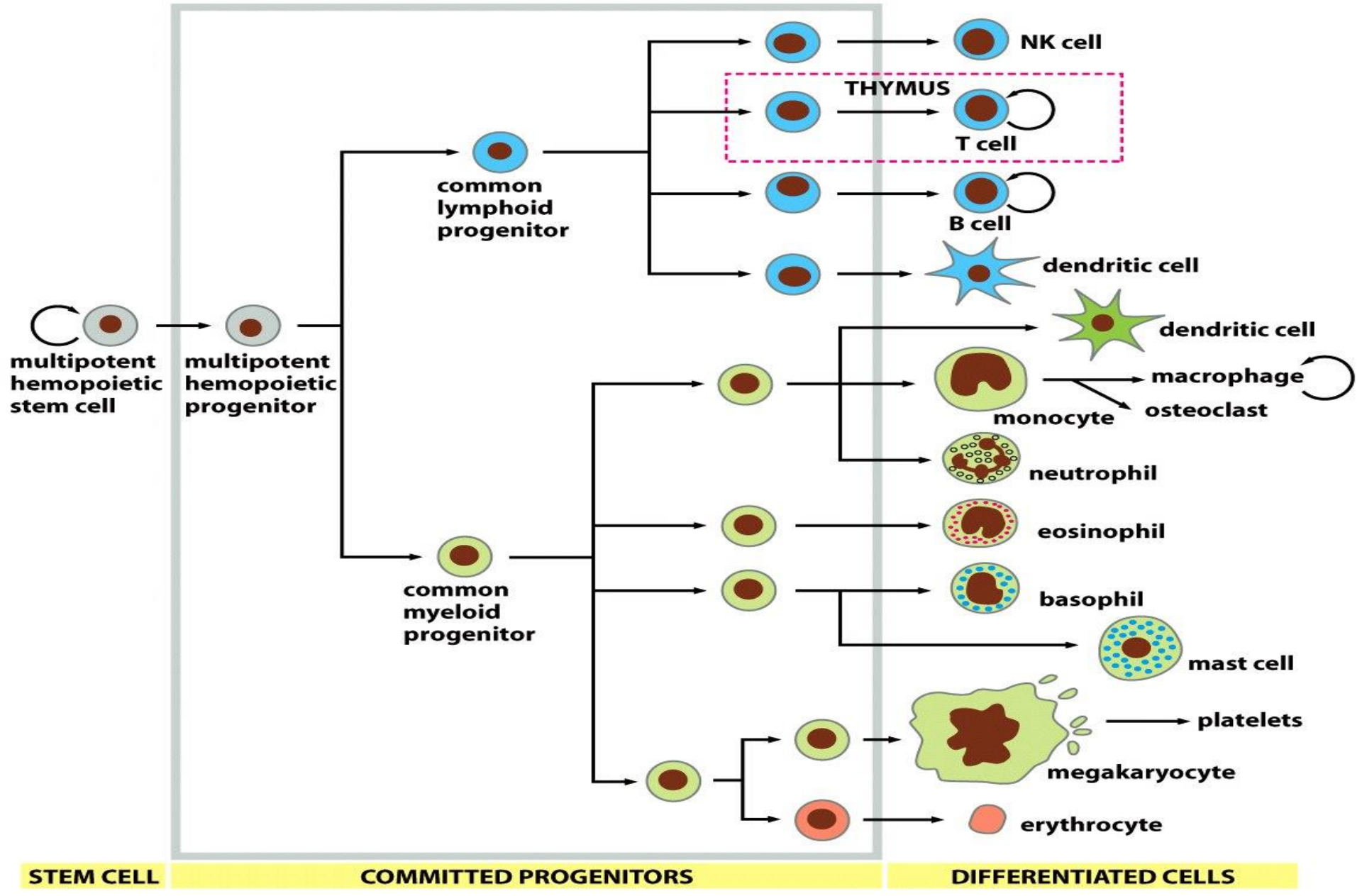
Fig. 11 - Lymphocyte

Leukopoiesis




Lymphoid Stem Cell
Pluripotent Stem Cell
Monocyte
Neutrophil
Eosinophil
Basophil
Myeloid Stem Cell
Platelets
Megakaryocytes

Cells of the Immune System

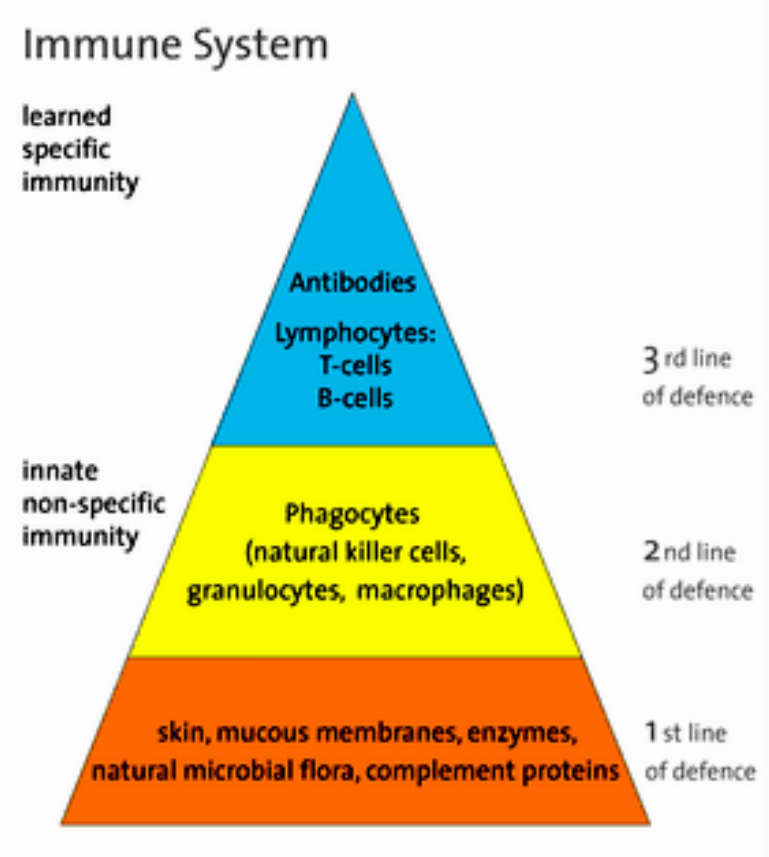


Immune System

- 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.



Types of Immunity

Immune system

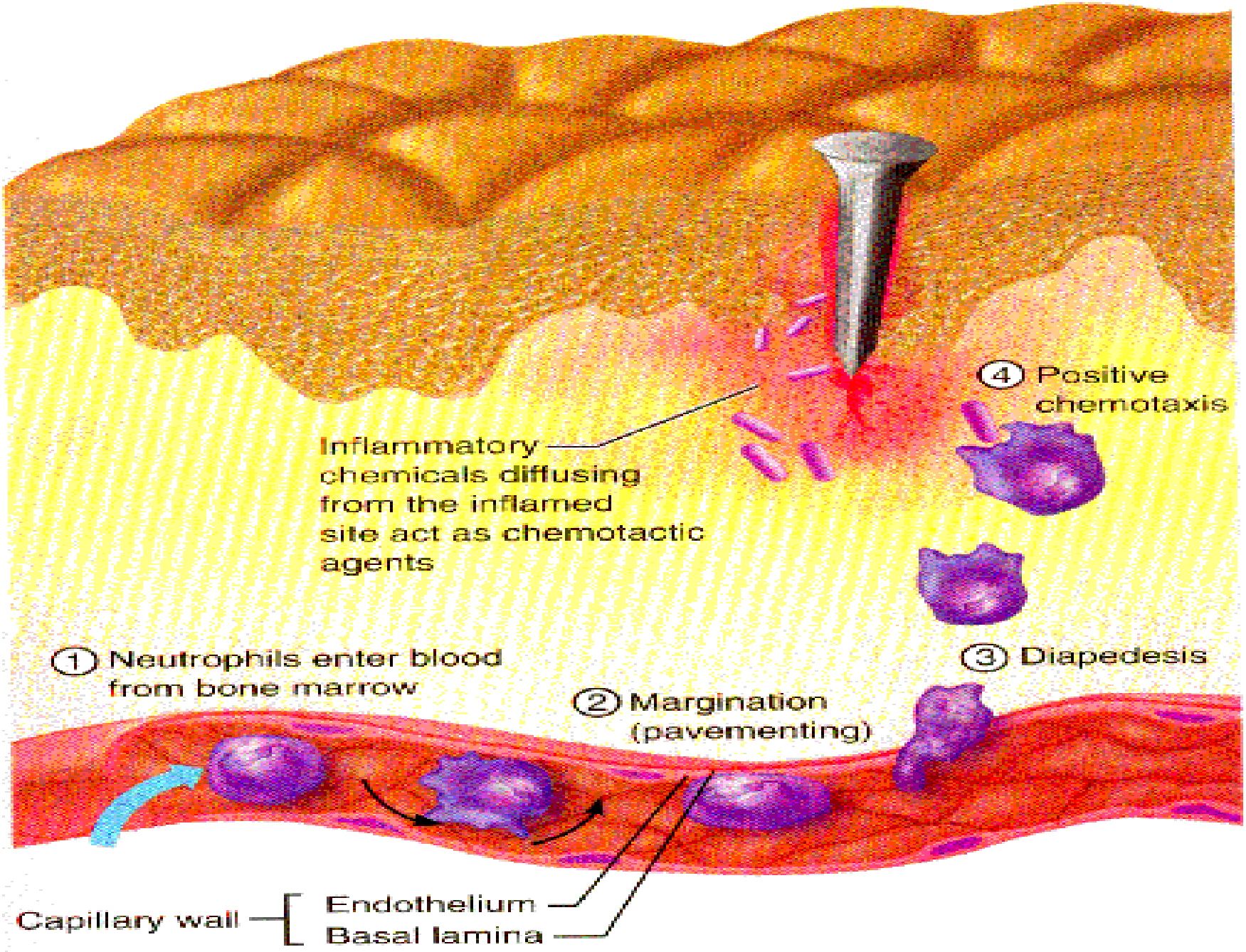
Innate (non-specific; natural) immunity

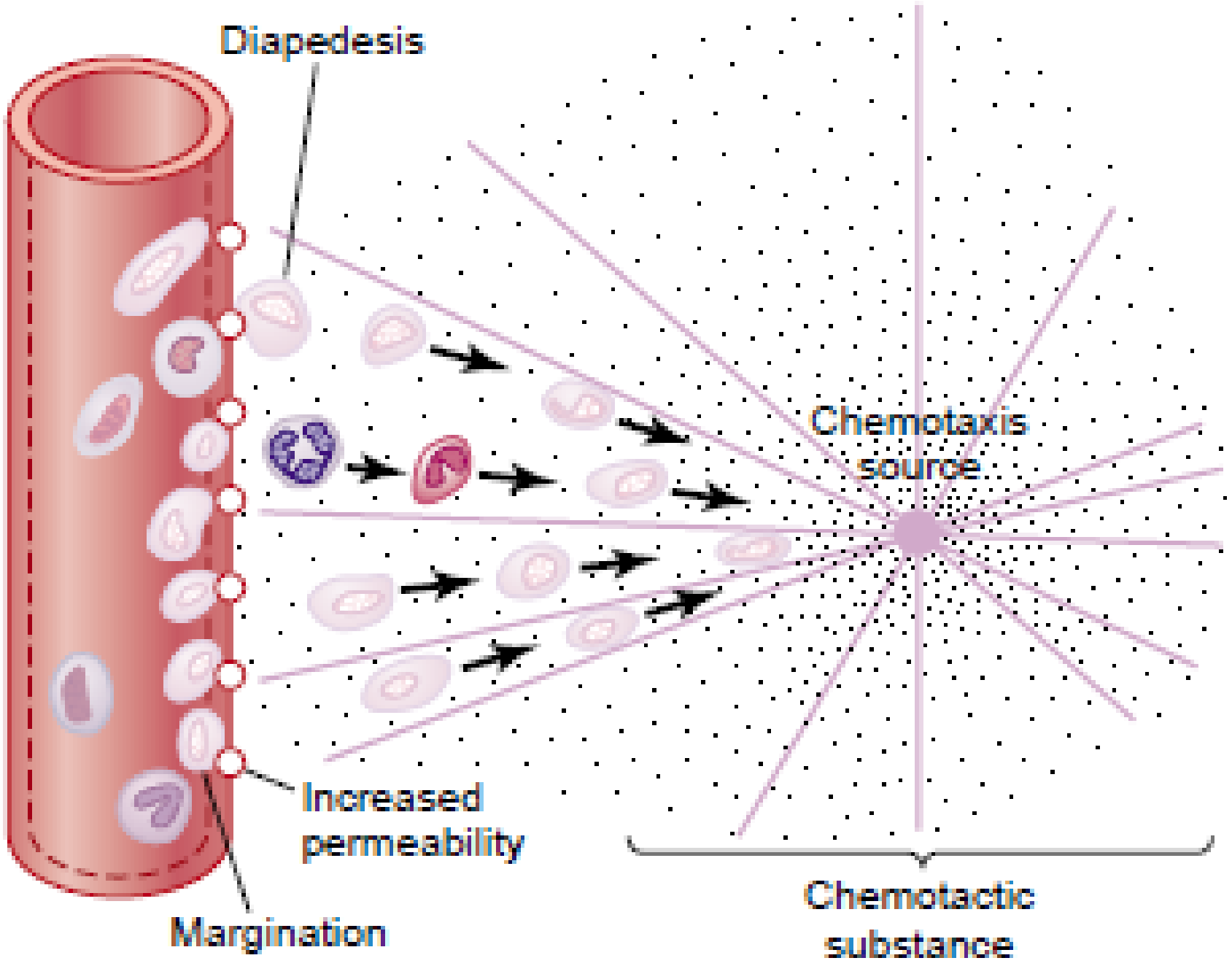
- Second line of defense
- Is present at birth
- Persists throughout life
- Can be mobilized rapidly and act quickly
- Attacks all antigens fairly equally

Adaptive (specific; acquired) immunity

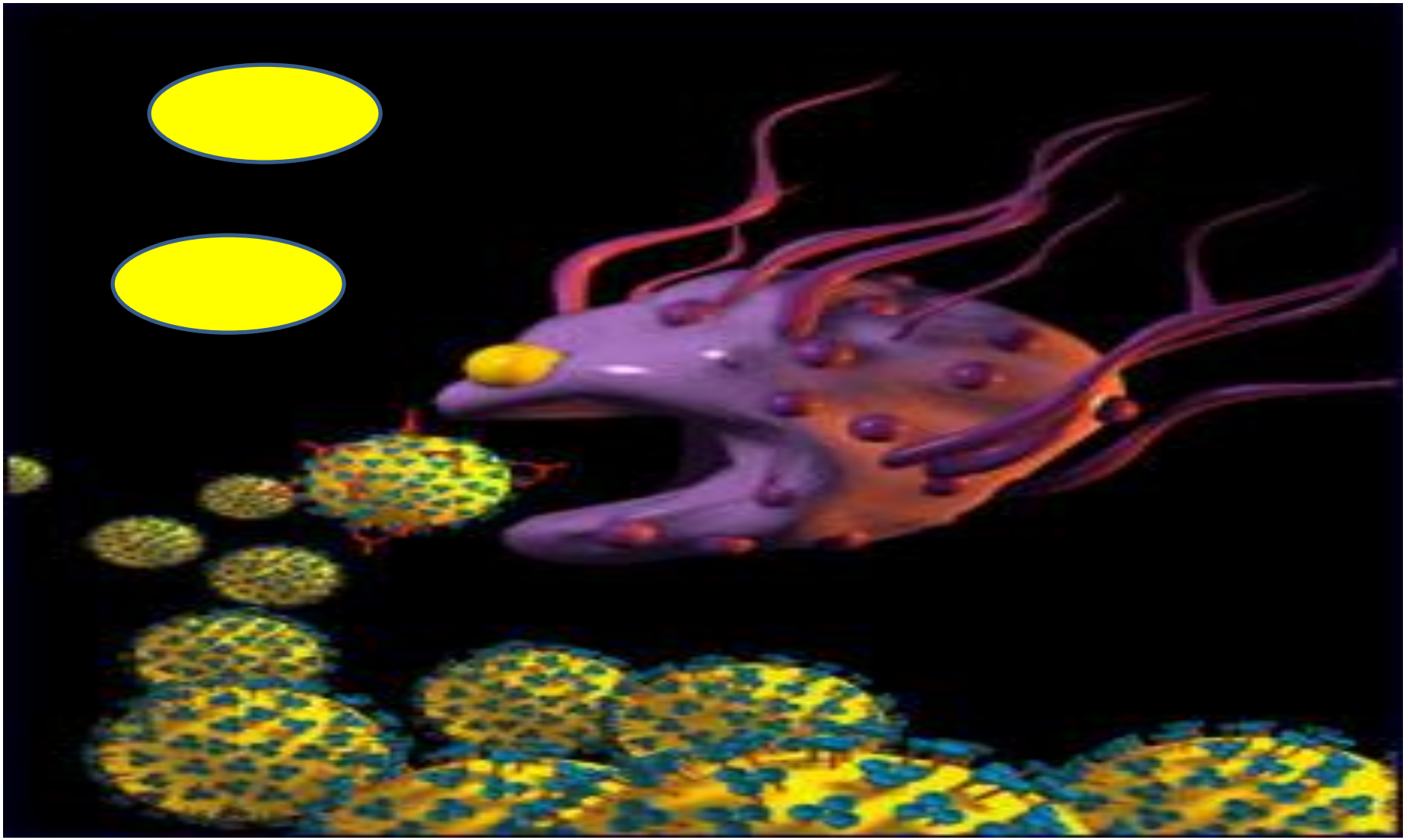
- Third line of defense.
- Antigen specificity. It is activated by thousands of diverse antigens.
- Responds with the proliferation of cells and the generation of antibodies.
- Responds slowly, being fully activated about 4 days after the immunologic threat.
- Exhibits immunologic memory, so that repeated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

Inflammatory (immune) response


4 Positive chemotaxis
Inflammatory chemicals diffusing from the inflamed site act as chemotactic agents
1 Neutrophils enter blood from bone marrow
3 Diapedesis
2 Margination (pavementing)
Capillary wall
Endothelium
Basal lamina


Diapedesis
Chemotaxis source
Increased permeability
Margination
Chemotactic substance

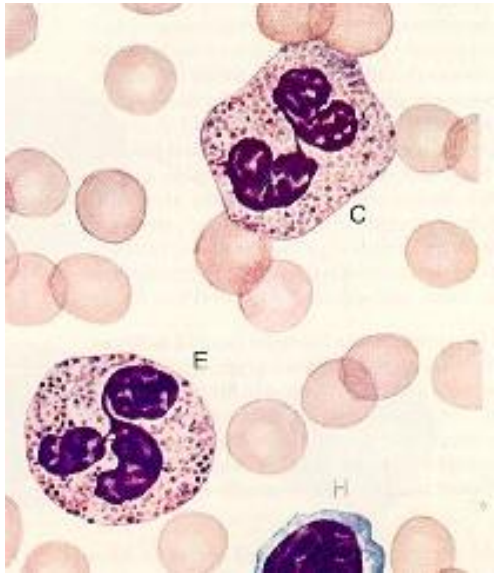
Why these bacteria look tasty?!

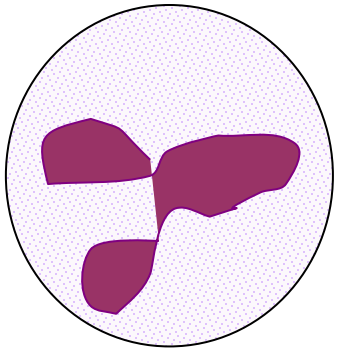



3b
4b

Neutrophils

- 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.

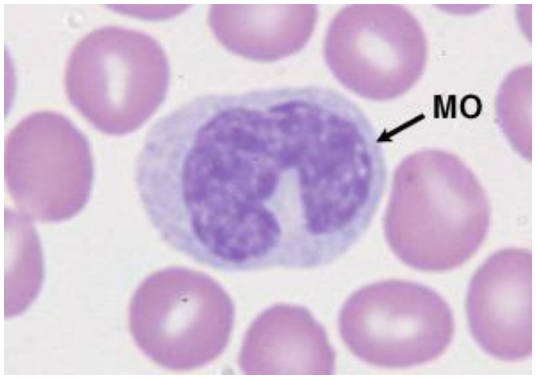




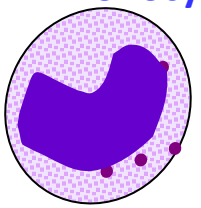
Monocytes/Macrophage

- 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 momocytes are big eaters
  - 15-20 µm
  - active cells 60-80 µm.
  - They have longer lifespan than neutrophils.



Monocyte



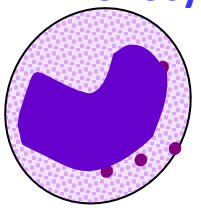
Macrophage
Phagocytosing
E coli

Monocytes/ Macrophage

- 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
  - Kuppfer 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

Monocyte



Macrophage Phagocytosing E coli

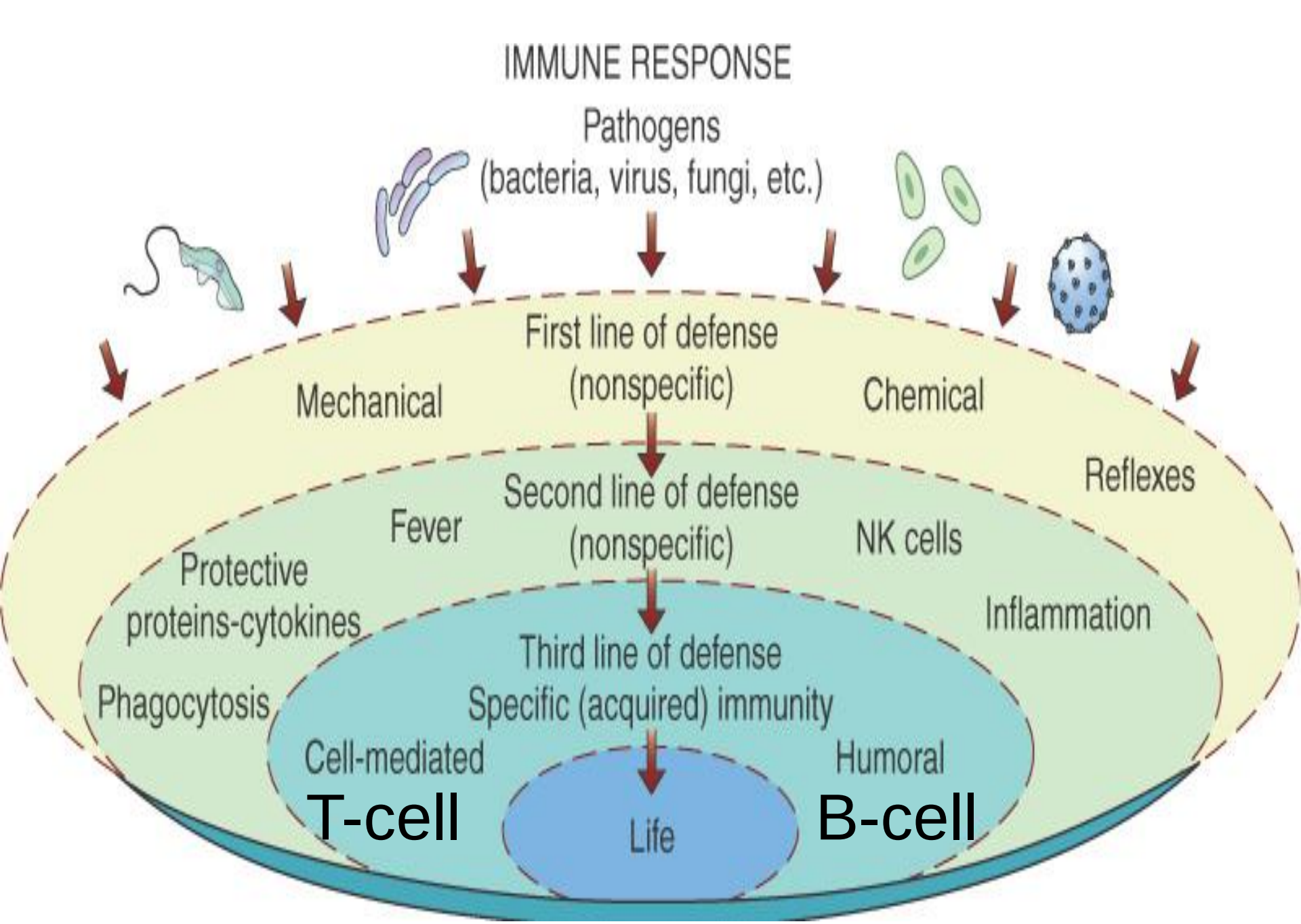
Macrophage and Neutrophil Responses During Inflammation

- 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.)
First line of defense
(nonspecific)
Mechanical
Chemical
Reflexes
Second line of defense
(nonspecific)
Fever
NK cells
Protective
proteins-cytokines
Inflammation
Third line of defense
Specific (acquired) immunity
Phagocytosis
Cell-mediated
Humoral
T-cell
Life
B-cell

Cellular Elements of the specific Immune System
Lymphocytes – T and B cells

- Make up 20–40% of circulating leukocytes

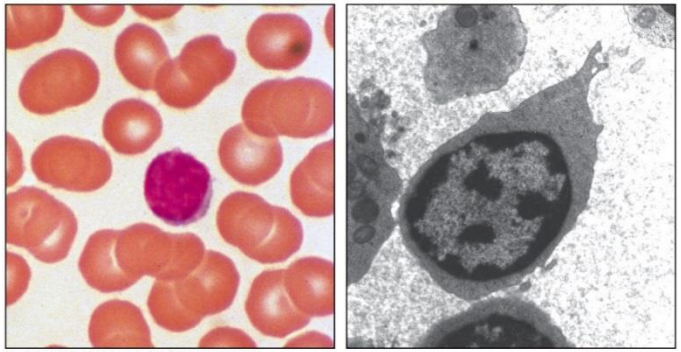


Figure 1-5 Immunobiology, 6/e. (© Garland Science 2005)

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**

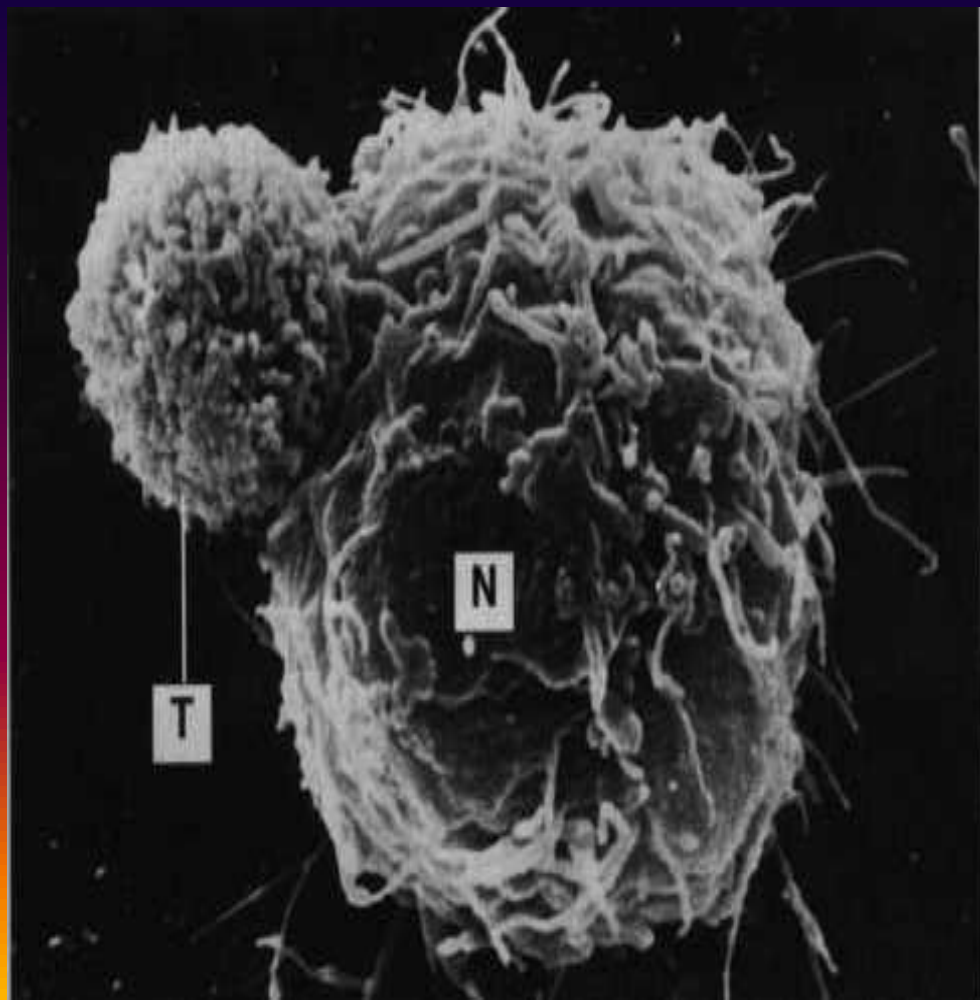
  - **The B lymphocytes are preprocessed in the liver during mid–fetal life and in the bone marrow in late fetal life and after birth. They are changed to plasma cells and are responsible for humeral immunity or antibody- mediated immunity.**

NK cell

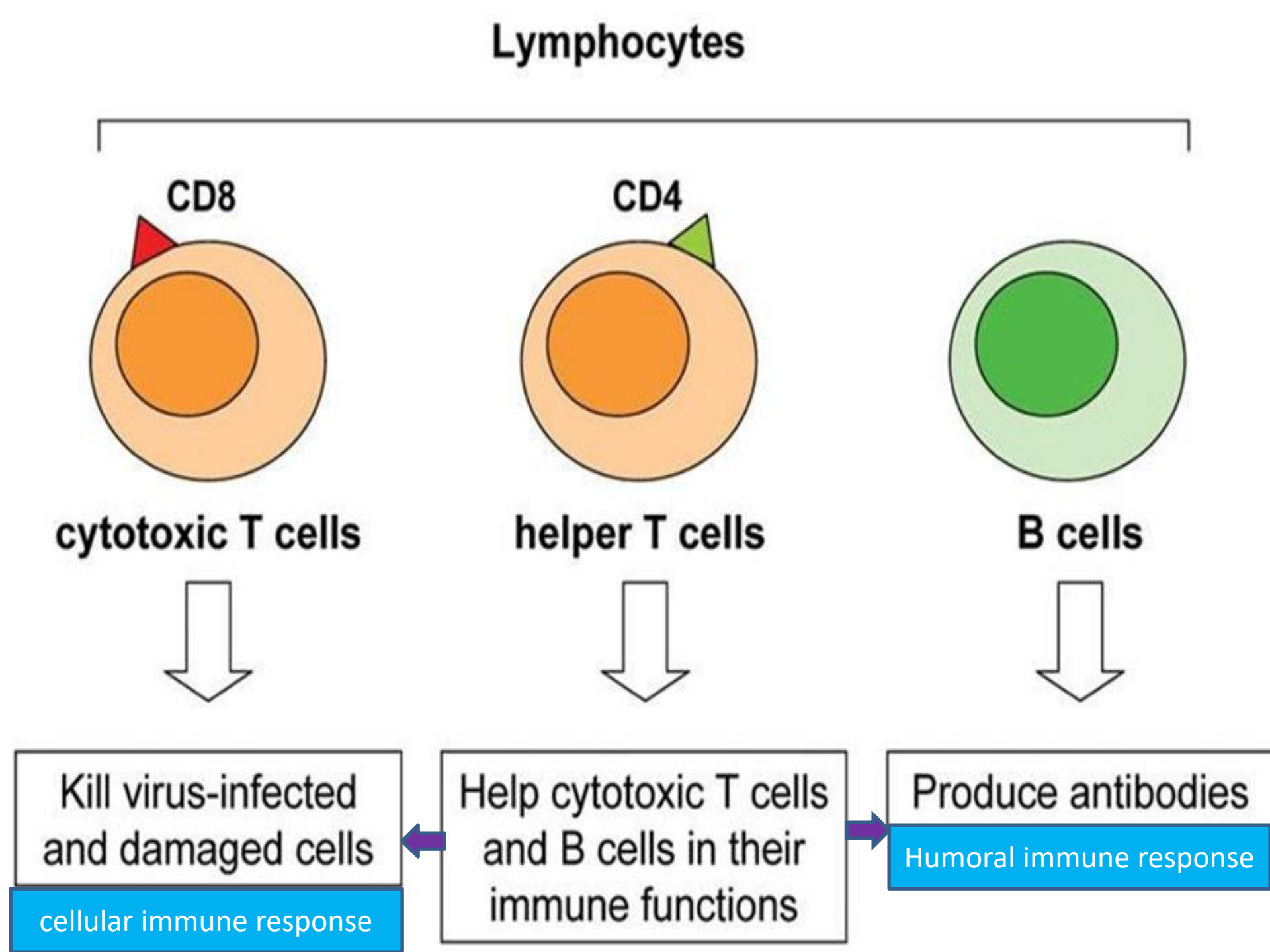
Natural killer cell.

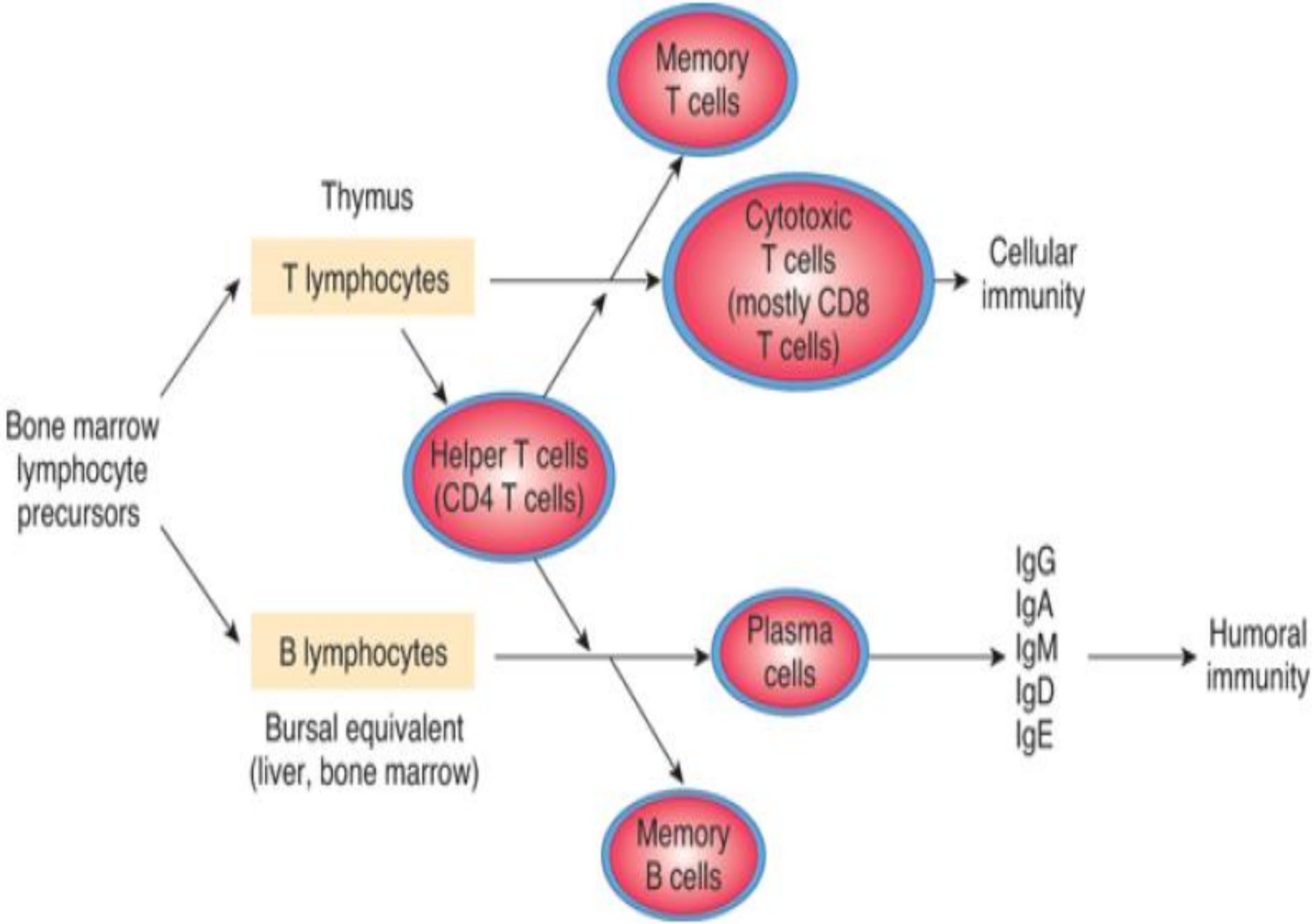
Also called Non B Non T lymphocyte.

Is a part of the non specific immune system.



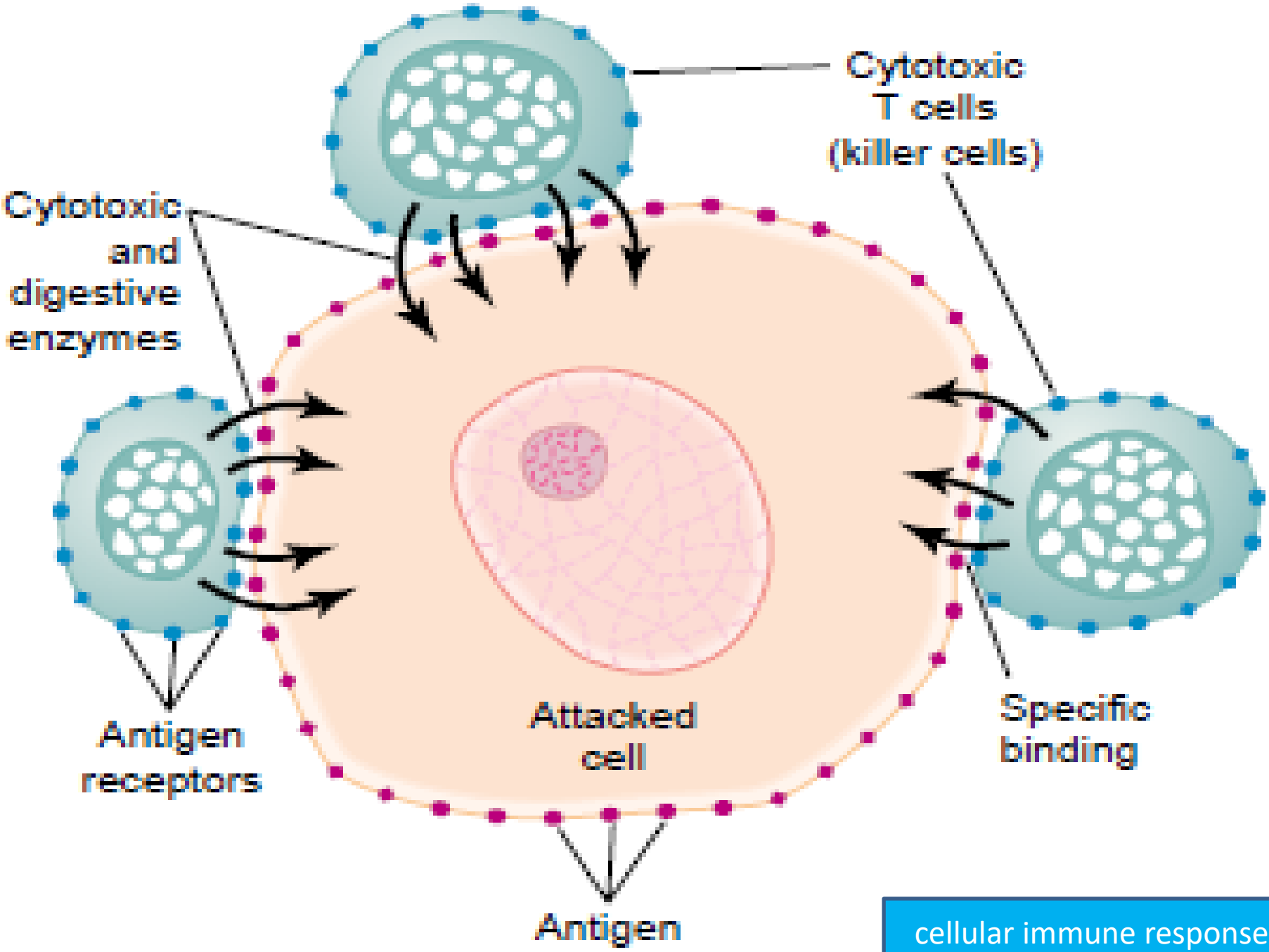
	Humoral immune response	Cellular immune response
Cells	B cells	T cells
Processing	BM & liver	Thymus gland
Site of action	Blood	Tissues
Antigen	Bacteria	TB , viruses & fungi Tumor Tissue rejection Delayed allergy
Types	Memory & plasma	Memory, helper, cyto-toxic


Lymphocytes
CD8
CD4
cytotoxic T cells
helper T cells
B cells
Kill virus-infected and damaged cells
cellular immune response
Help cytotoxic T cells and B cells in their immune functions
Produce antibodies
Humoral immune response

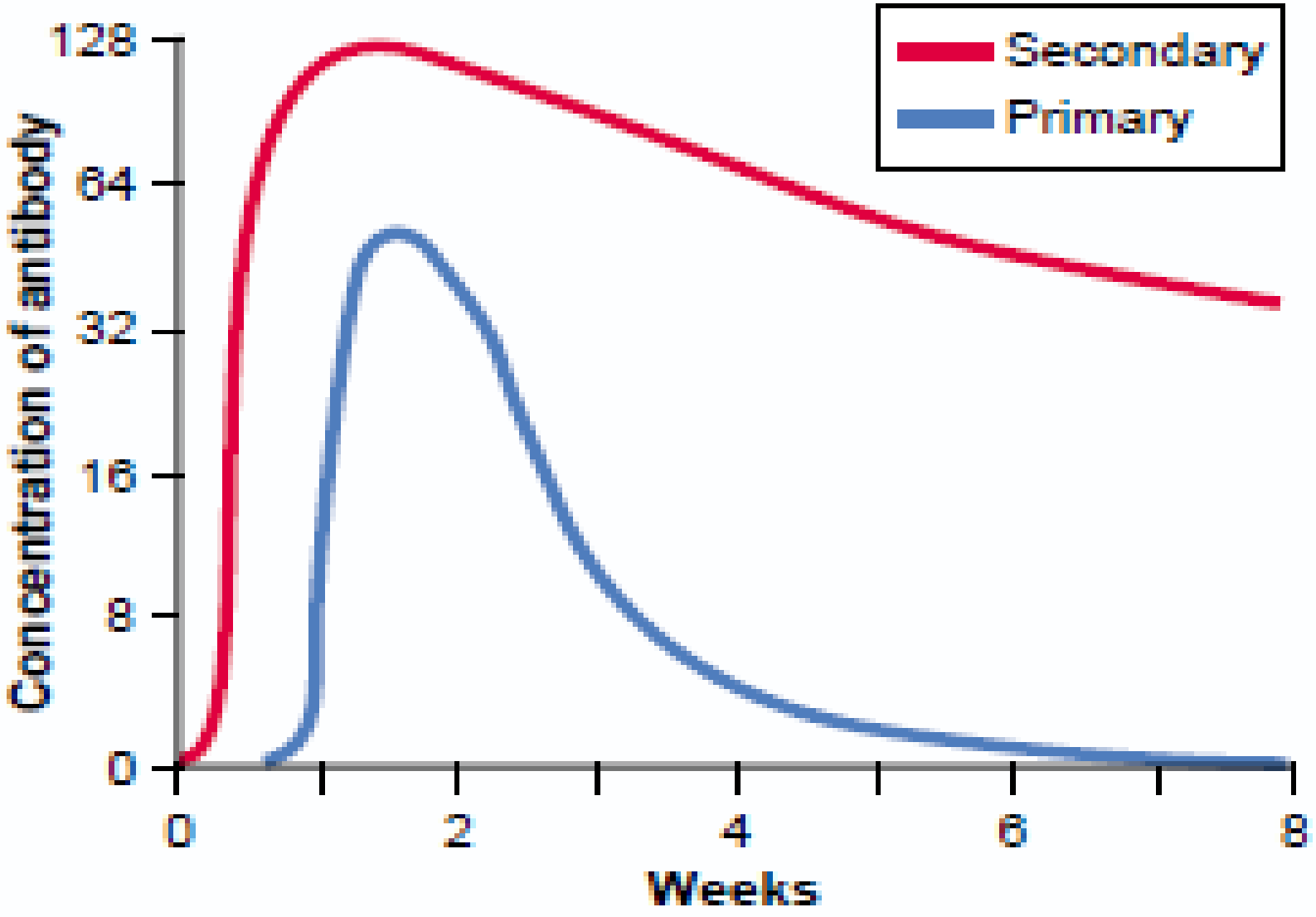

Memory
T cells
Thymus
T lymphocytes
Cytotoxic
T cells
(mostly CD8
T cells)
Cellular
immunity
Bone marrow
lymphocyte
precursors
Helper T cells
(CD4 T cells)
IgG
IgA
IgM
IgD
IgE
Plasma
cells
Humoral
immunity
B lymphocytes
Bursal equivalent
(liver, bone marrow)
Memory
B cells

	CD4 cells *	CD8 cells
Number	Most numerous	Less numerous
Called	T helper cells	Cytotoxic cells
Function	1) Stimulate other cells in the immune system. 2) Major regulator of all immune functions	1)Directly attack cells. 2) Defense against malignant and virus infected cells. 3) Tissue transplant rejection.
Secretes	Interleukins, Interferone	Perforins

- CD = Cluster of differentiation



cellular immune response



Humoral immune response

Pathological Leukocytosis

Condition	Definition	Causes
Neutrophilia	An increase in the number of neutrophils	❑ Infections: of all types as acute or chronic, bacterial, viral or fungal. ❑ Inflammation as rheumatic fever ❑ Tissue damage as trauma, burn ❑ Malignant tumors ❑ Smoking.
Eosinophilia	an increase in the number of eosinophils	❑ Allergic conditions as asthma, hay fever, skin allergy ❑ Parasitic infection ❑ Leukemia
Basophilia	an increase in the number of basophils	❑ Allergic conditions as asthma, hay fever, skin allergy ❑ Leukemia
Monocytosis	an increase in the number of momocytes	❑ Chronic infection as in tuberculosis ❑ Leukemia
Lymphocytosis	an increase in the number of lymphocytes	❑ Chronic bacterial and viral infections ❑ Leukemia

Leukemia

- It is a malignant disease of bone marrow causing marked increase in WBCs may reach 500.000/mm^3.

- 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/mm^3.
- 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.

Thank You