



# Organs and Cells of the Immune System

## Immunology Lecture 2

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# Objectives

- The organs and tissues of the immune system
- Haematopoiesis and formation of blood cells
- Immune cells classes, functions and circulation
- Immune cells development and maturation

# Anatomy of the Immune System



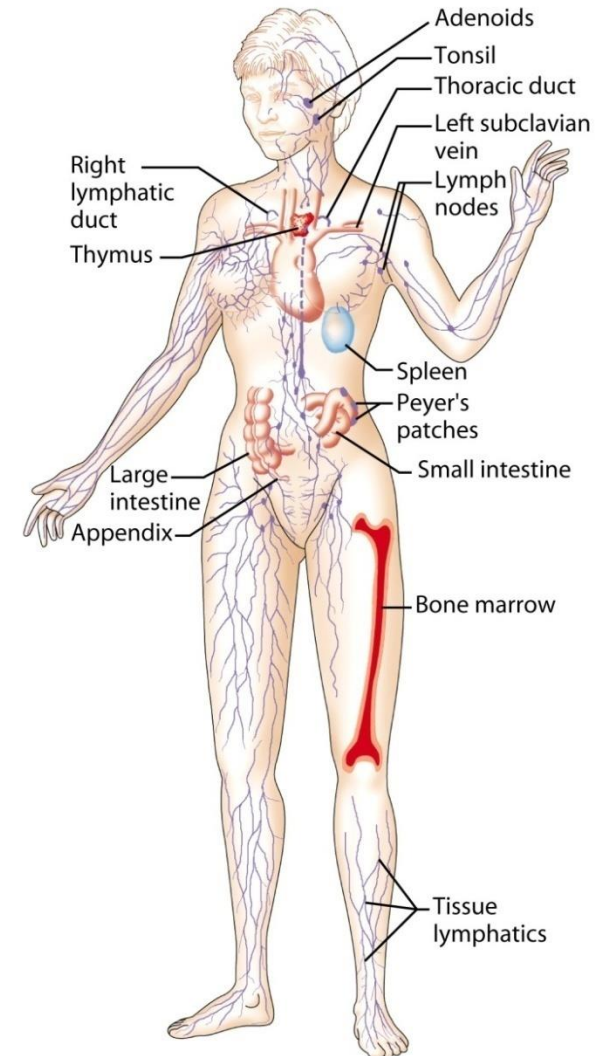
- **Lymphoid organs:**

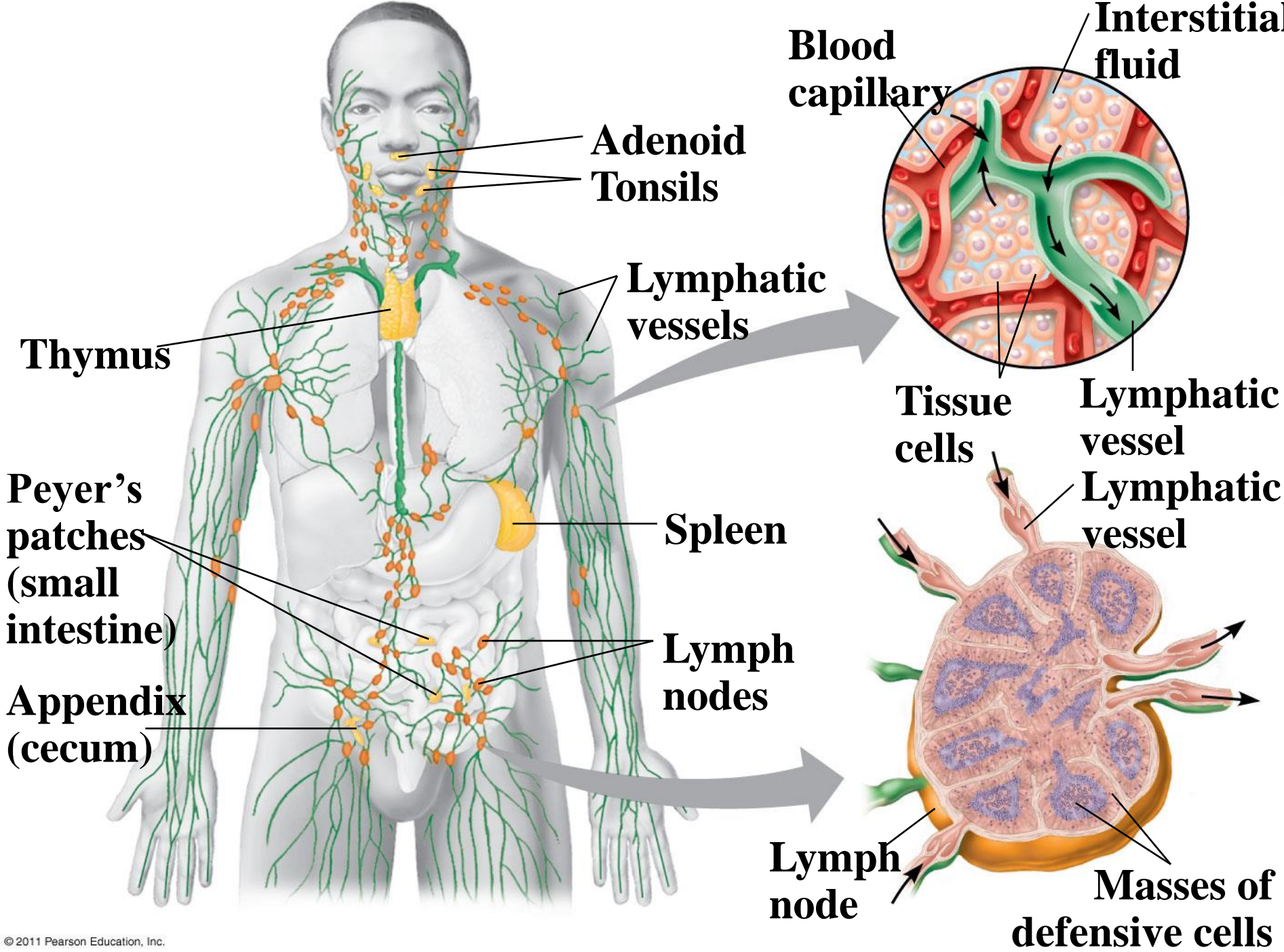
1. Primary or central lymphoid organs: bone marrow and thymus
2. Secondary or peripheral lymphoid organs: lymph nodes, spleen, and mucosal and cutaneous immune system

- **Blood cells in the immune sys:**

1. Innate immune cells: “phagocytes” macrophage, neutrophils, dendritic cells
2. Adaptive immune cells: “lymphocytes” T cells, B cells

- **Lymphatic and blood circulation**







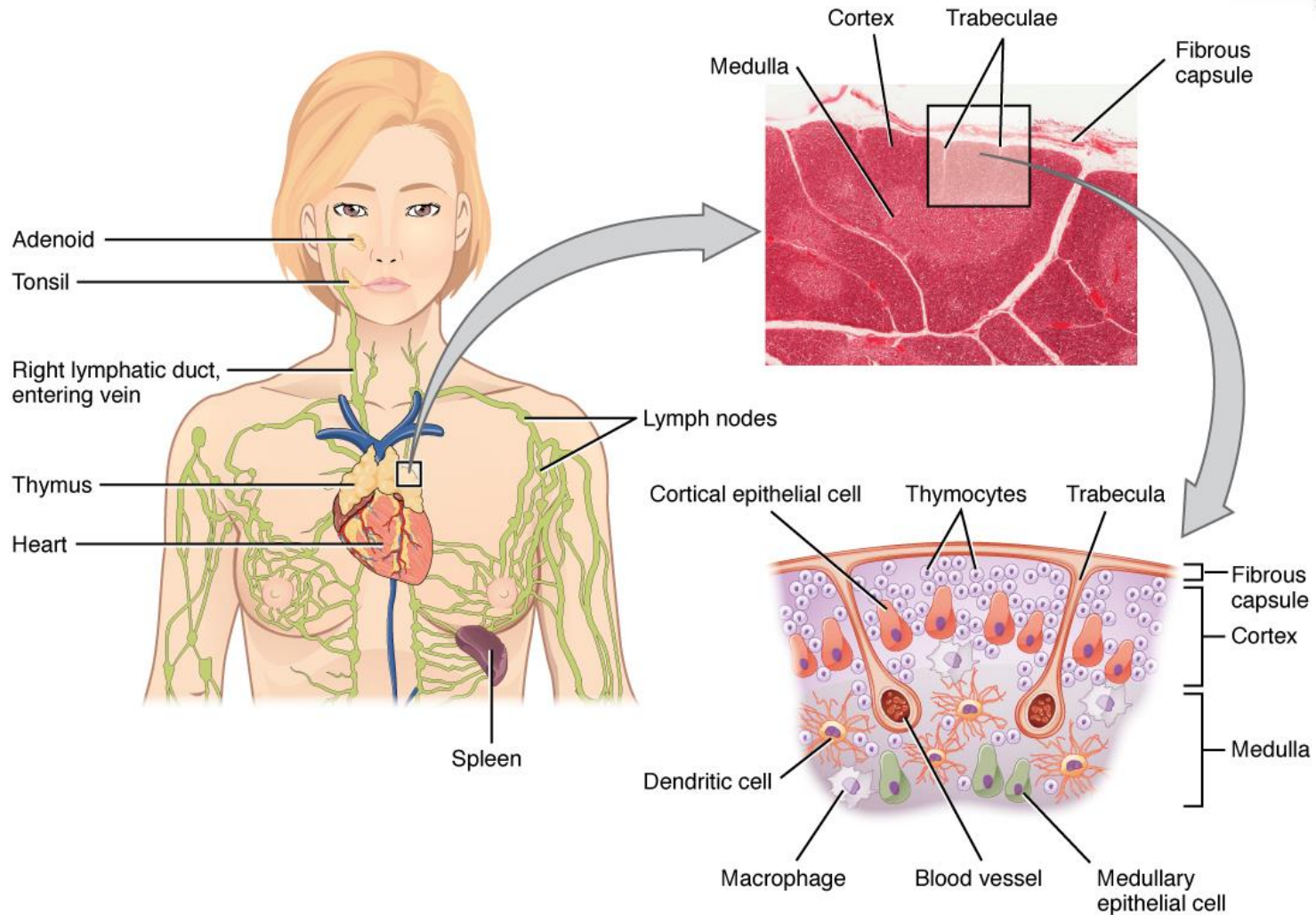
- The cells of the immune system spend much of their time in lymphoid organs. They develop (arise) in primary lymphoid organs, and they interact with antigens in secondary lymphoid organs.
  - Thymus: primary lymphoid organ for T cell development
  - Bone marrow: primary lymphoid organ for B cell development
  - Lymph nodes: collect antigens from tissues
  - Spleen: collects antigens from blood stream

# Lymphoid Organs

## 1. Thymus



- Flat bilobed organ situated above the heart
- Each lobe is surrounded by a capsule and divided into lobules separated by connective tissues called trabiculae
- The thymus reach its maximum size at puberty and then atrophies
- The thymus generation of T cells drop with time. By the age of 35 thymus generation of T cells drop to 20% and by the age of 65 it drop to 2% of newborn levels
- Play critical role in formation and maturation of T cells





## 2. Bone Marrow

- Bone marrow is the flexible tissue in the interior of bones
- On average, bone marrow constitutes 4% of the total body mass of humans
- There are two types of bone marrow: red marrow (also known as myeloid tissue) and yellow marrow.
- Bone marrow is the site of haematopoiesis and the origin of B cells in human
- The hematopoietic component of bone marrow produces approximately 500 billion blood cells per day



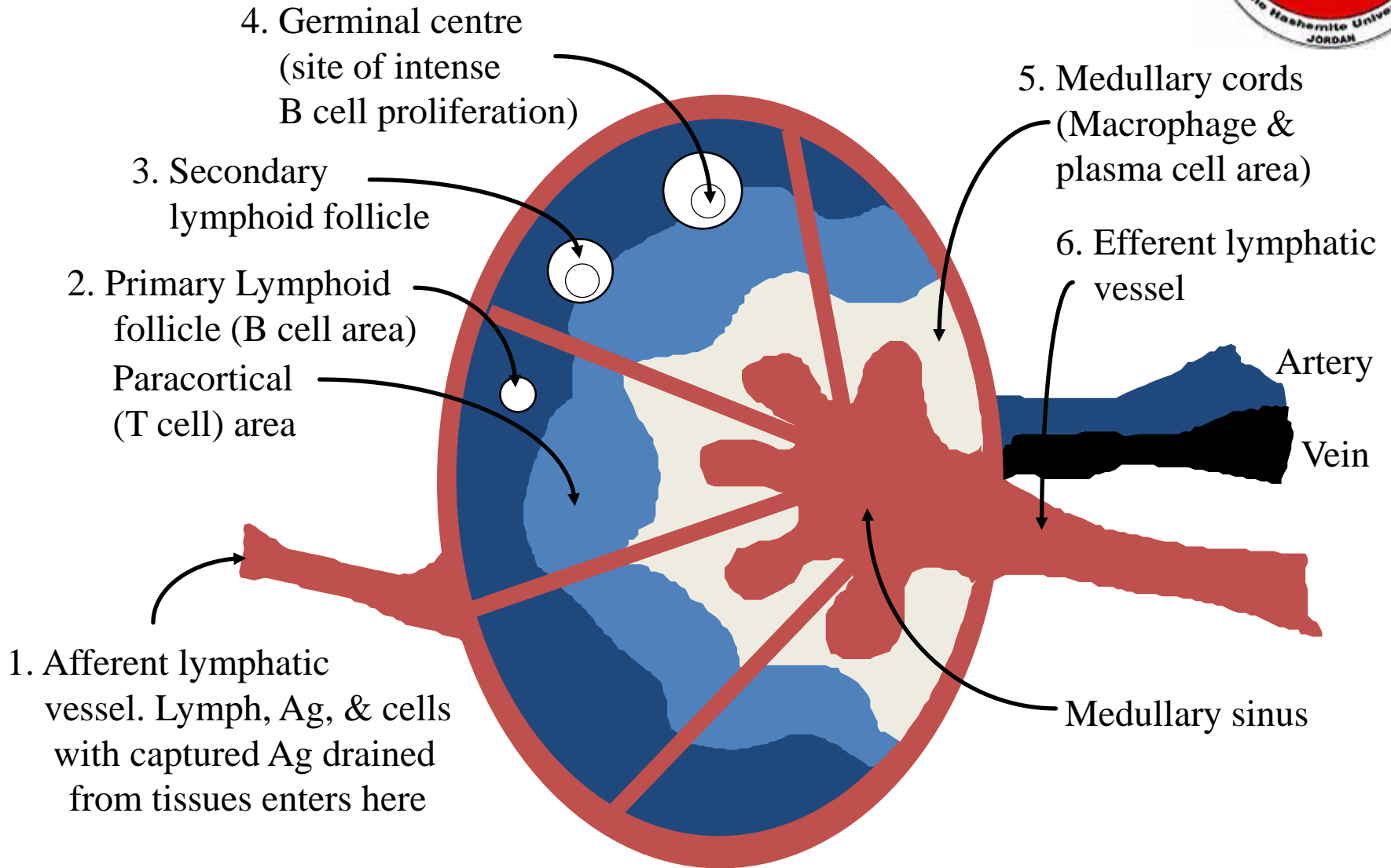


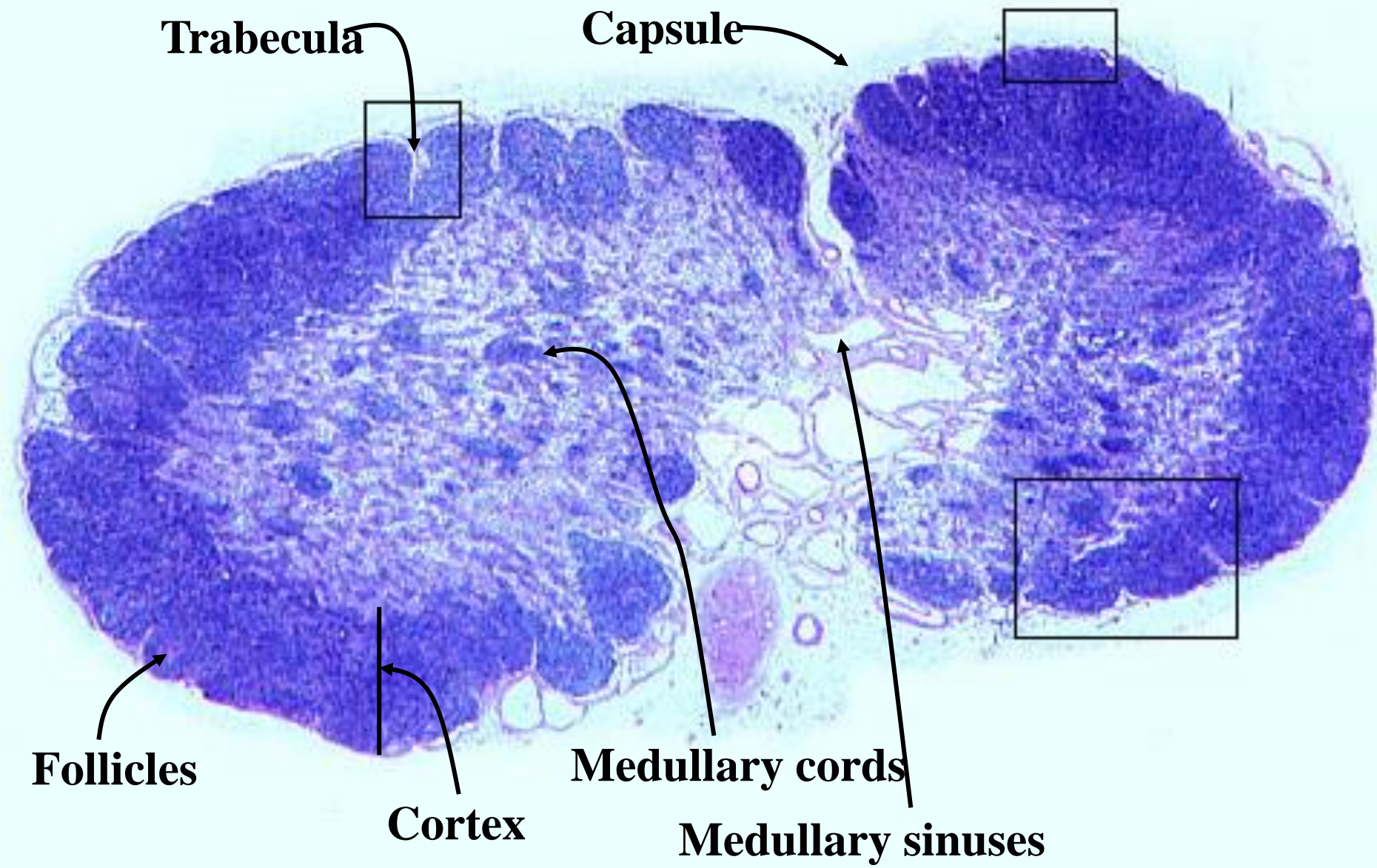
### 3. Lymph Nodes

- Lymph nodes are a nodular aggregates of lymphoid tissue located a long lymphatic channels through out the body
- As the lymph pass through the lymph nodes immune cells sample the antigens of microbes that might enter the body
- Antigens that might enter the body became concentrated and captured in the lymph nodes



# Lymph node

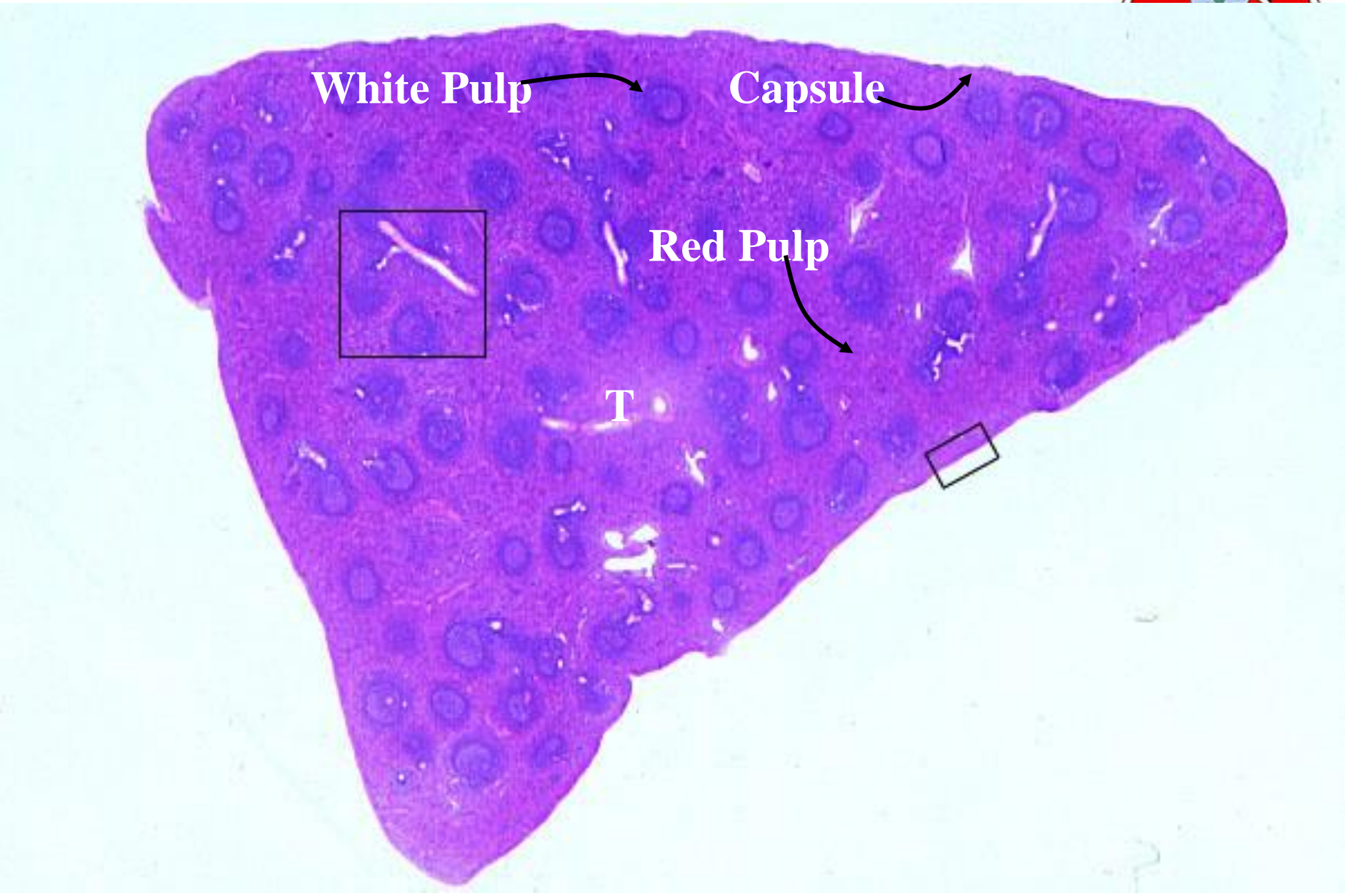






## 4. Spleen

- Abdominal organ that serve as a big lymph node
- Unlike the lymph nodes the spleen is not supplied by lymphatic vessels
- The spleen had two main compartment the red pulp and the white pulp separated by diffuse marginal zone
- Blood enter the spleen through a network of channels called sinusoids
- Blood-borne antigen are trapped and concentrated in the spleen
- Immune cells in the spleen identify, ingest and destroy microbes



**White Pulp**

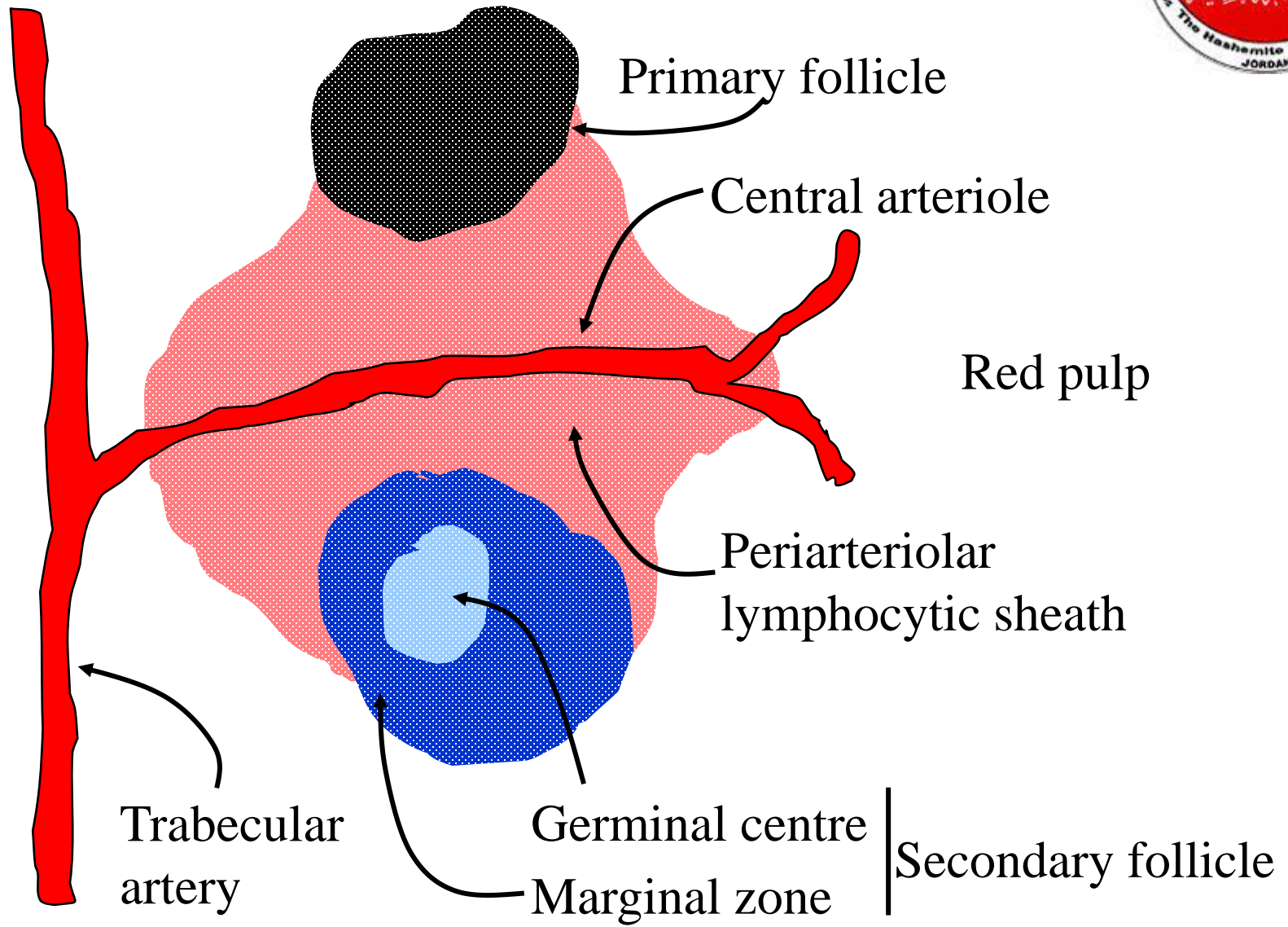
**Capsule**

**Red Pulp**

**T**



# Spleen





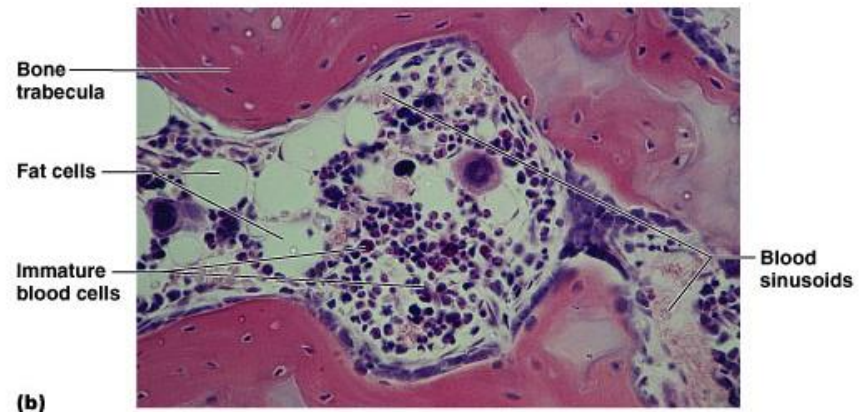
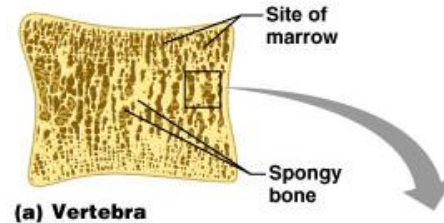
## 5. Cutaneous and Mucosal Lymphoid Organs

- Located under the epithelia of the skin, GIT and respiratory tracts. It includes pharyngeal tonsils, adenoids, appendix and peyer's patch
- Sites of immune response to microorganisms that breach epithelia



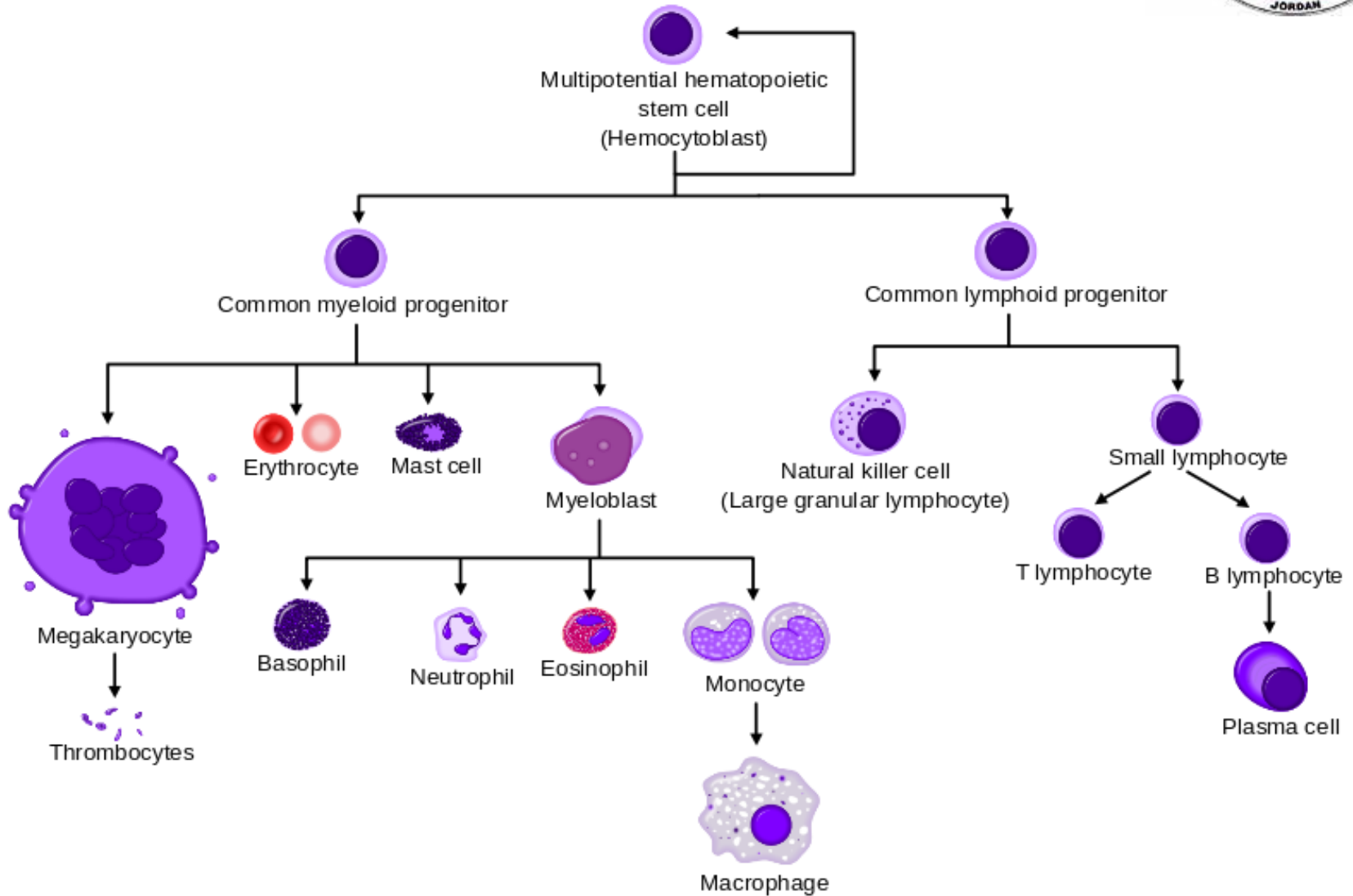
# Hematopoiesis

- Formation of blood cells
- Occurs mostly in red bone marrow
- All cells arise from same **blood stem cell** (pluripotent hematopoietic stem cells)

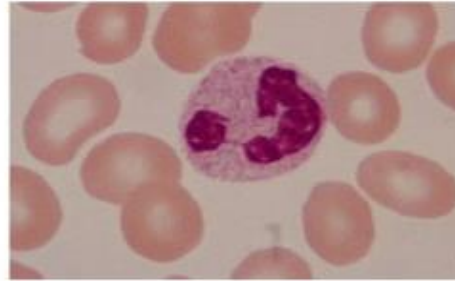




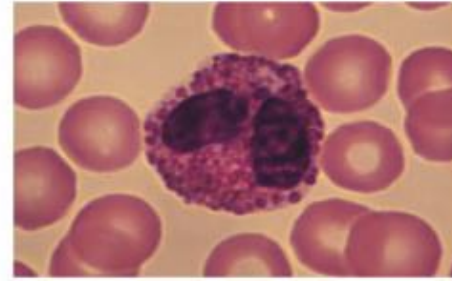
# Formation of Blood Cells



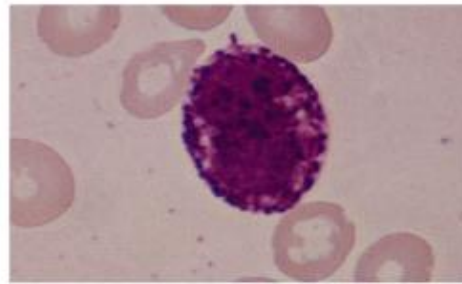
# Leukocytes



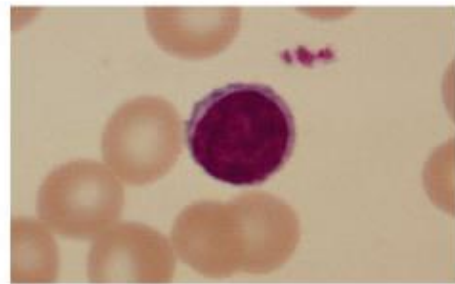
(a) neutrophil



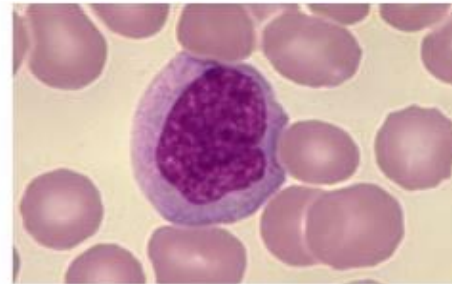
(b) eosinophil



(c) basophil



(d) small lymphocyte



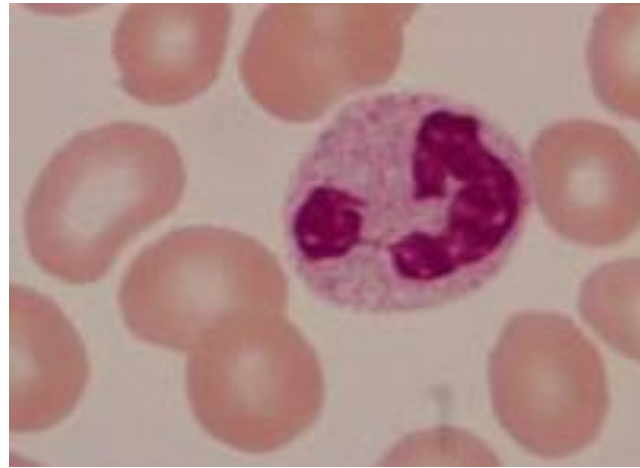
(e) monocyte



# Leukocyte Types

- Artificial division into granulocytes and agranulocytes
- Granulocytes: neutrophils, eosinophils, basophils (according to how stain)
  - Granules
  - Lobed nuclei
  - All are phagocytic
- Agranulocytes: lymphocytes, monocytes

# 1. Neutrophils

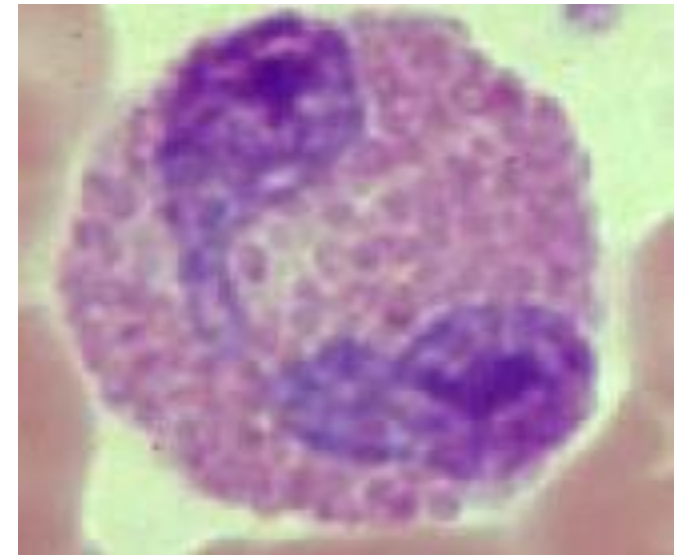
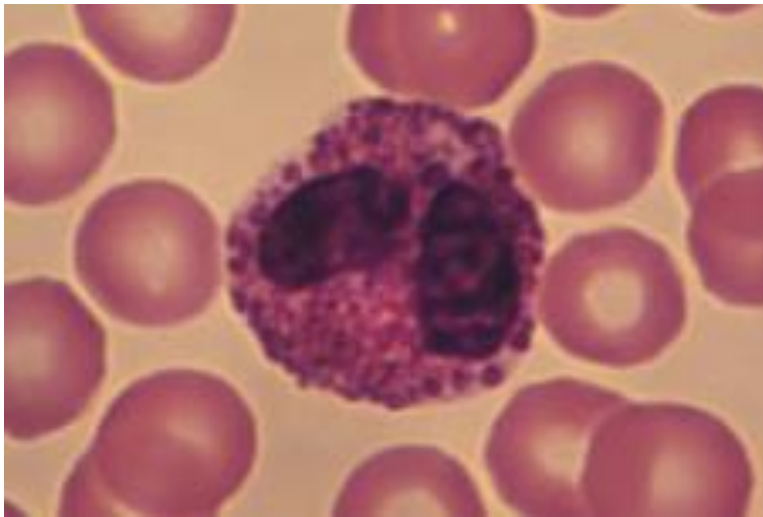


- 60% of all WBCs
- Other names: Polymorphonuclear cells (PMNs, polys, segs)
- Appearance: pink granules in cytoplasm, nucleus has 3-5 lobes
- Function: Phagocytosis of **bacteria**
  - Granules have enzymes
  - Can damage tissue if severe or prolonged
  - Form pus



## 2. Eosinophils

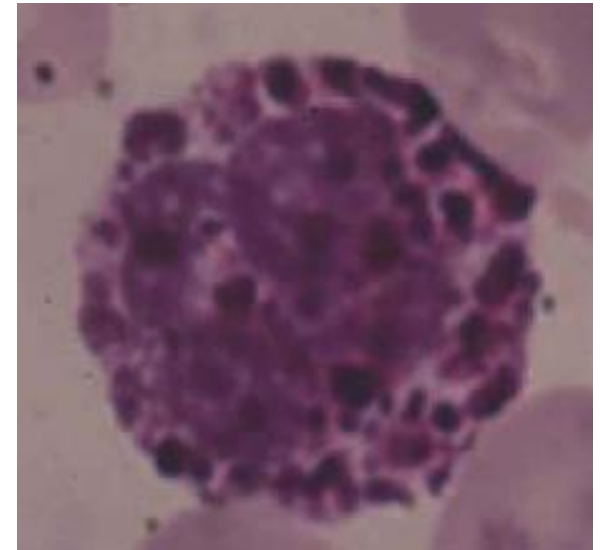
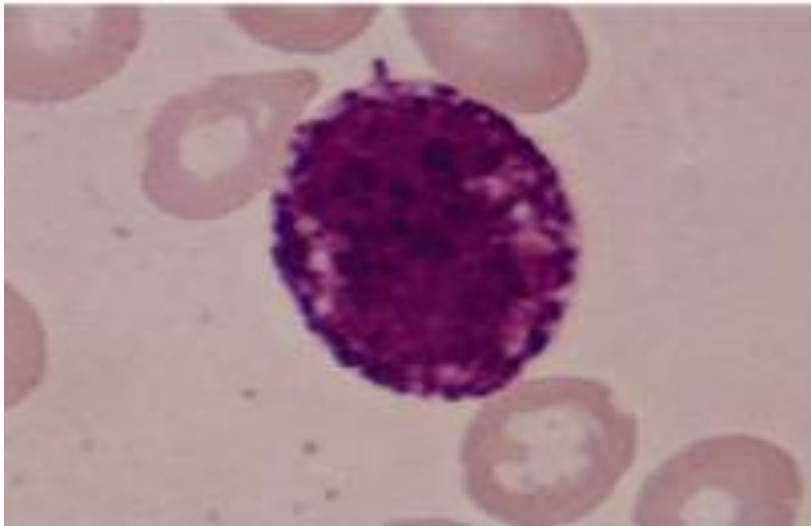
- 1-4 % of leukocytes
- Bilobed and contain eosinophilic granules which have digestive enzymes
- Role in ending allergic reactions and in fighting parasitic infections





## 3. Basophils

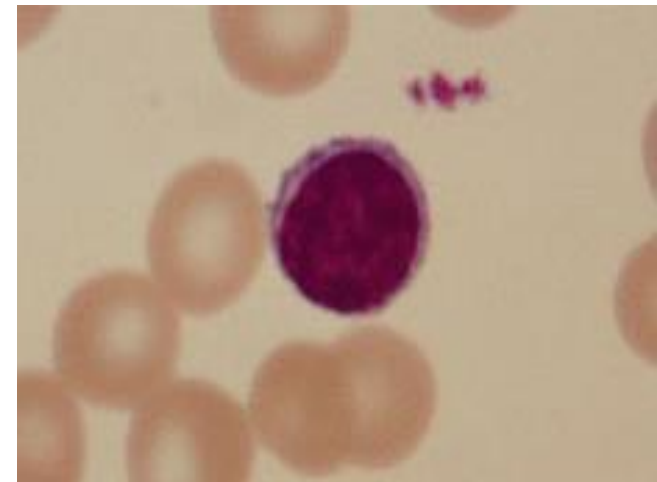
- Rarest WBC, <1% WBC
- Bilobed nucleus
- Dark purple granules (basophilic granules)
- Granules contain: histamine and heparin
- IgE receptors - Involved in allergy





## 4. Lymphocytes

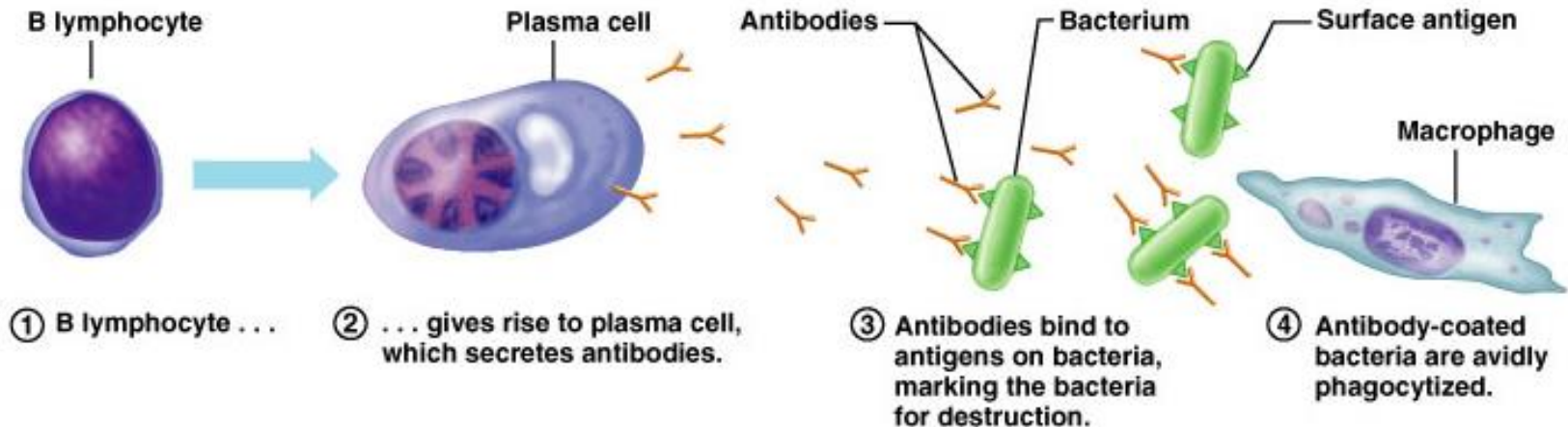
- Most important WBC 20-45%
- Small (same size as RBCs)
- Mostly present in lymphoid connective tissue, e.g. lymph nodes, tonsils, spleen
- Nucleus occupies most of the cell volume (little visible cytoplasm) and no specific granules
- Two main types attack antigens in different ways
  1. T cells
  2. B cellsplus “natural killer cells”





# B cells

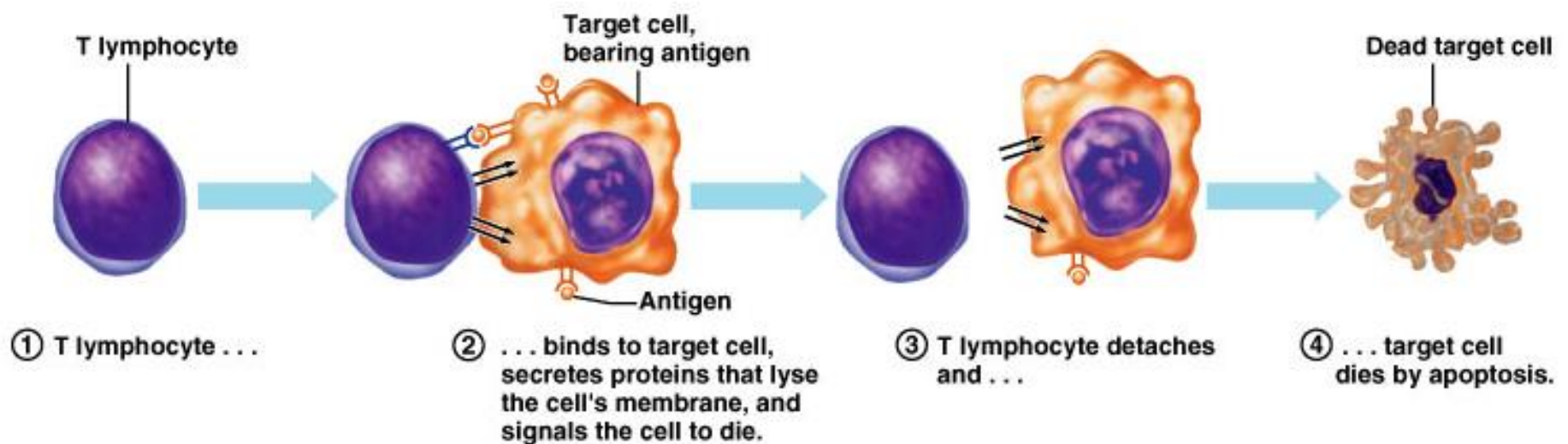
- Formed and mature in the bursa of Fabricius in birds and in bone marrow in mammals
- Differentiate into plasma cells that secrete antibodies or become a memory cells that live longer
- B cells also display antibodies on their membrane



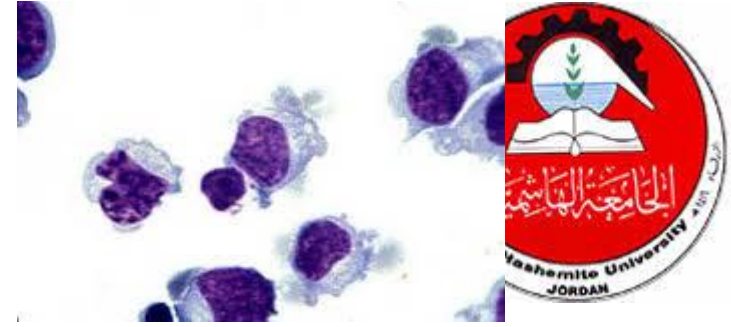


# T cells

- T lymphocyte mature in thymus
- T cells antigen binding molecule called T cell receptor
- T cells are subdivided into 3 main groups: Helper T cells, Cytotoxic T cells, and regulatory T cells

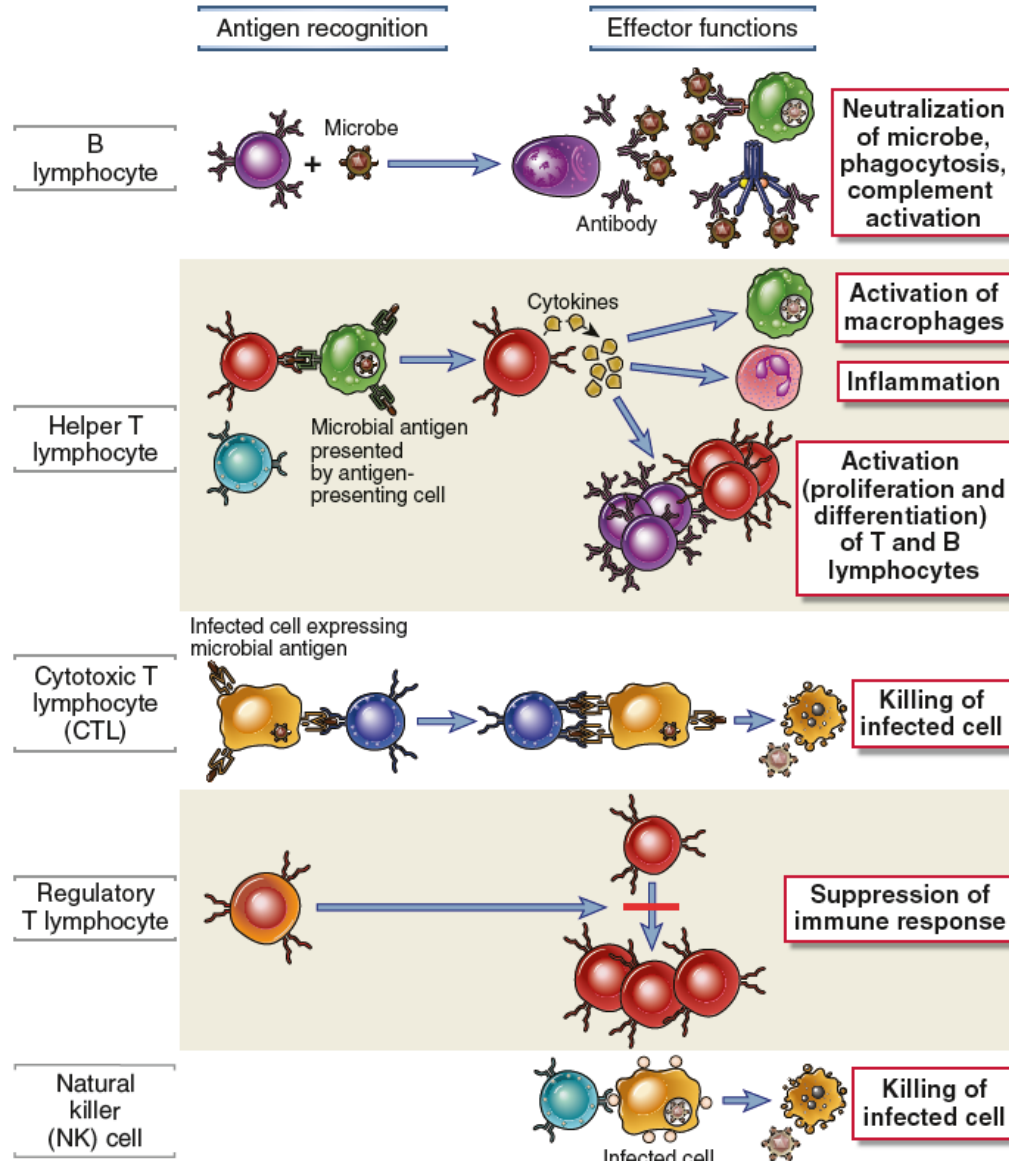


## 5. Natural Killer Cells (NK)



- Constitute 5-10% of human lymphocyte are large and granular cells
- Display cytotoxic activity against tumor cells and cells infected with viruses
- These cells do not have specific receptors for antigens on their surface and are considered part of innate immunity
- NK cells have receptors for antibodies and can destroy targeted cells through a process known as **antibody-dependent cell mediated toxicity**

# Classes of Lymphocytes



# 6. Monocytes/ Macrophages



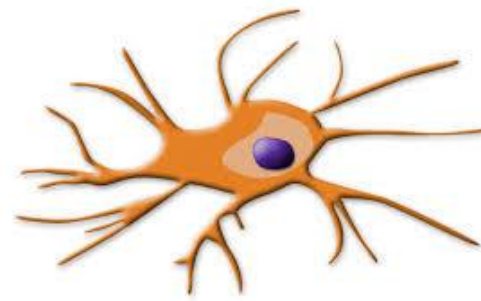
## Monocyte

- 3-8% WBC
- Monocytes circulate in blood for about 8 hours then it enlarge and migrate into tissues and differentiate into specific tissue macrophage
- Recruited to sites of inflammation

## Macrophages

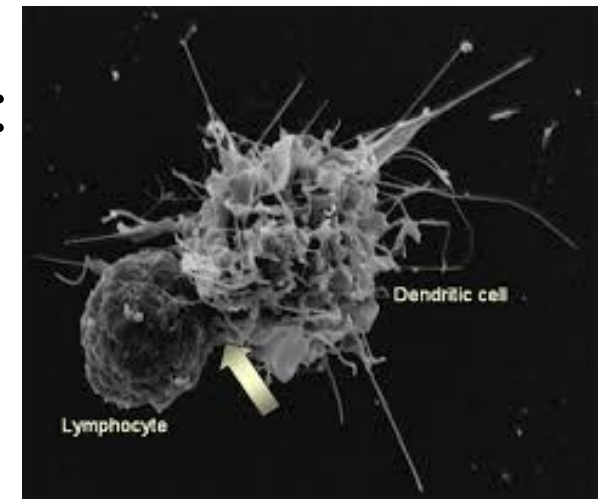
- Macrophage play role in phagocytosis, bacterial killing, and antigen presentation
- Some macrophages move through the body and remain as free macrophage and some reside in particular tissue and become fixed macrophage like:
  - Peritoneal cavity: peritoneal macrophages
  - Lung: alveolar macrophages
  - Spleen: splenic macrophages
  - Liver: Kupffer cells
  - Intestinal macrophage
  - Microglial cells in brain
  - Histocytes in connective tissue





## 7. Dendritic Cells

- Acquired its name because it is covered with long membrane extensions that resemble the dendrites of nerve cells
- Dendritic cells have 4 main classes:
  - Langerhans DCs
  - Interstitial DCs
  - Monocyte-derived DCs
  - Plasmacytoid-derived DCs
- DCs main functions are monitoring of body pathogen invasion and presentations of antigens for T cells



# Stages of Lymphocyte Activation



- Naïve lymphocytes
  - Mature lymphocytes that have not previously encountered antigen; function -- antigen recognition
  - Preferential migration to peripheral lymphoid organs (lymph nodes), the sites where antigens are concentrated, and immune responses start
- Effector lymphocytes
  - Activated lymphocytes capable of performing the functions required to eliminate microbes (effector functions)
  - Effector T lymphocytes: cytokine secretion (helper cells), killing of infected cells (CTLs)
  - B lymphocytes: antibody-secreting cells (e.g., plasma cells)
- Memory lymphocytes
  - Long-lived, functionally silent cells; mount rapid responses to antigen challenge (secondary responses)

# Function of Immune Cells



- Lymphocytes of the adaptive immune system
  1. T helper cells: regulate other immune cells
  2. T cytotoxic (killer) cells: kill infected cells
  3. B cells: produce antibodies (immunoglobulin)
- Dendritic cells and macrophage: directly kill microbes by phagocytosis and other mechanisms. They also help to activate T cells (connection between innate and adaptive immunity)
- Dendritic cells and other Antigen presenting cells (APCs) also play role in capturing microbes and then process and display antigens
- NK cells are lymphocytes: Recognizes and kill abnormal cells like tumour cells, and virus infected cells

# Lymphocyte Circulation



- Lymphocytes constantly circulates between tissues in such a way that
  1. naïve lymphocytes traverse the peripheral lymphoid organs where immune response are initiated
  2. the effectors lymphocytes migrates to sites of infections to eliminates microbes
- Lymph: Fluids from all epithelia, connective tissues and paranchymal organs is drained by lymphatic's



# Lymphocyte Circulation

## Lymphocyte Circulation:

1. Lymphocytes & lymph return to blood via thoracic duct
2. Naïve lymphocytes enter lymph nodes from blood

**Naïve lymphocytes:** Have not seen Ag

blood → Lymph nodes → lymphatics → thoracic duct → blood

**Small T & B lymphocytes:** Recirculating population of lymphocytes

**Effector cells:** Recognize (“seen”) Ag; Differentiate in lymph nodes

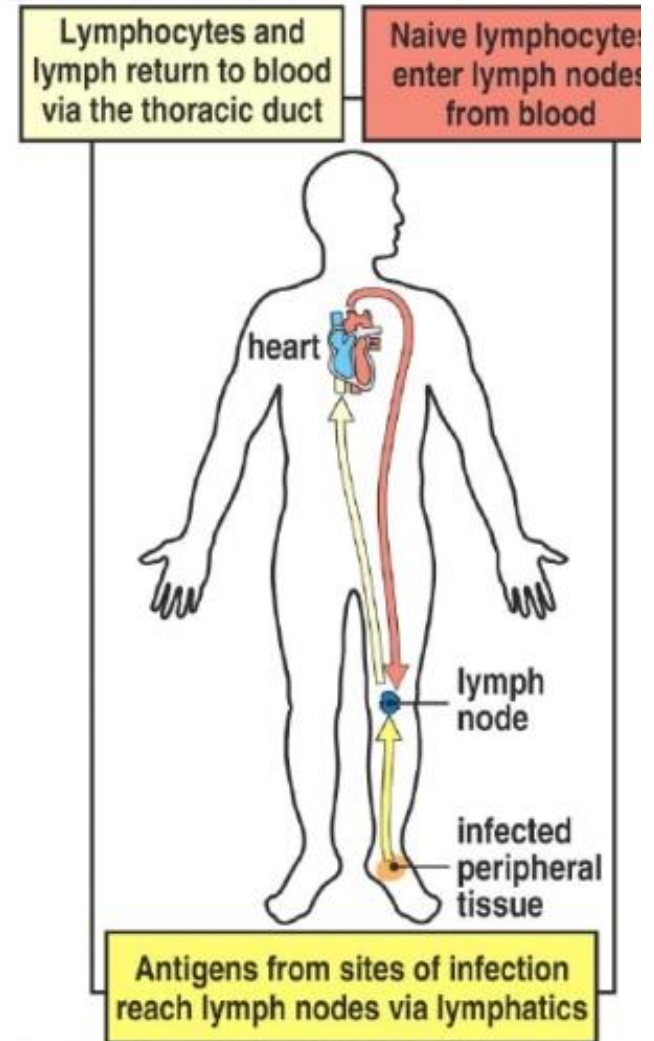


Figure 1-11 Immunobiology, 6/e. (© Garland Science 2005)

# The CD nomenclature

- Structurally defined leukocyte surface molecule that is expressed on cells of a particular lineage and recognized by a group (“cluster”) of specific antibodies is called a member of a cluster of differentiation (CD)
- Used to classify leukocytes into functionally distinct subpopulations, e.g., helper T cells are CD4+, Cytotoxic T cells are CD8+, and Regulatory T cells are CD4+ and CD25+
- Often involved in leukocyte functions
- Antibodies against various CD molecules are used to:
  1. Identify and isolate leukocyte subpopulations
  2. Study functions of leukocytes
  3. Eliminate particular cell populations