The Immune System: Innate Immunity

Chapter 15

3 Lines of Defense

First Line of Defense

- Nonspecific defense
- Purpose: prevent entry
- Two components:
  - Physical
  - Chemical
- Primary players = skin and mucous membranes
  - respiratory, digestive, urinary, and reproductive systems

Skin – physical

- Two major layers
  - Epidermis
    - Epidermal dendritic cells
  - Dermis

Skin -- chemical

- Dermicidins
- Perspiration
  - Salt
- Lysozyme
- Sebum
  - pH

Mucous membranes

- Two distinct layers
  - Epithelium
  - Deeper connective layer
    - supports epithelium
Epithelium

- Thin, outer covering of mucous membranes
- Tightly packed
- Continuous shedding
- Goblet cells → secrete mucous
- Ciliated cells → propel mucous

Microbial Antagonism

- How?
  - Secrete antimicrobial substances
  - Consume nutrients
    - makes them unavailable to pathogens
  - Alter pH
  - Helps stimulate second line of defense
  - Provide vitamins to host

Other Components of First Line

- Chemical secretions
  - Lysozyme
    - Tears, saliva, urine, sweat
  - Acidity
    - Stomach, urine, vaginal secretions
  - Iron-binding chemicals
    - Gastroferritin, transferrin, vaginal and prostate secretions

First Line of Defense

- Nonspecific defense
  - First line of defense is breached
  - Cells, antimicrobial chemicals, and processes
Blood
- Formed elements \(\rightarrow\) cells & cell fragment
- Plasma \(\rightarrow\) mostly water + electrolytes, dissolved gases, nutrients, & proteins
  - Complement proteins
  - Antibodies
  - Clotting factors
    - Remove clotting factors \(\rightarrow\) serum

Formed elements
- Erythrocytes
- Platelets
- Leukocytes
  - Granulocytes
  - Agranulocytes

Granulocytes
- Contain large granules
- 3 types
  - Basophils- stain with basic dyes
    - methylene blue
  - Eosinophils- stain with acidic dyes
    - eosin
  - Neutrophils- stain with a mixture of acidic and basic dyes

Agranulocytes
- Do not contain granules in cytoplasm
- 2 types
  - Lymphocytes
  - Monocytes

<table>
<thead>
<tr>
<th>Type</th>
<th>%</th>
<th>Functions</th>
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<tbody>
<tr>
<td>Basophils</td>
<td>0.5 –</td>
<td>Release histamine</td>
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<tr>
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<td>1%</td>
<td>Mediate inflammation</td>
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<tr>
<td>Eosinophils</td>
<td>2 –</td>
<td>Phagocytic cells capable of diapedesis</td>
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<td>4%</td>
<td>↑ during allergic rxns, parasitic worm infections</td>
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<td>Neutrophils</td>
<td>60 –</td>
<td>Phagocytic cells capable of diapedesis</td>
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<td>70%</td>
<td>↑ during bacterial infections Mediate inflammation</td>
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<table>
<thead>
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<th>Type</th>
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<th>Functions</th>
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<tbody>
<tr>
<td>Lymphocytes</td>
<td>20 – 25%</td>
<td>Mostly involved in specific immunity (T-cells, B-cells) [NK cells (\rightarrow) non-specific]</td>
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<tr>
<td></td>
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<td>↑ in response to viral infection</td>
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<tr>
<td>Monocytes</td>
<td>3 – 8%</td>
<td>Mature into macrophages</td>
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</table>
**Macrophages**
- Professional Phagocytes
  - Wandering macrophages
  - Fixed macrophages
- Mononuclear phagocytic system
  - Macrophages + monocytes

**Second Line of Defense**
- Phagocytosis
- Extracellular killing
- Nonspecific chemical defenses
- Inflammation
- Fever

**Phagocytosis: 5 Steps**

**Extracellular Killing**
- Eosinophils
  - Attach to parasitic helminths (worms)
  - Secrete toxins
    - Eosinophilia → helminth infection

- Neutrophils
  - Secrete toxic chemicals
  - NETs
- Natural killer lymphocytes (NK cells)
  - Secrete toxins
    - Virally infected cells and cancerous cells
Nonspecific Chemical Defenses

- Lysozyme
- Complement
- Interferon
- Defensins

Complement System

- Set of serum proteins
  - Numbered by order of discovery
- Complement activation → lysis of foreign cell
  - Classical Pathway
    - Ag-Ab activate
  - Alternate Pathway
    - Pathogens / products activate

Results of Complement Activation

- MAC attack
  - c5b, c6, c7, c8, c9
- Opsonization
  - c3b
- ↑ Permeability of capillaries
  - c3a, c5a
- Recruitment of phagocytes
  - c3a, c5a

Alternate Pathway

- Antibody independent
- Useful during early stages of infection

Classical pathway

Opsonization
**Interferons**
- Proteins released by host cells
- Inhibit viral spreading
- Most effective against dsRNA viruses
- Cause many symptoms associated with viral infections
- **3 Classes**
  - Alpha & Beta – early stages of infection
  - Gamma – later stages of infection
    - Activates macrophages

**Inflammation**
- Nonspecific response to tissue damage
- Characterized by:
  - Redness, heat, swelling, and pain
- Two types
  - **Acute**
  - **Chronic**

**Defensins**
- Small peptides
- Mechanisms of action
  - Punch holes in cytoplasmic membranes
  - Interfere with internal signaling, other metabolic processes
  - Interfere with bacterial heat shock proteins
  - Inflammation → defensin production

**Fever**
- Body temp > 37°C
- Pyrogens → hypothalamus
- Various types of pyrogens
  - Bacterial toxins
  - Components of lysed bacteria
  - Antibody-antigen complexes
  - Interleukin-1 (IL-1)

**Fever production**
- Hypothalamus → prostaglandin
  - Resets “thermostat”
- Result: muscle contractions, ↑ metabolic activity, constriction of blood vessels
- Decrease in IL-1 production
- Body temp returns to normal
Benefits of Fever

- Enhances effects of interferons
- Inhibits growth of some microorganisms
- May enhance:
  - phagocytes
  - cells of specific immunity
  - tissue repair