Lesson 21 – Basic immunology: The second line of defense

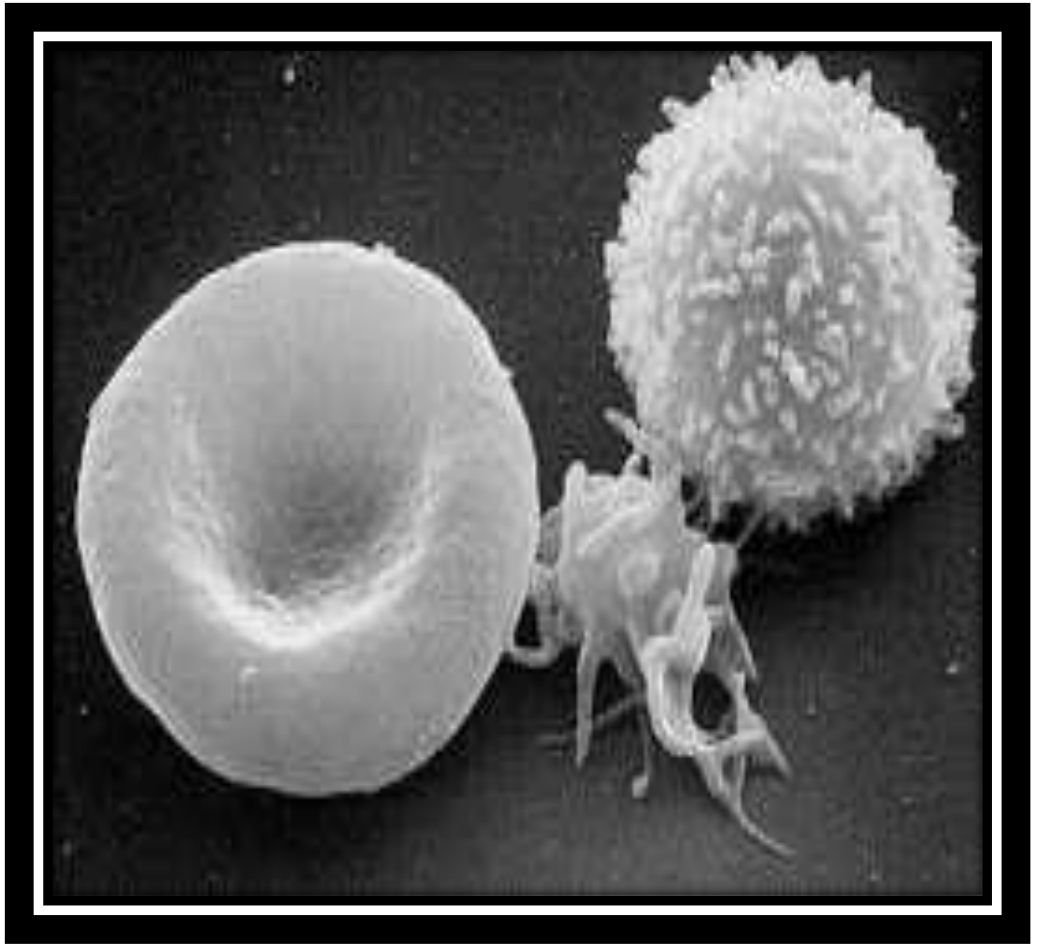
The second line of defense (SLD) (non specific)

- Operates when pathogens penetrate skin or mucous membranes
- It involves **cells, antimicrobial chemicals, and processes**, but no physical barriers
- Many of these components are contained or originate in the blood from its formed elements

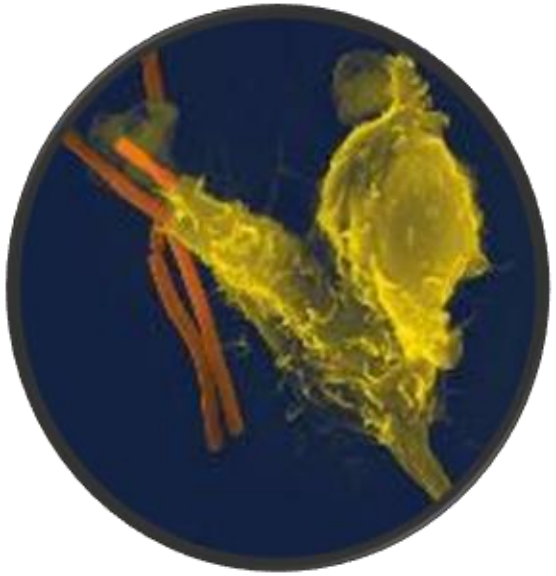
From blood formed elements to SLD

Three types of formed elements

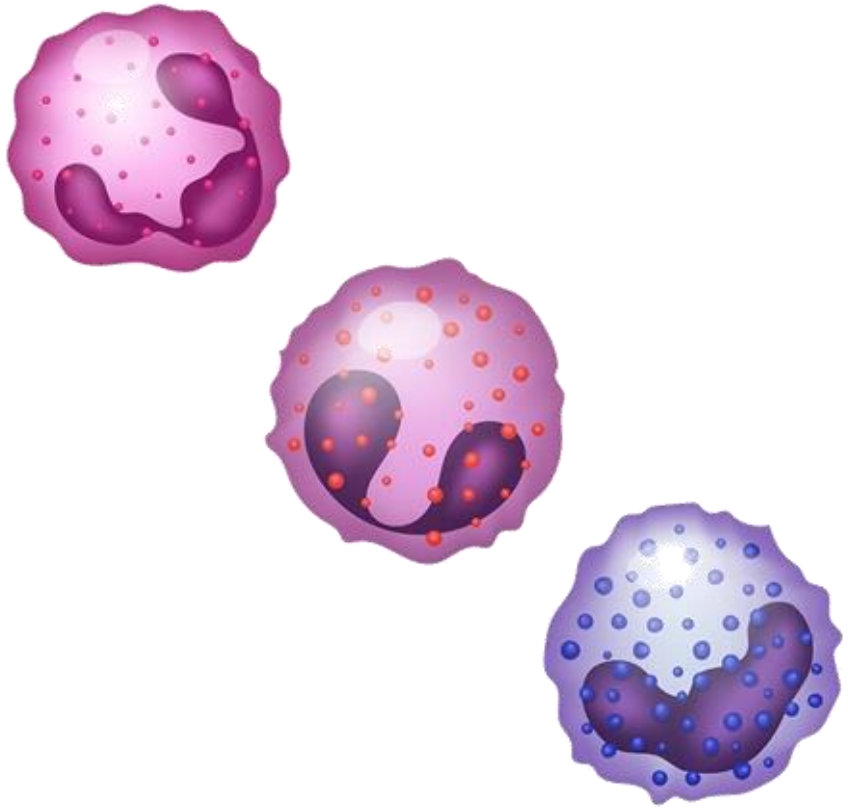
- **erythrocytes** - red blood cell, carry oxygen & carbon dioxide in the blood
- **platelets** (also called thrombocytes) - involved in blood clotting
- **leukocytes (aka white blood cells) -** involved in defending the body against invaders
  - 2 groups
    - granulocytes
    - agranulocytes

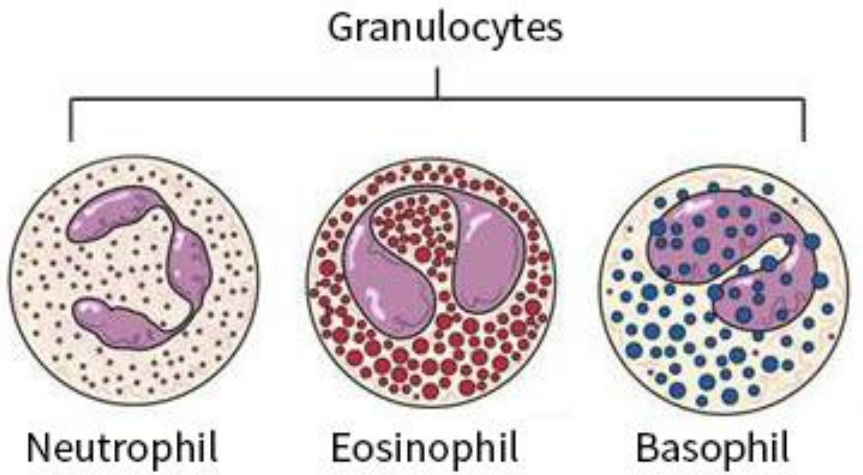


Leukocytes - granulocytes



- Category of **white blood cells (WBCs)** characterized by the presence of **granules** in their cytoplasm
- 3 types:
  - **Neutrophils**
  - **Eosinophils**
  - **Basophils**

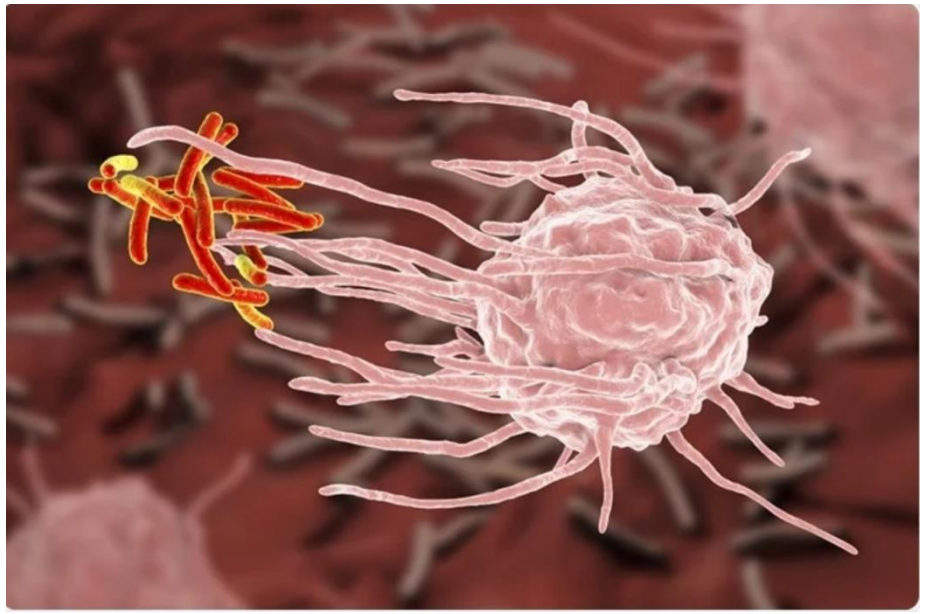


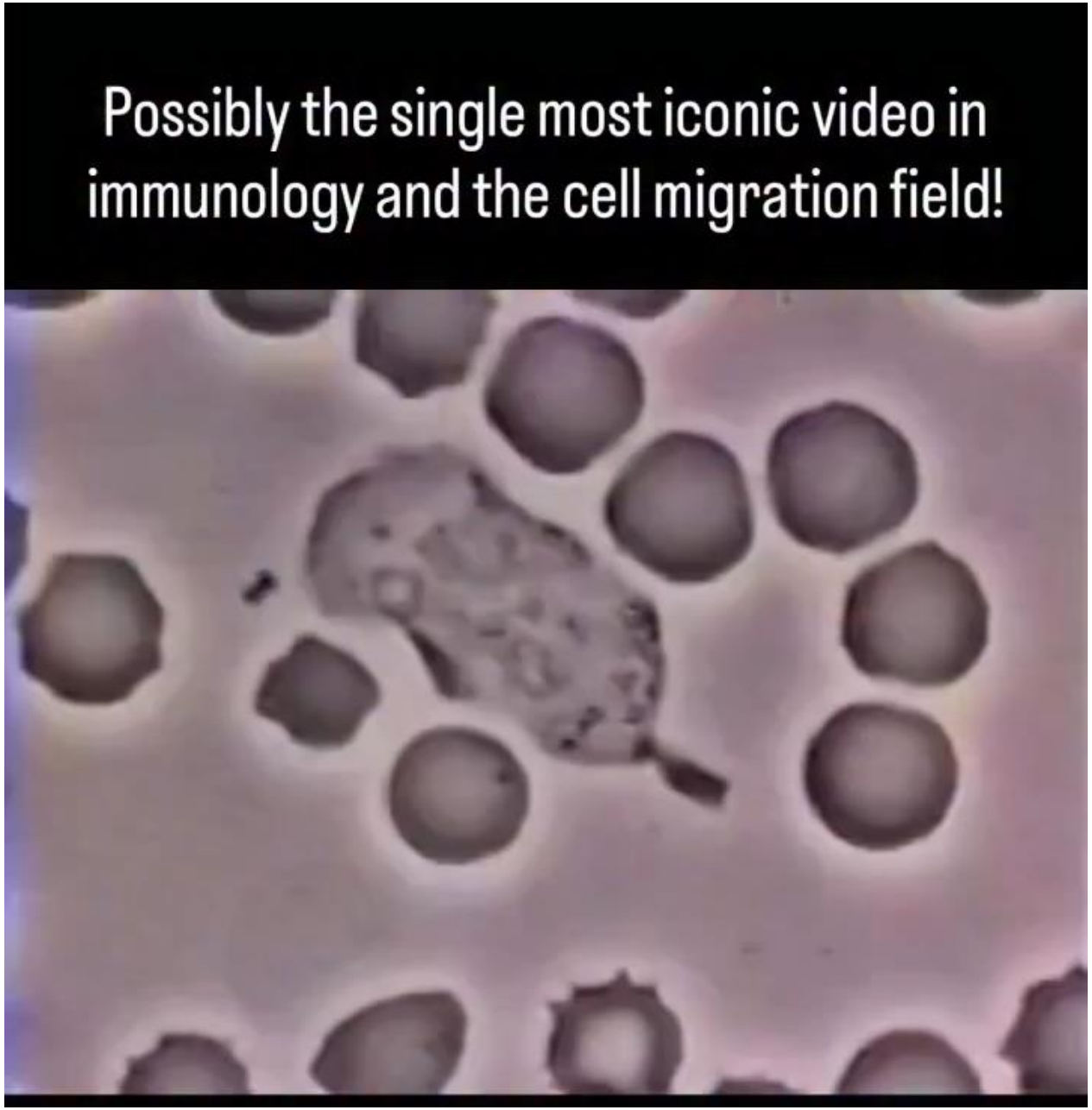


Leukocytes - granulocytes

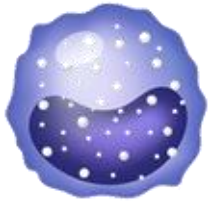
- **Neutrophils** 
  - Most abundant WBCs
  - Predominant cells in purulent exudate (or *liquor puris*), accounting for its whitish appearance
  - Respond quickly following tissue injury
  - Hallmark of acute inflammation
- **Eosinophils** 
  - Main effector cells in allergic responses and asthma
  - Also fight helminth (worm) colonization
- **Basophils** 
  - Least common granulocyte
  - When activated, release inflammatory and pro-inflammatory compounds

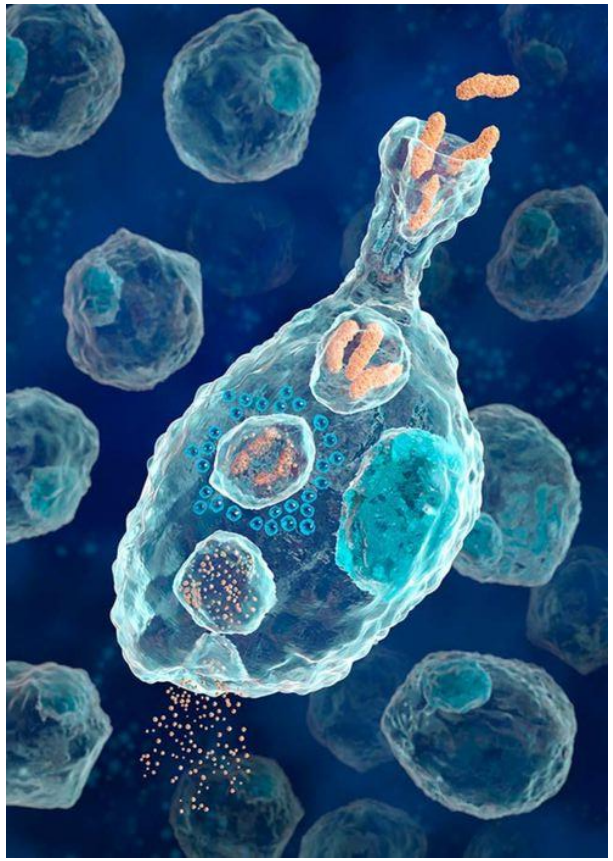
Neutrophils and eosinophils can *phagocytize* pathogens




Possibly the single most iconic video in immunology and the cell migration field!

Leukocytes - agranulocytes

- Category of **WBCs** characterized by the absence of **granules** in their cytoplasm
- 2 types:
  - **Lymphocytes** 
    - most involved in the **SPECIFIC IMMUNITY** (3rd line of immune defense - TLD)
  - **Monocytes** 
    - leave the blood and mature into **macrophages** (phagocytic cells of the SLD)

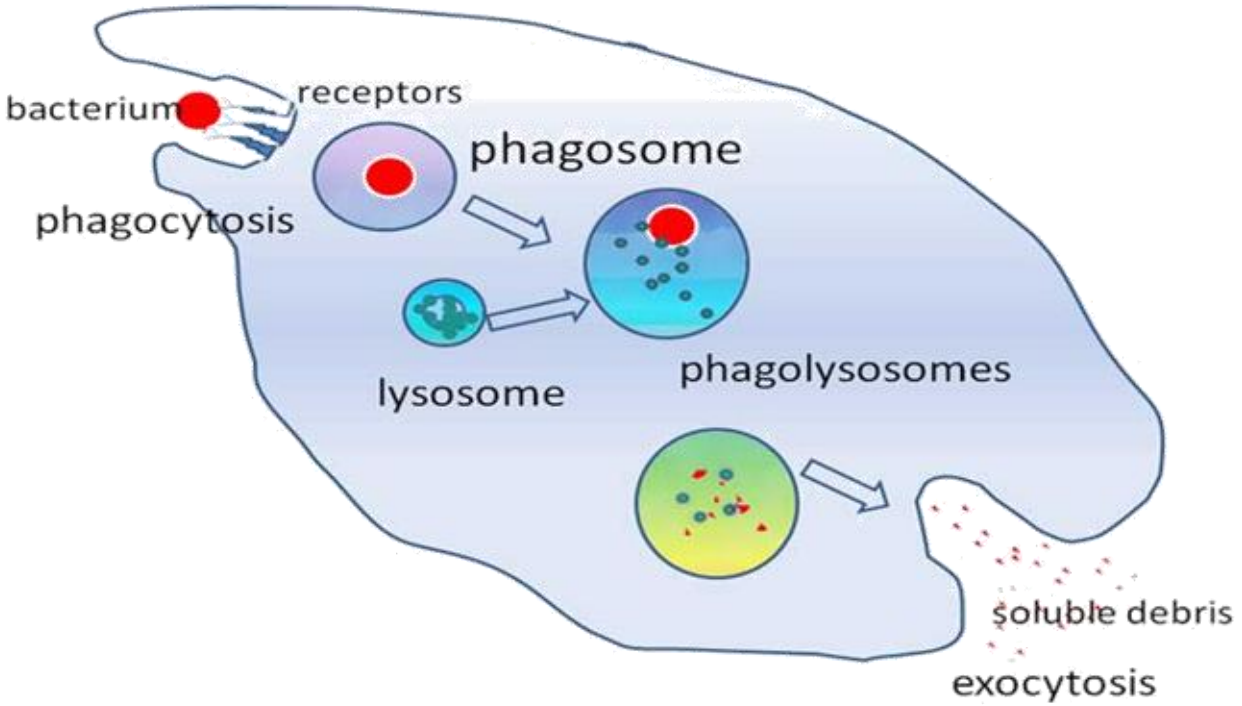


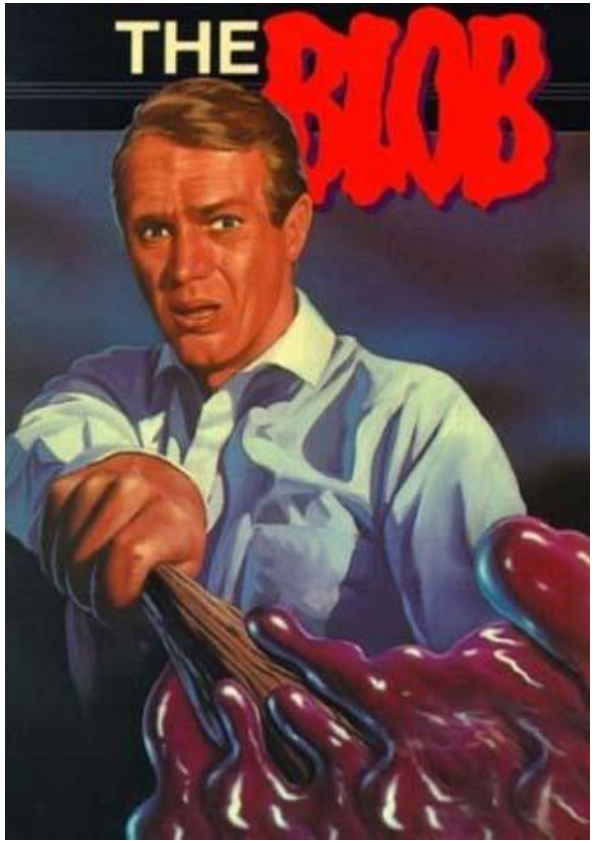
Components of the SLD

- **Leukocytes**
- **Nonspecific chemical defenses**
- **Inflammation**
- **Fever**

Leukocytes - SLD

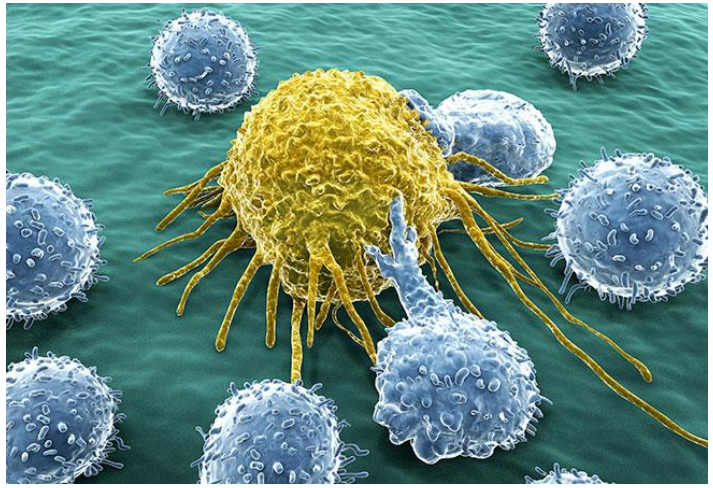
- **Leukocytes (WBCs) as intracellular killers**
- **Phagocytosis**
  - These cells ingest and destroy foreign microorganisms

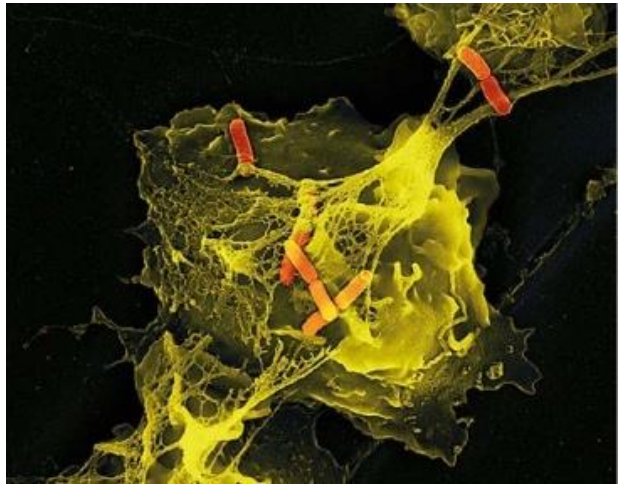


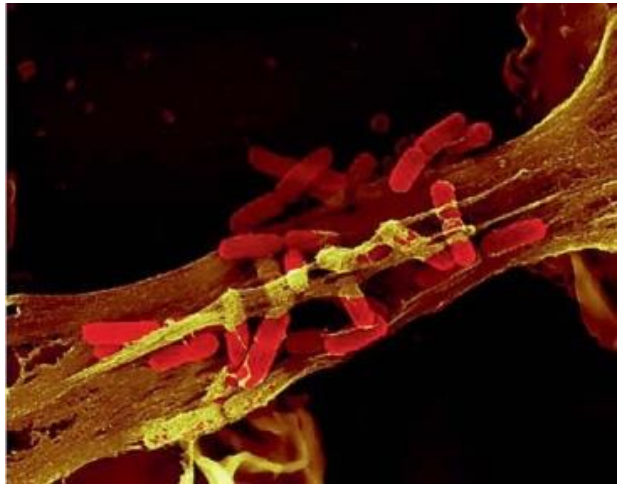


Leukocytes - SLD

- **Leukocytes as extracellular killers**
- **Natural killer lymphocytes (NK cells)**
    - Secrete toxins onto surface of virally infected cells or cancer cells
    - Differentiate normal body cells because they have membrane proteins similar to the NK cells
- **Neutrophils and eosinophils**
    - They can also ensnare and kill pathogens by capturing them in extracellular structures called web-like **extracellular traps (NETs)**
        - made of DNA and antimicrobial proteins
        - bind, disarm and kill pathogens extracellularly







TYPES OF WHITE BLOOD CELLS (LEUKOCYTES)

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Key Players in the Immune System's Defense

GRANULOCYTES (Contain Granules)

NEUTROPHIL

- Most Abundant (40-70%).
- Primary Defense against **Bacteria & Fungi.**
- Performs **Phagocytosis** (Engulfs & Destroys).
- Rapid Response to Infection.

EOSINOPHIL

- Combats **Multicellular Parasites.**
- Modulates **Allergic Inflammatory Responses.**
- Less Common (1-4%).
- Granules stain red with eosin.

BASOPHIL

- Rarest Type (<1%).
- Releases **Histamine** (Vasodilation, Inflammation) & **Heparin** (Anticoagulant).
- Involved in **Allergic Reactions.**

AGRANULOCYTES (Lack Visible Granules)

LYMPHOCYTE

- Crucial for **Specific (Adaptive) Immunity.**
- **B-Cells:** Produce Antibodies.
- **T-Cells:** Directly Attack Infected/Tumor Cells, Regulate Immune Response.
- Also includes **Natural Killer (NK) Cells.** (20-40%).

B-cell T-cell

MONOCYTE

- Largest WBC (2-8%).
- Differentiates into **MACROPHAGES** (Big Eaters) in tissues.
- Performs **Phagocytosis, Antigen Presentation,** and **Cytokine Production.**
- Longer lifespan than granulocytes.

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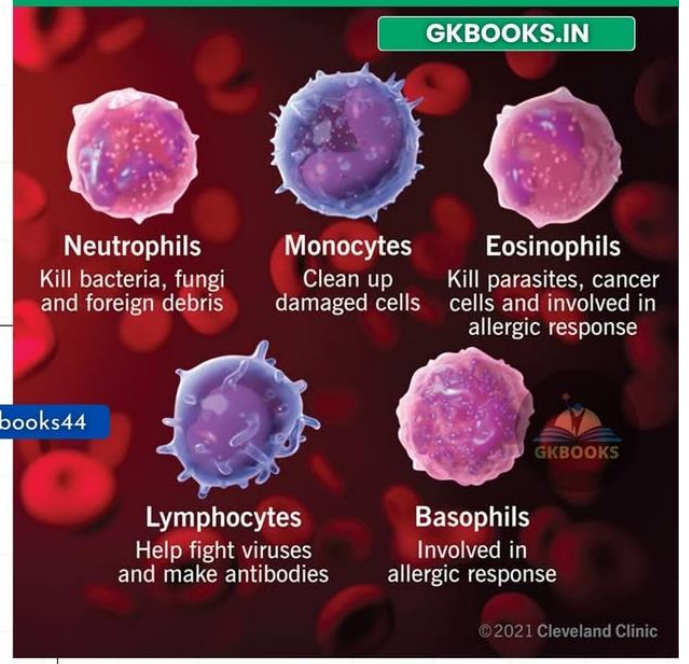
KEY ROLES OVERVIEW

- **PATHOGEN DEFENSE:** Bacteria, Viruses, Parasites, Fungi.
- **INFLAMMATION & ALLERGY:** Modulates immune responses.
- **TISSUE CLEANUP & REPAIR:** Removes debris, dead cells.

Source: Hematology & Immunology Principles. Visualizations are simplified for educational purposes.

Mole

WHITE BLOOD CELLS



Overview

- White Blood Cells (WBCs), also called leukocytes, are crucial components of the immune system.
- They defend the body against infections, foreign invaders, and abnormal cells.
- Normal WBC count: 4,000–11,000 per microliter of blood.

Types of White Blood Cells

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- **Neutrophils**
  - Most abundant (~50–70% of WBCs).
  - First responders to infection; engulf bacteria and fungi.
- **Lymphocytes**
  - Include B cells, T cells, and Natural Killer cells.
  - Key role in adaptive immunity and antibody production.
- **Monocytes**
  - Largest WBCs; differentiate into macrophages and dendritic cells.
  - Help in long-term defense and tissue repair.
- **Eosinophils**
  - Combat parasites and play a role in allergies.
  - Release enzymes to break down pathogens.
- **Basophils**
  - Least common WBCs.
  - Release histamine during allergic reactions and inflammation.

Functions of WBCs

- Recognize and destroy pathogens.
- Produce antibodies for targeted defense.
- Regulate immune responses.
- Remove dead or damaged cells.

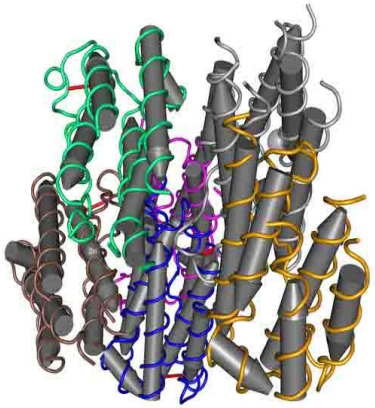
Key Facts

- WBCs are produced in bone marrow.
- Lifespan varies: hours (neutrophils) to years (memory lymphocytes).
- Abnormal counts may indicate infection, inflammation, or blood disorders.

Health Connection

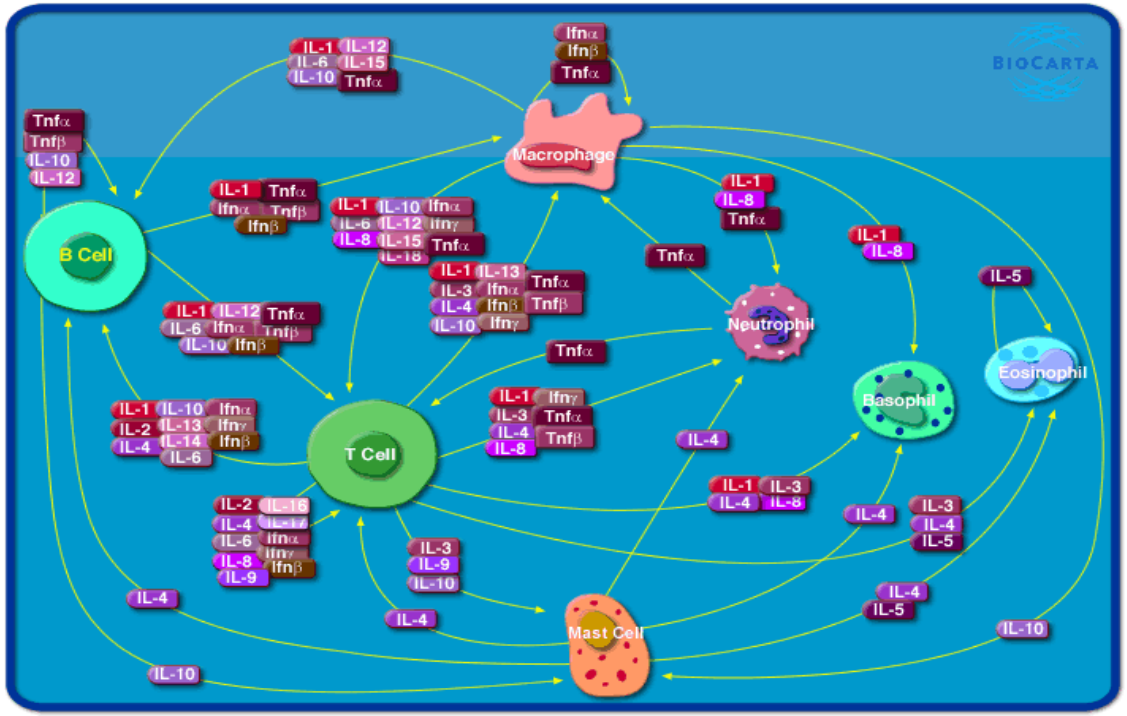
- **High WBC count (Leukocytosis):** Often signals infection or inflammation.
- **Low WBC count (Leukopenia):** May result from bone marrow problems, autoimmune diseases, or certain medications.

Nonspecific chemical defenses - SLD



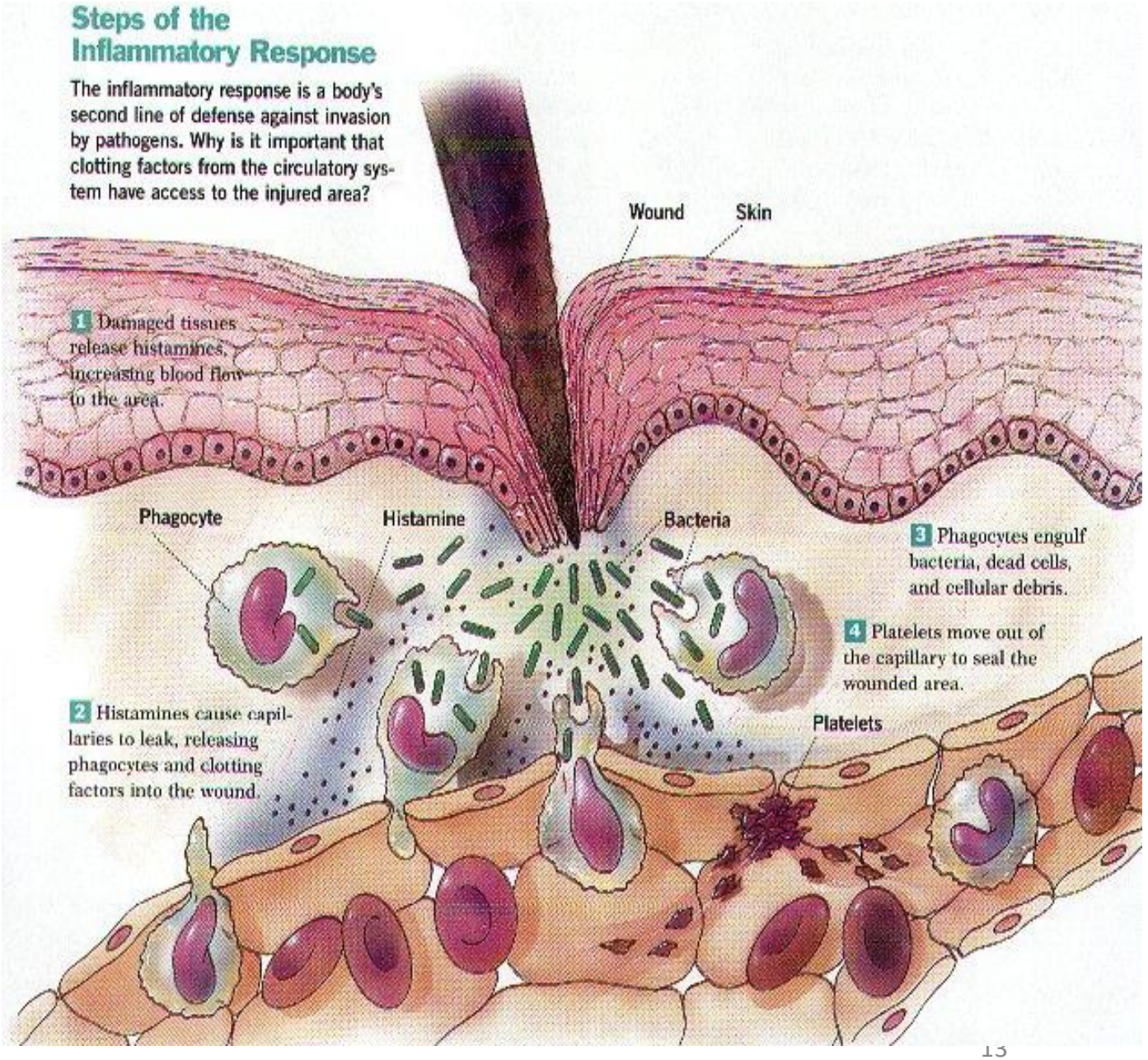
Lysozyme, Defensins and Cytokines (including interferons and interleukins)

- Augment phagocytosis
- Some attack pathogens directly
- Some enhance features of nonspecific resistance



Inflammation - SLD

- Nonspecific response to tissue damage
- important microcirculatory events that occur during the inflammatory process include
  - vascular permeability change due to release of histamines
  - **leukocyte recruitment and accumulation** and
  - release of inflammatory mediators
- Associated with heat, swelling and pain



Fever - SLD

- Body temperature above normal range of 36.5–37.5 °C (98–100 °F)
- Various types of pyrogens
  - Bacterial toxins
  - Cytoplasm of bacteria released by lysis
  - Antibody-antigen complexes
  - Interleukin-I (IL-1, a cytokine)
- Benefits
  - Speed of immune system reaction increased
  - Inhibits growth of some temperature sensitive microorganisms
  - Increase perspiration