Human Immune Response

Part 1: innate immunity
Our bodies are under constant attack from pathogens

- A pathogen is an organism that can cause disease

- Pathogens include:
  - Bacteria
  - Viruses
  - Protists
  - Fungi
Review: BACTERIA

cell wall
plasma membrane
cytoplasm
circular naked DNA
There are two types of responses to pathogens

<table>
<thead>
<tr>
<th>INNATE IMMUNITY</th>
<th>ACQUIRED IMMUNITY</th>
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<tbody>
<tr>
<td><strong>Non-specific:</strong> doesn’t distinguish one infectious agent from another</td>
<td><strong>Specific</strong> response to a particular antigen</td>
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<tr>
<td><strong>Rapid</strong> response to pathogens</td>
<td><strong>Slower</strong> response to pathogens</td>
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<tr>
<td>Is present before any exposure to pathogens</td>
<td>Requires previous exposure to the pathogen</td>
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<tr>
<td>Is effective from the time of birth</td>
<td>Built over a life time of exposure to pathogens</td>
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Innate

Nonspecific defenses

1st line:
Skin, mucous membranes, chemicals

2nd line:
Phagocytosis, complement, interferon, inflammation, fever

Specific defenses

3rd line:
Lymphocytes, antibodies

ACQUIRED
Two types of Innate Immunity

“First Line of Defense”

External defenses
- Skin
- Mucous membranes
- Chemical secretions

“Second Line of Defense”

Internal defenses
- Phagocytic cells
- Natural killer cells
- Antimicrobial proteins
- Inflammation
- Fever
External Defense: Skin

- Cannot normally be penetrated by bacteria and viruses
External Defense: Skin

Secretions from sebaceous and sweat glands keep the skin in a pH range of 3 to 5 (acidic) which kills most microbes.
External Defense: Mucous Membranes

Line digestive, respiratory, and genitourinary tracts

Secrete a mucous that traps microbes and particles
External Defense: Mucous Membranes

- In the trachea, ciliated epithelial cells sweep out mucus and trapped microbes.
- Prevents these from entering the lungs.
- Swallowing exposes them to the acidic environment of the stomach.
Microbial infection is also inhibited by saliva, tears, and mucus secretions.

All of these secretions contain antimicrobial proteins.
An example is *lysozyme*, an enzyme that digests the cell walls of many bacteria.
Review

Innate

Nonspecific defenses
- 1st line: Skin, mucous membranes, chemicals
- 2nd line: Phagocytosis, complement, interferon, inflammation, fever

Specific defenses
- 3rd line: Lymphocytes, antibodies

ACQUIRED
Two types of **Innate Immunity**

**“First Line of Defense”**

*External defenses*
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6.3.4
Internal Defense: Phagocytic cells

White blood cells (leukocytes) that ingest invading organisms
Internal Defense: Phagocytic leucocytes

Three types:

1. Macrophages
2. Esinophils
3. Neutrophils

IB WILL ask you to know and explain leucocytes as white blood cells than do phagocytosis.
Internal Defense: Phagocytic cells

Macrophages

- Large, long-lived phagocytes

- Cells extend long pseudopodia, engulf the microbe into a vessicle which fuses with a *lysosome*.
This diagram is in your note packet. IB **WILL ask** about this process. Be sure you understand it! This is how LEUCOCYTES work.

1. Microbe adheres to phagocyte
2. Phagocyte forms pseudopods that eventually engulf the particle
3. Phagocytic vesicle is fused with a lysosome
4. Microbe in fused vesicle is killed and digested by lysosomal enzymes within the phagolysosome, leaving a residual body
5. Indigestible and residual material is removed by exocytosis

Leucocyte recognizes the microbe as being an invader
Thanks to the fluidity of the cell membrane
Key word here is vesicle

“Hydrolase” is general term for enzyme that does a hydrolysis reaction

This diagram is in your note packet. IB **WILL ask** about this process. Be sure you understand it! This is how LEUCOCYTES work.
A leucocyte engulfing a streptococcus bacteria chain
Internal Defense: Phagocytic cells

Esinophils

- Help fight large parasitic invaders
- Position themselves alongside the parasite and discharge destructive enzymes through exocytosis
Internal Defense: Phagocytic cells

Neutrophils

• Most abundant white blood cell

• Recruit and activate other cells of the immune system

IB will NOT ask you to differentiate between these three!
Internal Defense: Phagocytic cells

Neutrophils

• Have three strategies for directly attacking micro-organisms

  – phagocytosis (ingestion)

  – release of anti-microbial proteins

  – generation of neutrophil extra cellular traps (NETs)
A “NET” – the extracellular “trap” secreted by neutrophil cells. IB won’t ask about this… but it’s COOL!
A “NET” – the extracellular “trap” secreted by neutrophil cells. IB won’t ask about this, but it’s COOL!
Internal Defense: Natural Killer Cells

- Do not attack microbes directly
- They destroy infected cells (typically those infected with viruses)
- Also attack abnormal body cells that could become cancerous
- They attack the cell’s membrane and cause the cell to lyse
**Internal Defense: Antimicrobial Proteins**

- A variety of proteins that attack microbes directly or impede microbe reproduction
- Example: Lysozyme
- Example: Interferons
  - Secreted by virus-infected cells
  - Do not benefit the infected cell but induce neighboring cells to produce chemicals that inhibit viral reproduction
Internal Defense: Inflammation

- Tissue damage leads to a localized inflammatory response
  - Could be injury
  - Could be invasion by microbes

- Capillaries respond by:
  - Increased dilation (widening to allow more leucocytes to access the damaged tissue)
  - Increased permeability (capillaries have fenestrations that widen to allow more immune proteins through to access the damaged tissue)
  - Enhanced delivery of clotting elements (see the notes you took yesterday)

- Leads to increased redness, heat, and swelling
An example of inflammation due to a spider bite.
Major events in the local inflammatory response

1. Chemical signals released by activated macrophages and mast cells at the injury site cause nearby capillaries to widen and become more permeable.

2. Fluid, antimicrobial proteins, and clotting elements move from the blood to the site. Clotting begins.

3. Chemokines released by various kinds of cells attract more phagocytic cells from the blood to the injury site.

4. Neutrophils and macrophages phagocytose pathogens and cell debris at the site, and the tissue heals.
Internal Defense: 
Fever

- If damage or infection is severe, a widespread non-specific response may occur
- Increased body temperature
- Inhibits growth of some microbes
- Facilitates phagocytosis
- Speeds up repair of tissue
Two types of **Innate Immunity**

*“First Line of Defense”*

**External defenses**
- Skin
- Mucous membranes
- Chemical secretions

*“Second Line of Defense”*

**Internal defenses**
- Phagocytic cells
- Natural killer cells
- Antimicrobial proteins
- Inflammation
- Fever
6.3.1 Define *pathogen*. 

6.3.3 Outline the role of skin and mucous membranes in defense against pathogens. 

6.3.4 Outline how phagocytic leucocytes ingest pathogens in the blood and in body tissues.
Which of the following is NOT a "first line of defense" in the immune response?

A. Fever
B. Skin
C. Mucous membranes
D. Lysozyme
E. Tears
F. Saliva
Which of the following is NOT a cell of the innate immune system?

A. Natural killer
B. Macrophage
C. Neutrophil
D. T cell
E. Eosinophil
F. Skin
Which cell type is part of the innate immune system?

A. Lymphocyte
B. Leukocyte
pH of the skin is:

A. Basic
B. Acidic
Which of the following cells acts by killing cells that have been infected by a virus?

A. Skin
B. Neutrophil
C. Macrophage
D. Lymphocyte
E. Esinophil
F. Natural Killer
Which molecule disrupts the viral life cycle by preventing the replication of DNA in infected cells?

A. Lysozyme  
B. Interferons  
C. Phagocytol  
D. NETs
Review

- “Second line defenses”
- Pathogen
- Acquired
- Virus
- Skin
- Phagocytic cells
- Natural killer cells
- Antimicrobial proteins
- Inflammation
- Fever
- Macrophages
- Esinophils
- Neutrophils
- Interferons

- Bacteria
- Innate
- “First line defenses”
- Mucous membrane
- Sebaceous gland
- Sweat gland
- Cilia
- Trachea
- Lysozyme
- Leukocyte
- Pseudopodia
- Lysosome
- Exocytosis
- NETs