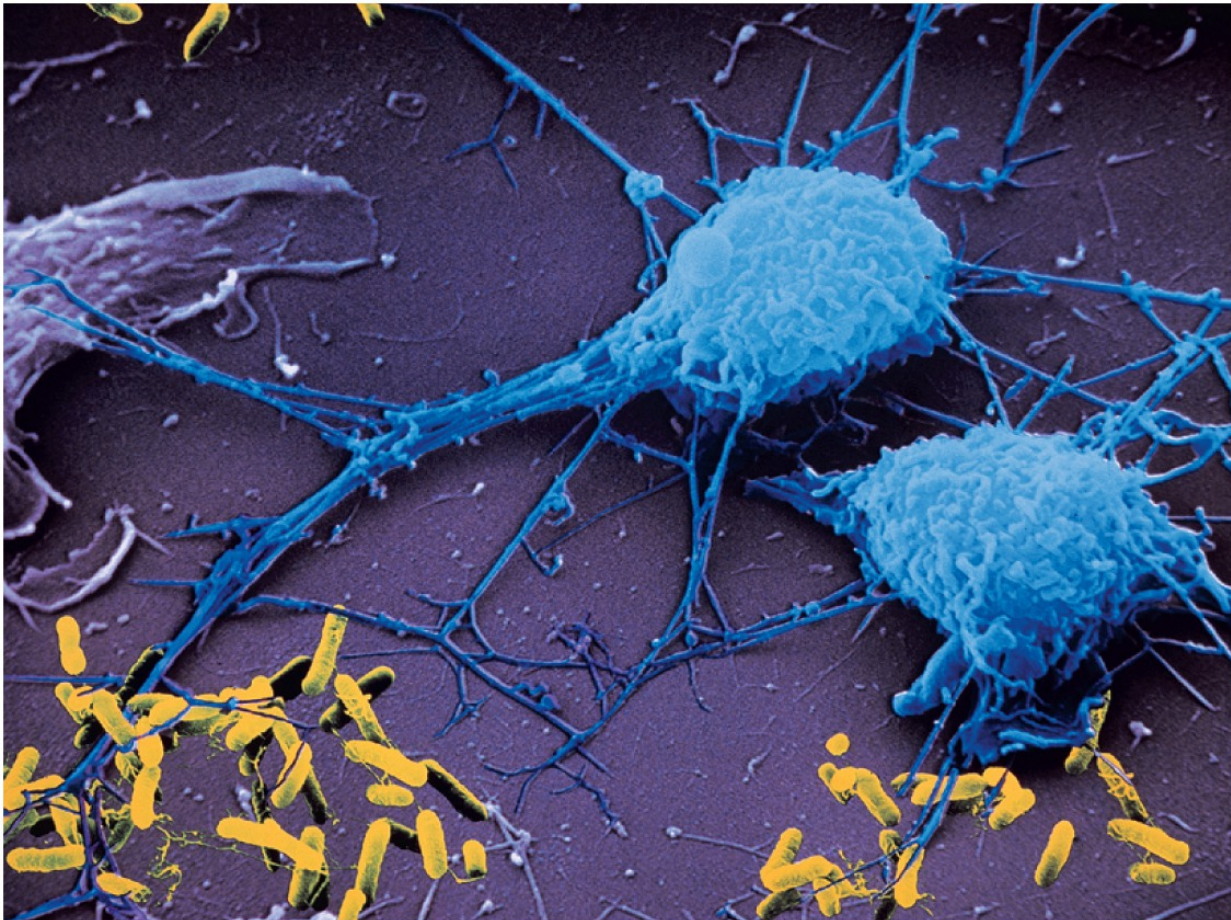


Chapter 21.3

What is the Difference Between Lymphatic Cells, Lymphatic Tissue, and Lymphatic Organs?

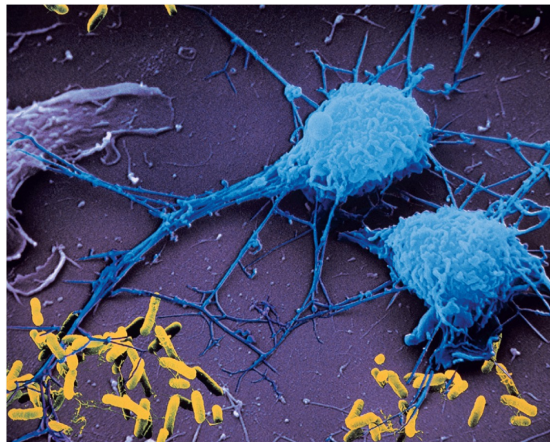


What is the Difference Between Lymphatic Cells, Lymphatic Tissue, and Lymphatic Organs?

Lymphatic cells are white blood cells. These are the cells responsible for cleaning up cell damage and ridding the body of pathogens.

Lymphatic cells are “nomadic”. Meaning they do not form organs and are free to move through your body. One moment they are in the blood, then in the interstitial space, then using the seams of connective tissue to penetrate into our organs. Crazy!

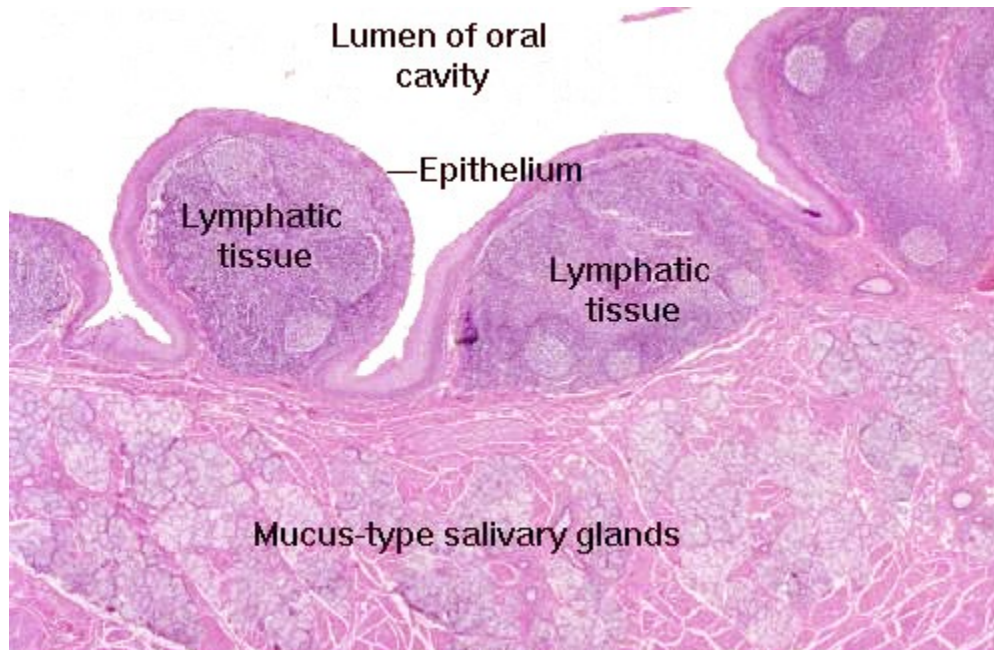
These cells are constantly on the hunt looking for pathogens.



What is the Difference Between Lymphatic Cells, Lymphatic Tissue, and Lymphatic Organs?

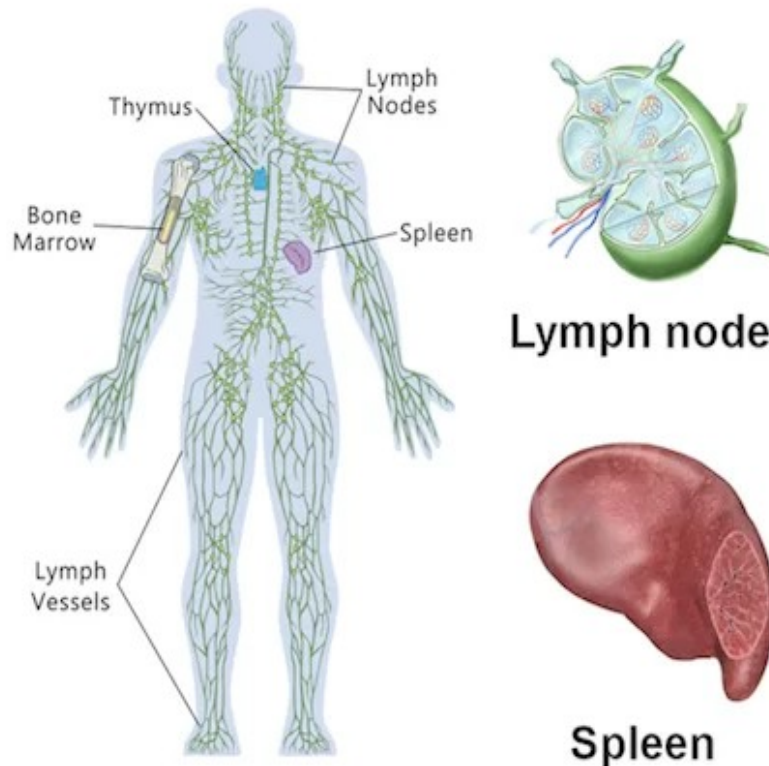
Lymphatic cells form lymphatic tissue when different classes of WBC converge in an area to destroy a pathogen. Each type of WBC bring their unique function as they cluster together.

As a team they will overcome the threat. (If we are lucky!) After their victory, the **cells disband** and return to their nomadic function after pathogen defeated.



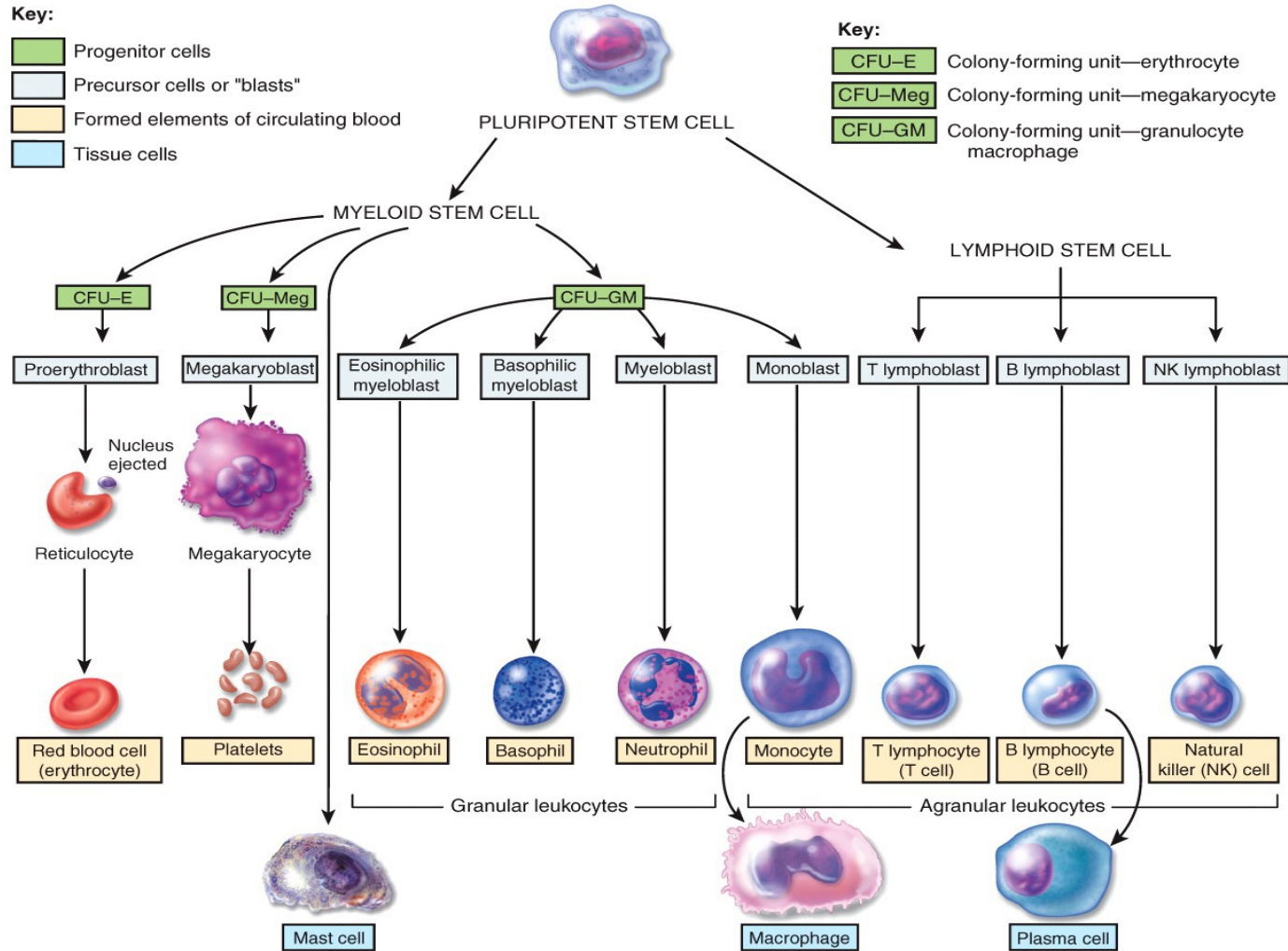
What is the Difference Between Lymphatic Cells, Lymphatic Tissue, and Lymphatic Organs?

Lymphatic organs are surrounded by a connective tissue capsule with many different types of “**resident WBCs**”. Lymphatic organs provide a resting place for lymphatic cells, like a half-way house. We find the highest concentration of lymphocytes and macrophage inside lymphatic organs. The WBC are free to leave and wander about your body.



Lymphatic Cells

We have already covered the formed elements of blood. You should already have flash cards made to review the function of these WBCs. Slides six through 26 are a review.



Leukocytes (WBCs)

- **Least abundant** of all the formed elements // 5,000 to 10,000 WBCs/ μ L (out numbered by RBC and platelets)
- Primary function = protect against infectious microorganisms and other pathogens
- WBCs have conspicuous nucleus
- **Spend only a few hours in the blood stream before migrating out of blood and into connective tissue (i.e. reticuloendothelial system)**
- Retain their organelles for protein synthesis
- All WBC have granules but some cells don't stain!

Types of Leukocytes

- Granulocytes // these cells stain // known as the “NEBs”

- neutrophils (60-70

- eosinophils (2-4%)

- basophils (<1%)

← The “NEB”

- Agranulocytes // these don't stain

- lymphocytes (25-33%)

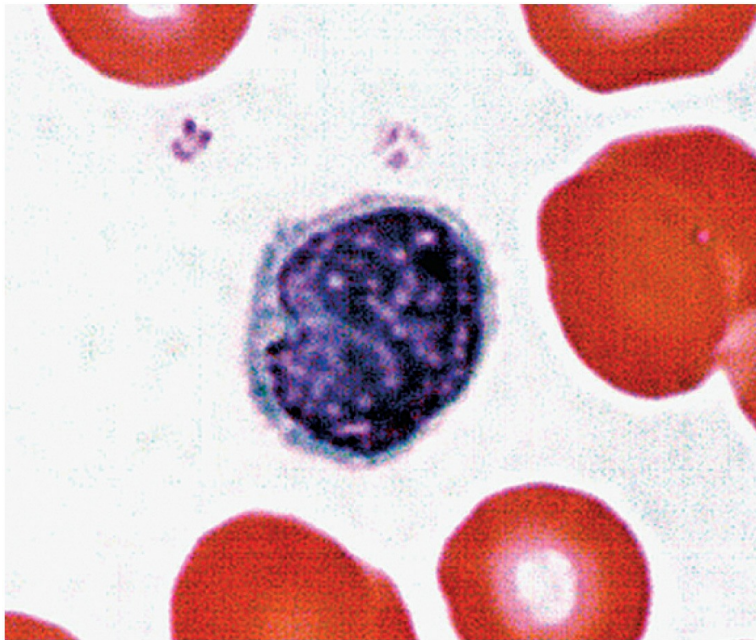
- monocytes (3-8%)

← The “LM”

-
- How to remember WBC ranking = Never let monkeys eat bananas

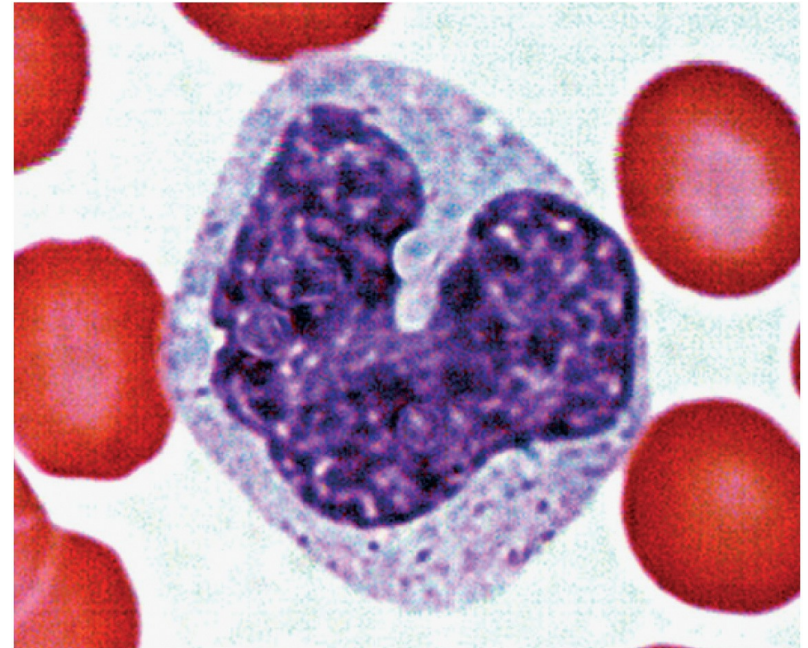
Immunity and Agranulocytes

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Lymphocyte

10 μm



Monocyte

10 μm

Agranulocytes

The Lymphocytes and Monocytes

Three Types of Lymphocytes

Natural killer cells (NK)

- large lymphocytes
- responsible for immune surveillance
- attack and destroy bacteria
- Attach and destroy transplanted tissue
- Attack and destroy host cells infected with viruses or cells that become cancerous

• **T lymphocytes (T cells)**

- mature in thymus
- Helper T Cells, Cytotoxic T Cells, Memory T Cells, Regulatory T Cells

• **B lymphocytes (B cells)**

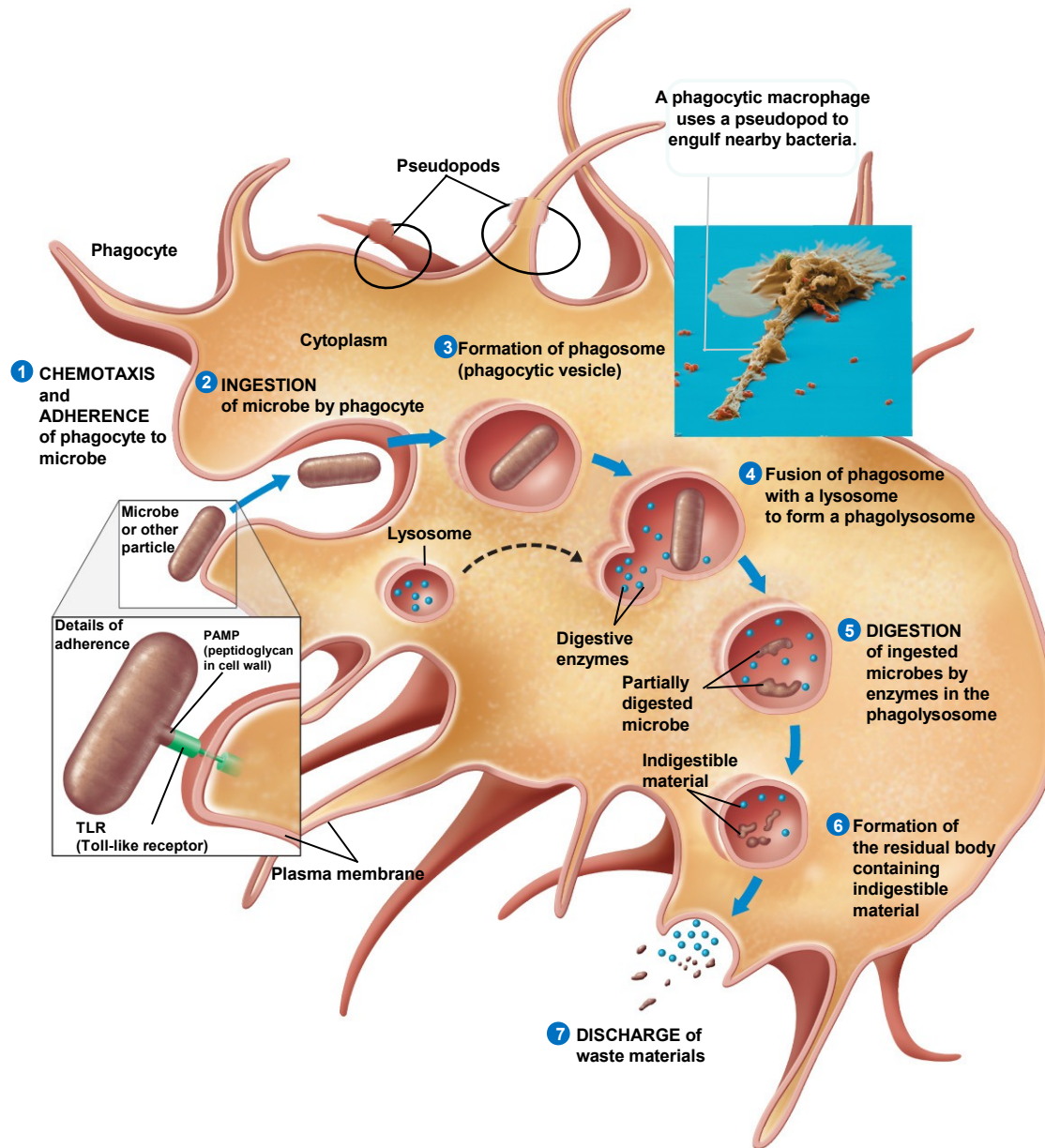
- activation causes proliferation and differentiation into **plasma cells**
- **Plasma cells** produce **antibodies**
- Memory B Cells
- Antigen presenting cell

Monocytes

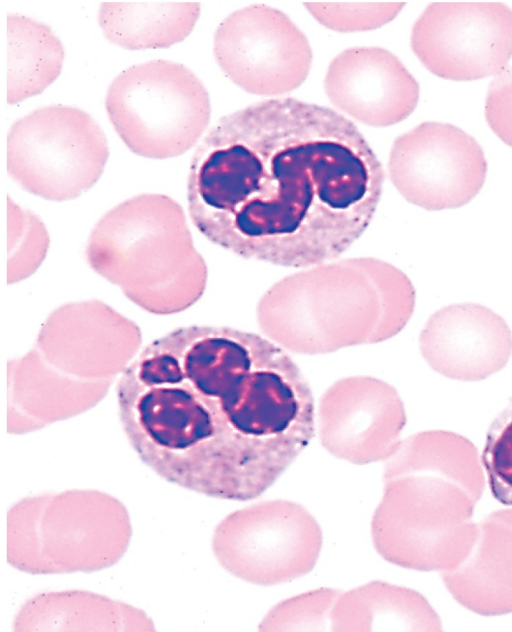
(Monocytes Change to Macrophage)

- 3-8% // largest WBC; ovoid, kidney or horseshoe shaped nucleus
- increased numbers in viral infections and inflammation
- produce and secrete **cytokines** = group of molecules which regulate an immune response
- same cell will leave bloodstream and transform into **macrophages** (i.e. big eater) – performs two important functions
- #1 - phagocytize pathogens and debris // the “garbage collector”
- #2 - “present” antigens to activate other immune cells // **antigen presenting cells** (APCs) /// shares this function with B cells and dendritic cells

The Phases of Phagocytosis and Antigen Presentation

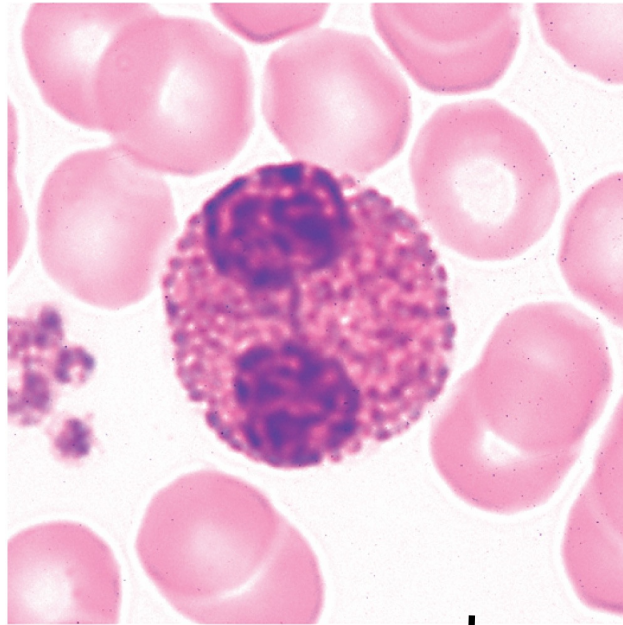


Immunity and Granulocytes



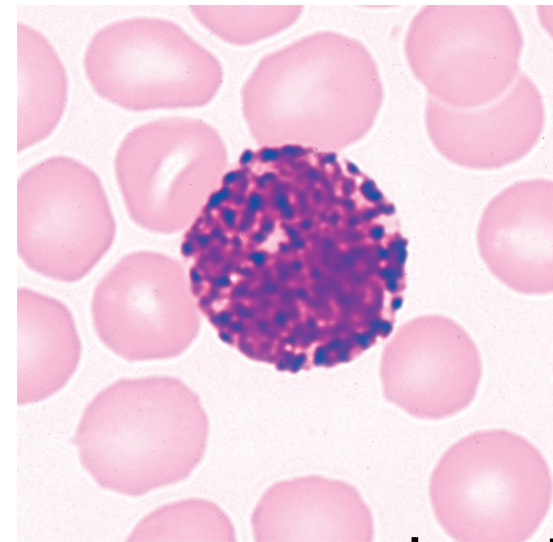
Neutrophils

10 μm



Eosinophil

10 μm



Basophil

10 μm

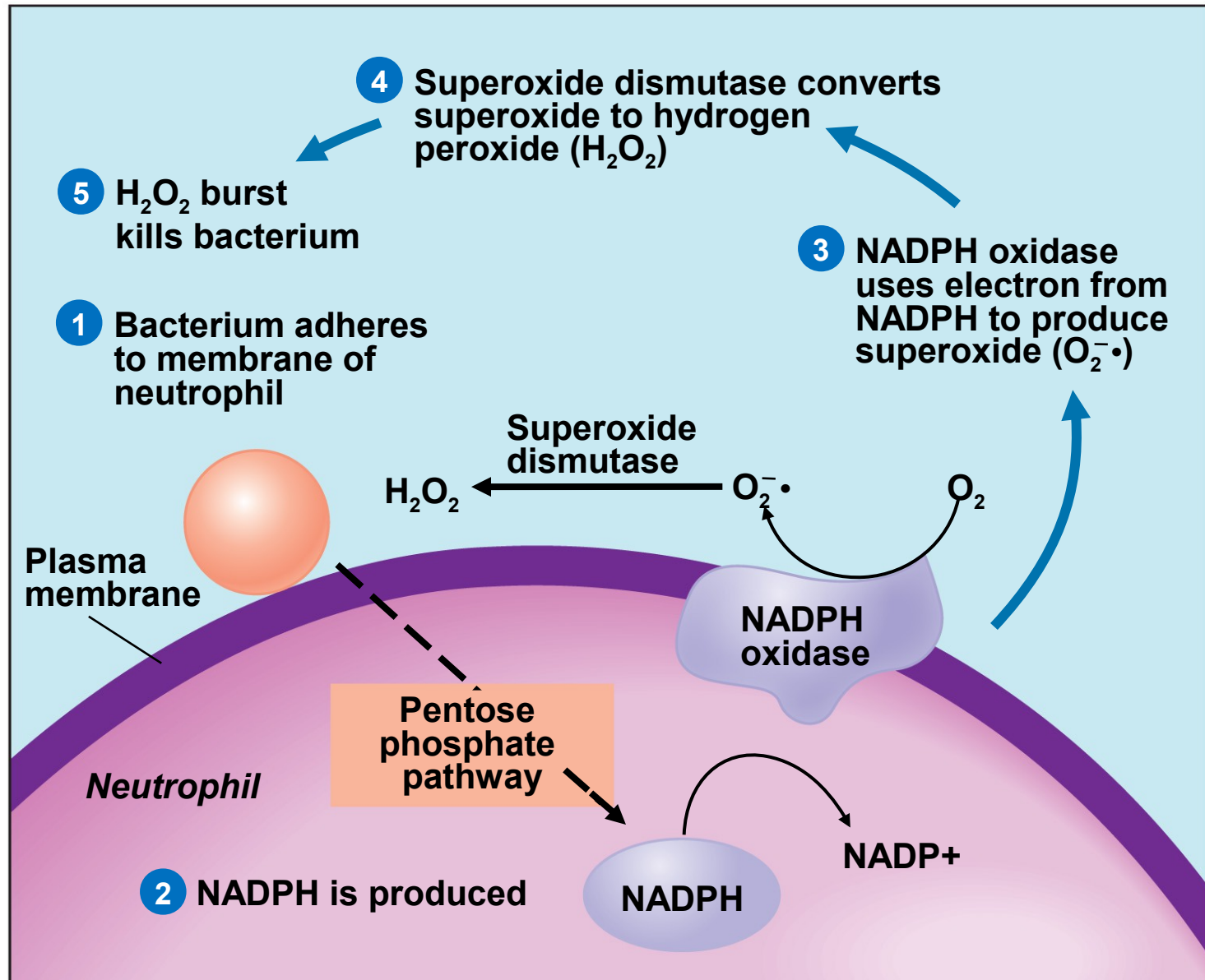
Granulocytes

Neutrophils, Eosinophils, and Basophils

- **Neutrophils**
 - 60-70% of WBC
 - Also known as polymorphonuclear leukocytes
 - Barely visible granules in cytoplasm // 3 to 5 lobed nucleus
 - phagocytosis of bacteria while in blood / phagosomes kill bacteria
 - Emigrate into tissue spaces / chemotaxis
 - First WBC to arrive in the first phase of inflammation
 - increasing numbers in response to **bacterial infections** / neutrophilia – increase 5x
 - release antimicrobial chemicals // called the “**respiratory burst**” – like a nuclear bomb! // hypochlorite – hydrogen peroxide – free radicals

What is an “Oxidative Burst”?

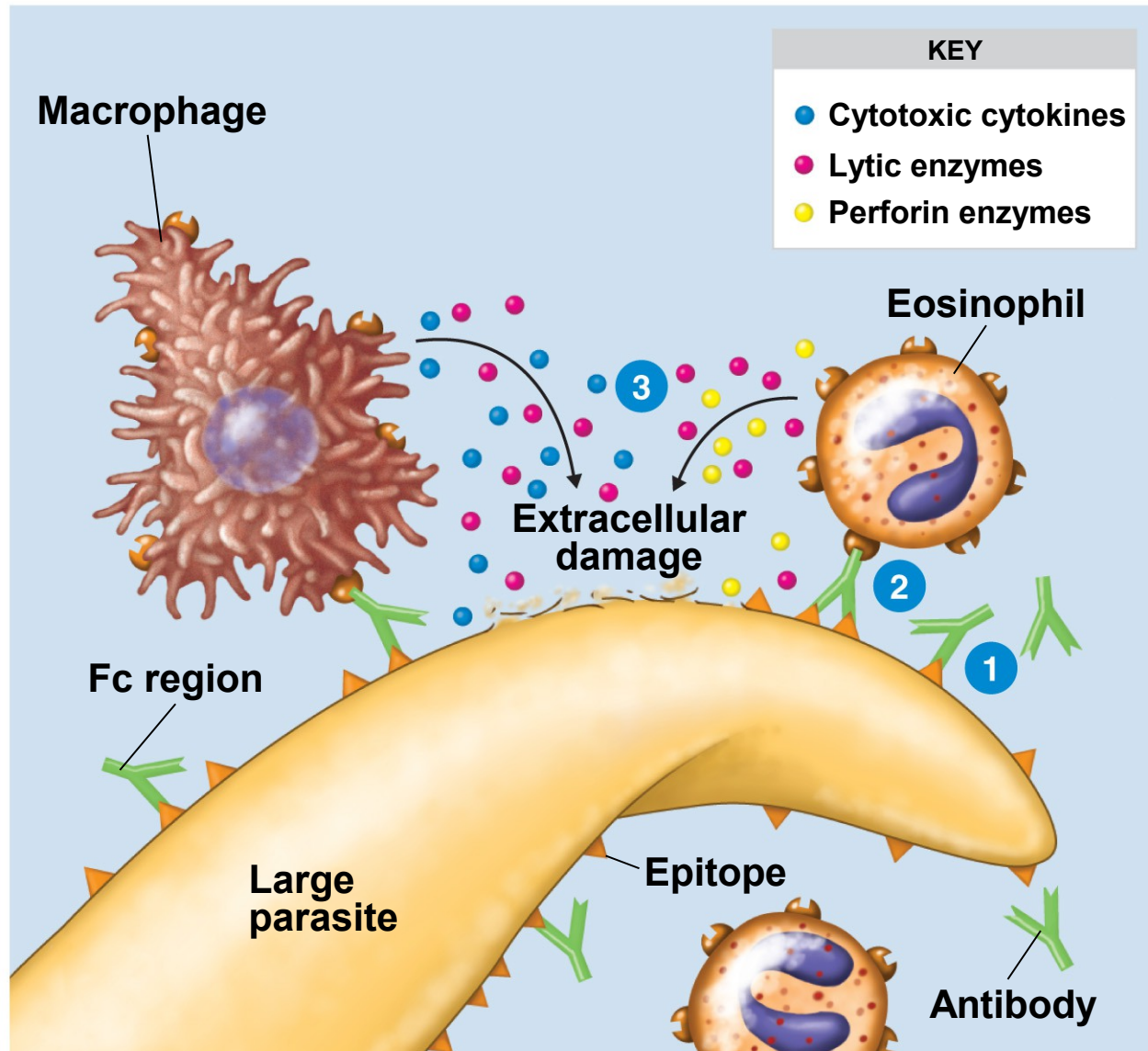
Neutrophils and eosinophils produce oxidative bursts (also known as a respiratory burst).
(Neutrophils also produce hypochlorite to kill bacteria)



Eosinophils

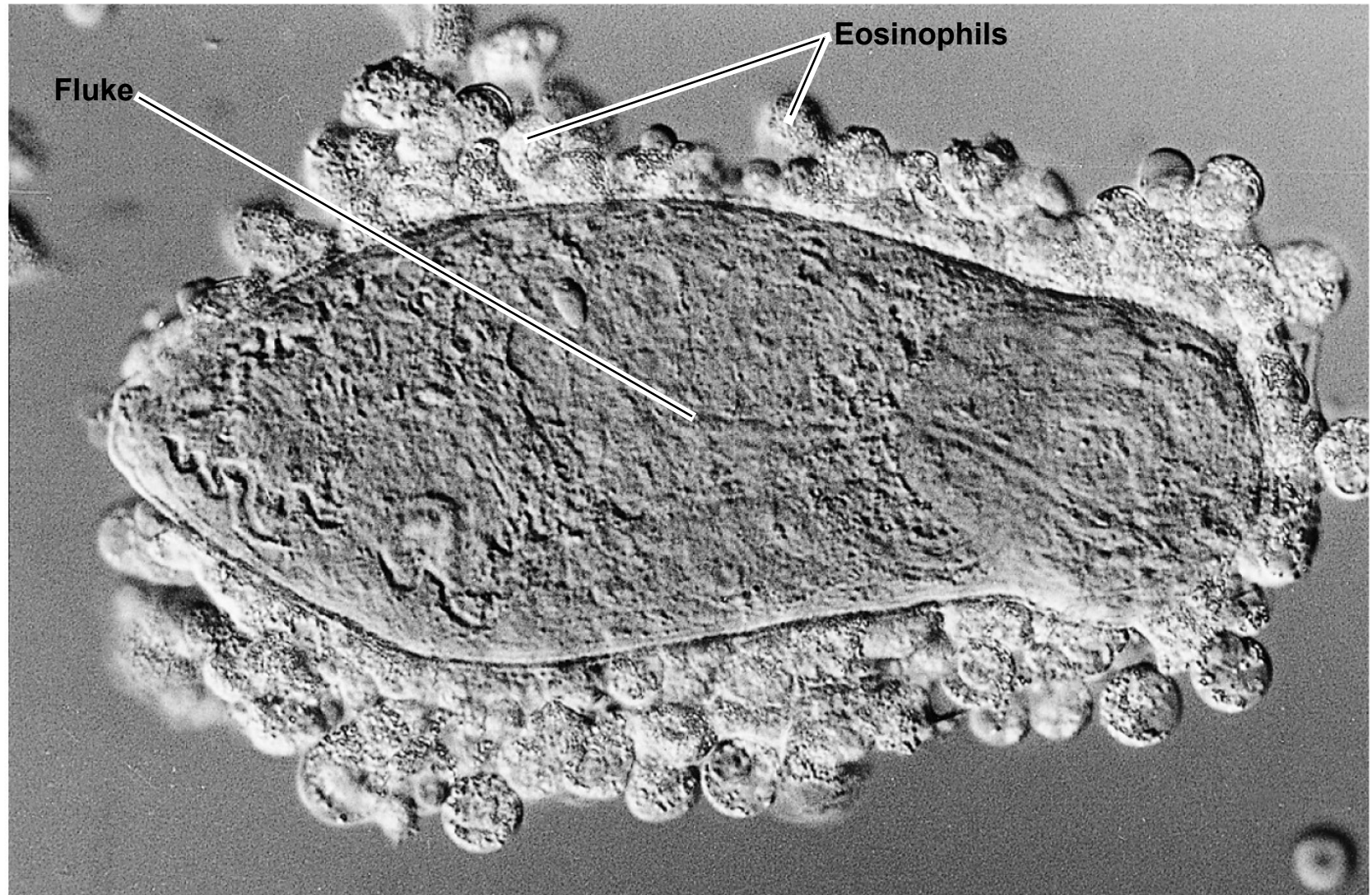
- found especially in the mucous membranes
- 2 - 4% // large rosy-orange granules, bi-lobe nucleus
- stand guard against **parasites, allergens**, and other pathogens
- **kill tapeworms and roundworms** by producing superoxide, hydrogen peroxide, and toxic proteins
- promote action of **basophils** and **mast cells**
- **phagocytize antigen-antibody complexes**
- limit action of **histamine** and other inflammatory chemicals
- Increase numbers in collagen diseases, allergies, diseases of spleen and CNS

Antibody-dependent cell-mediated cytotoxicity (ADCC).



Organisms, such as many parasites, that are too large for ingestion by phagocytic cells must be attacked externally.

Antibody-dependent cell-mediated cytotoxicity (ADCC).



(b) Eosinophils adhering to the larval stage of a parasitic fluke.

SEM

20 μ m

Basophils

(Basophils Change into Mast Cells)

Less than one percent // solid staining cytoplasm

Basophils in blood // called mast cells in tissue

Emigrate from blood to tissue // Change into a **mast cells**

Fix themselves to extracellular collagen fibers of the matrix

Acquire over time surface receptors = E class antibodies

As new IgE produced by plasma cells during “first exposure” to pathogen

Antibodies used to render invading pathogen harmless and tag it for destruction

Some of these same antibodies insert themselves into plasma membrane of mast cells

These mast cells will now be able to interact with similar pathogens in the future.

Basophils

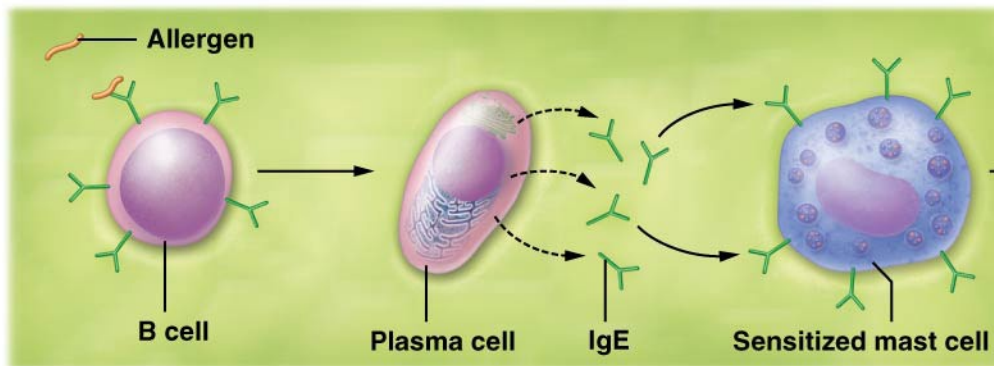
(Basophils Change into Mast Cells)

- Upon second exposure foreign antigen cause mast cells to release histamine and heparin
- See increased numbers in chicken pox, sinusitis, diabetes // suggest increasing incident of inflammation
- **histamine** (vasodilator) // speeds flow of blood to an injured area
- secrete **heparin** (anticoagulant) // promotes the mobility of other WBCs in the area

Basophils Become Mast Cells After They Acquire IgE “Receptors”

(Type I hypersensitivity response.)

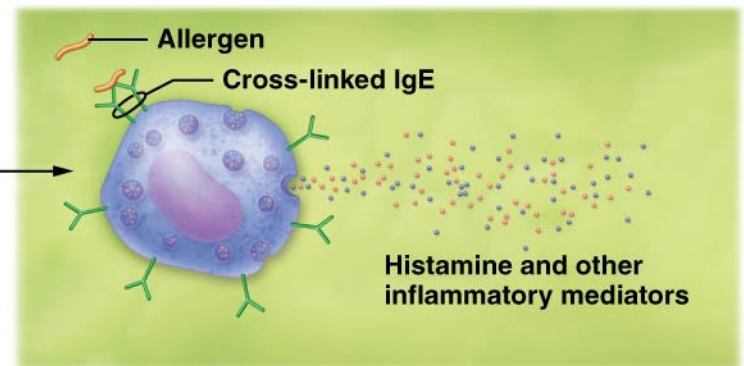
First exposure



① An allergen binds a B cell.

② The B cell differentiates into plasma cells that secrete IgE antibodies, which bind to a mast cell, sensitizing it.

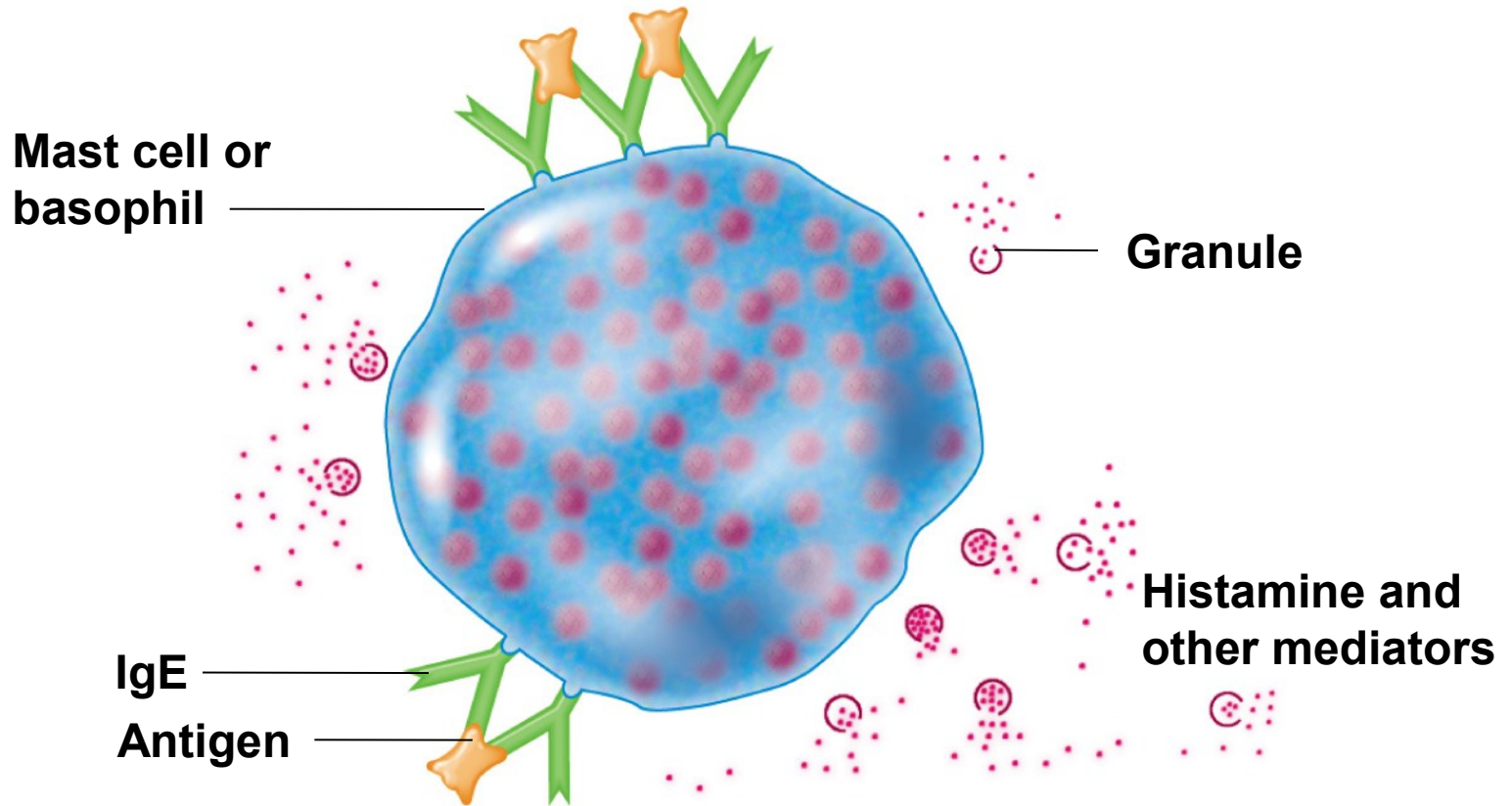
Subsequent exposures



③ The allergen binds the sensitized mast cell, and IgE molecules on the cell form cross-links that cause the cell to release inflammatory mediators from its granules, triggering an inflammatory response.

Note: Basophils are in the blood / Mast cells are attached to collagen fibers within connective tissue.

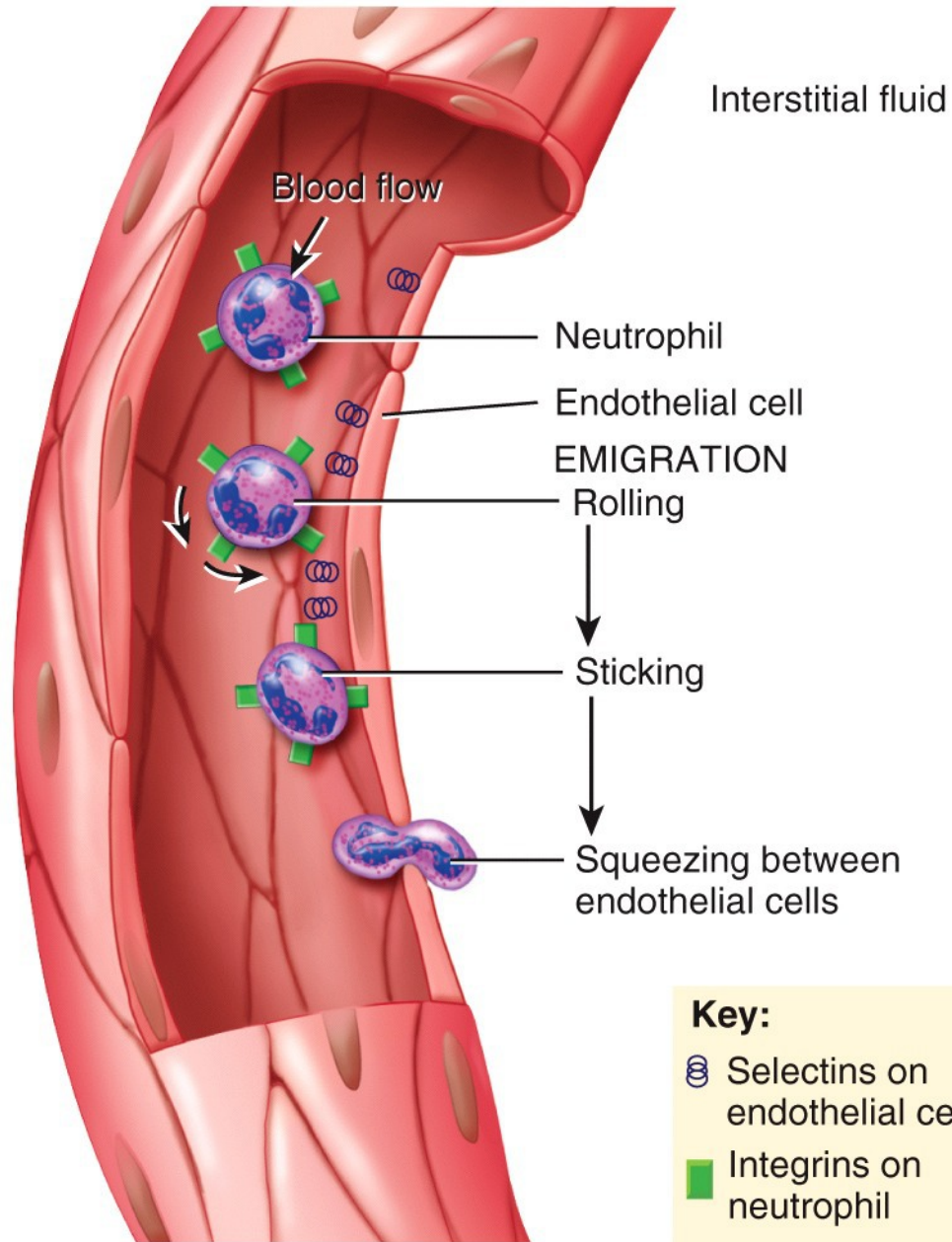
The mechanism of anaphylaxis mediated by mast cell.



IgE antibodies, produced in response to an antigen, coat mast cells and basophils. When an antigen bridges the gap between two adjacent antibody molecules of the same specificity, the cell undergoes degranulation and releases histamine and other mediators.

Diapedesis: How Leukocytes Emigrate into Tissue Spaces

- Circulating WBCs do not stay in bloodstream
 - Area of inflammation causes endothelial cells outer face to become “sticky” – results in margination
 - Granulocytes (NEB) leave in 8 hours and live 5 days longer
 - Monocytes leave in 20 hours, transform into macrophages and live for several years
 - Lymphocytes provide long-term immunity // live for decades // continuously recycled from blood to tissue fluid to lymphatic system and back into the blood



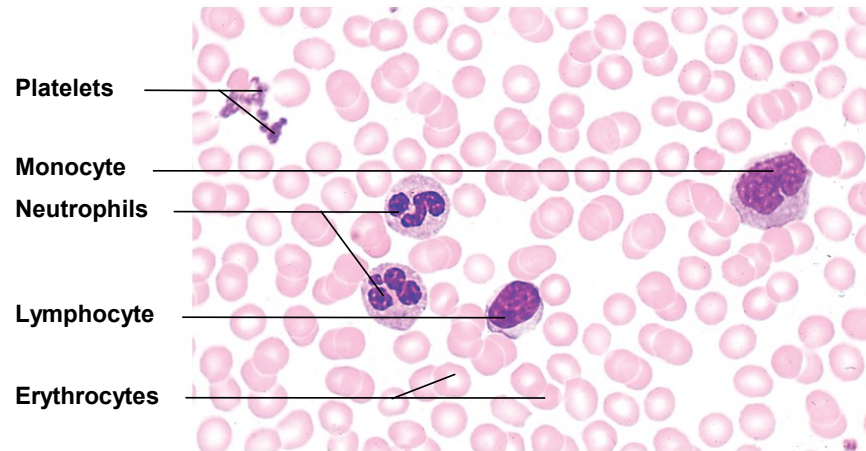
Leukocyte Disorders

- **leukopenia** - low WBC count below 5000/ μ L
 - causes: radiation, poisons, infectious disease
 - effects: elevated risk of infection
- **leukocytosis** - high WBC count above 10,000/ μ L
 - causes: infection, allergy and disease
 - differential WBC count – identifies what percentage of the total WBC count consist of each type of leukocyte

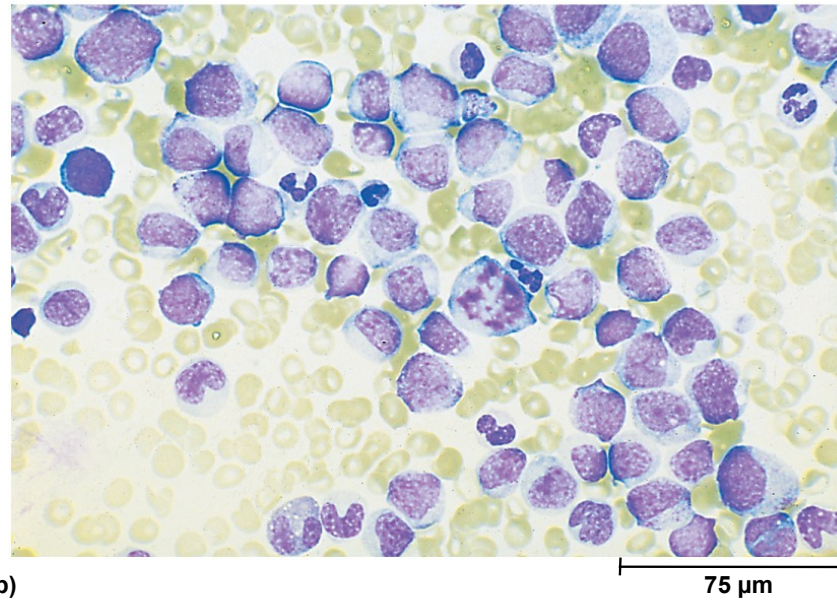
Leukocyte Disorders

- Leukemia - cancer of hemopoietic tissue that usually produces an extraordinary high number of circulating leukocytes and their precursors
 - myeloid leukemia – uncontrolled granulocyte production
 - lymphoid leukemia - uncontrolled lymphocyte or monocyte production
 - acute leukemia – appears suddenly, progresses rapidly, death within months
 - chronic leukemia –undetected for months, survival time three years
 - effects - normal cell percentages disrupted; impaired clotting; opportunistic infections

Normal and Leukemic Blood



(a)



(b)



What Is Lymphatic Tissue?

(Note - Lymphatic Tissue is Not an Organ!)

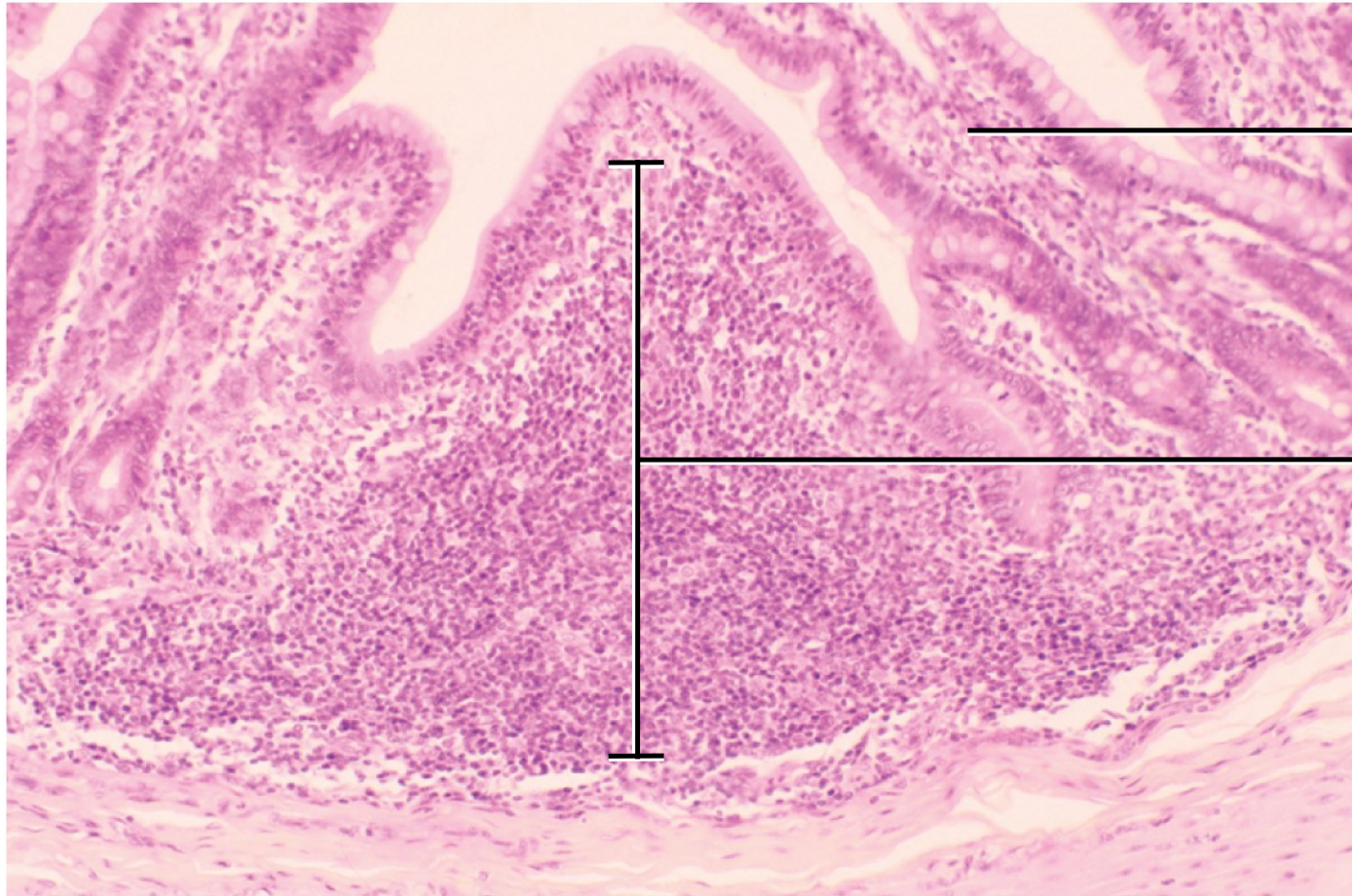
- Lymphatic tissue are “groups or clusters” of transient “mobile lymphocytes” located within the connective tissues of mucous membranes and in the seams of connective tissue within various organs of the body
 - Not surrounded by connective tissue
 - Simplest form is called **diffused lymphatic tissue**
 - If diffused then lymphocytes are more scattered, rather than densely clustered
 - prevalent in body passages open to the exterior /// respiratory, digestive, urinary, and reproductive tracts
 - E.g. mucosa-associated lymphatic tissue (MALT)

Lymphatic tissue is found in three areas.



- #1 – Form lymphatic follicles
 - concentrated masses of leukocytes
 - lymphocytes and macrophages will congregate in response to pathogens // then disperses after pathogen defeated
 - present in the tonsils
 - present under mucous membranes
- #2 - Peyer patches – dense clusters in the ileum, the distal portion of the small intestine

Lymphatic Nodule



Intestinal villus

**Lymphatic
nodule**



Where Is Lymphatic Tissue Found In Body?

#3 - Also Found Inside All Lymphatic Organs

- Lymphatic organs have well-defined anatomical sites
- Lymphatic organs have connective tissue capsules /// *Spleen, thymus, tonsils, and lymph nodes*
- Capsules separate the lymphatic tissue from neighboring tissues
- Dense area of WBCs form “germination centers” // identifiable as “white pulp”

Lymphatic Organs



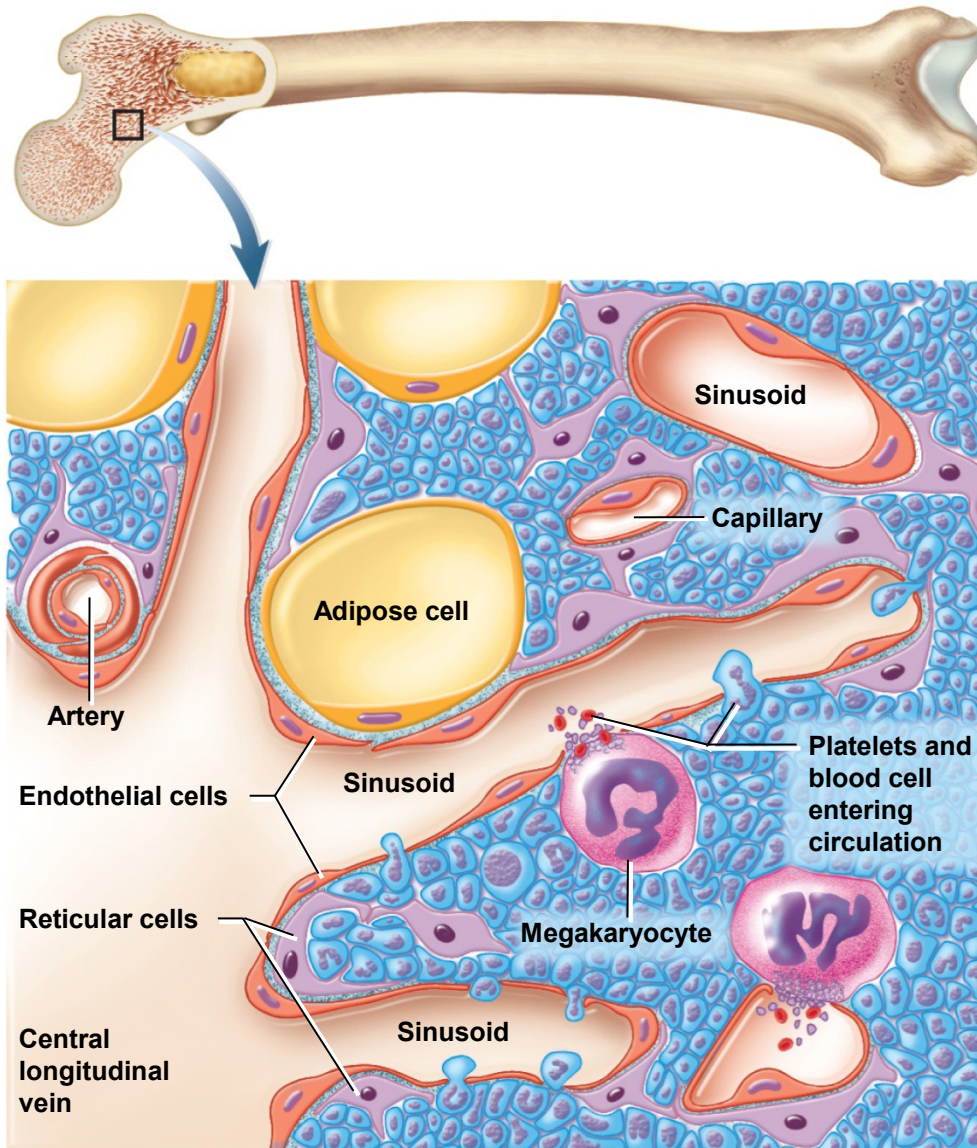
Primary lymphatic organs

- red bone marrow and thymus
- where T and B cells become immunocompetent
 - able to recognize and respond to antigens
 - T and B cells develop plasma membrane receptors matched to pathogen's antigen

Secondary lymphatic organs

- lymph nodes, tonsils, and spleen
- T and B cells “deployed” to secondary lymphatic organs
- T and B cells are now “immuno-competent cells”
- these cells stay “naive” (not active) until T and B cells recognize foreign antigen

Histology of Red Bone Marrow



What type of capillaries are in red bone marrow?

Why?