Pathogens

- Disease causing organisms
- Resistance
- Immunity
Bacteria

- Most common pathogens
Disease Causing Organisms

Cholera

Staphylococcus epidermidis bacteria
Bacterial diseases

- Tuberculosis
- Cholera
- Bubonic Plague
- Tetanus

Effects generally due to toxins or enzymes produced by bacteria
Disease Causing Organisms

- Endotoxins
  - Botulism
    - *Clostridium botulinum*
Disease Causing Organisms

- **Antibiotics**
  - May inhibit cell wall formation or protein synthesis in bacteria
  - Overuse may result in resistance
    - MRSA
    - Tuberculosis
Viruses

- Invade host cells
  - Insert DNA or RNA
    - Control cell’s metabolism and produce more viruses
    - Cell death can result from rupture, toxins, depleted essential components
- Specific to certain types of cells
- Simple structure
  - Nucleic acids surrounded by a protein coat
HOW DO VIRUSES WORK?

1. Viral genome enters host cell.
2. Viral genome is replicated and transcribed.
3. Viral mRNAs are translated and proteins processed.
4. Particles assemble inside host, then burst or bud to exterior.

if host cell is a bacteria, virus is a bacteriophage

viral replication is a genetic process
Disease Causing Organisms

- **Viruses**
  - Hepatitis (A, B, and C)
  - Human Immunodeficiency Virus
    - AIDS
  - Polio
  - Small pox
  - Herpes zoster
    - Shingles
Immune System

- Resistance to disease
- Two intrinsic systems
  - Innate (non-specific) defense system
  - Adaptive (specific) defense system
**Innate defenses**

- **Surface barriers**
  - Skin
  - Mucous membranes

- **Internal defenses**
  - Phagocytes
  - NK cells
  - Inflammation
  - Antimicrobial proteins
  - Fever

**Adaptive defenses**

- **Humoral immunity**
  - B cells

- **Cellular immunity**
  - T cells
Immune System

- Innate response
  - Variety of non-specific barriers and mechanisms to protect
    - Body surfaces
    - Phagocytes
    - Natural killer cells (NK)
    - Inflammation
    - Complement system
    - Interferon
    - Fever
Innate response

- Body surfaces and surface barriers
  - Physical barrier to most microorganisms
- Components
  - Skin and mucous membranes
  - Oil and sweat
  - Tears
  - Gastric juices
  - Mucus coated hairs in the nose
  - Cilia of upper respiratory tract
Innate Response

- Phagocytes
  - Functions
    - Engulf particulate matter by endocytosis → phagosome → fuses with lysosome
    - Recognition of foreign material aided by complement or antibody binding
    - Macrophages are the chief phagocytic cells
(a) A macrophage (purple) uses its cytoplasmic extensions to pull spherical bacteria (green) toward it. Scanning electron micrograph (1750x).
(b) Events of phagocytosis.

1. Phagocyte adheres to pathogens or debris.

2. Phagocyte forms pseudopods that eventually engulf the particles forming a phagosome.

3. Lysosome fuses with the phagocytic vesicle, forming a phagolysosome.

4. Lysosomal enzymes digest the particles, leaving a residual body.

5. Exocytosis of the vesicle removes indigestible and residual material.
Innate response

- Natural killer cells
  - Poorly understood
  - Large granular lymphocytes
  - Target viral infected and tumor cells
Immune System

- Innate response
  - Inflammation
    - Triggered whenever body tissues are injured or infected
  - Three components
    - Prevents the spread of damaging agents
    - Disposes of cell debris and pathogens
    - Sets the stage for repair
Immune System

Innate response

- Inflammation
  1. Inflammatory mediators
     - Histamine, kinins, prostaglandins, complement, lymphokines
     - Increased permeability and vasodilation
     - Edema
  2. Chemotaxis
     - Lymphokines $\rightarrow$ WBC attraction
  3. Removal of pathogens and debris
     - Pus, abscess, granuloma
Immune System

- **Innate response**
  - Complement system
    - Plasma proteins which stimulate phagocytosis and are cytotoxic
      - Function
        1. Active molecules become embedded in bacteria wall ➔ expand ➔ form channels ➔ water enters ➔ cell lysis
        2. Potentiates inflammatory response
      - Activation
        1. Antibody binding exposes complement sites
        2. CHO on bacteria bind to complement
Innate defenses → Internal defenses

Leukocytosis. Neutrophils enter blood from bone marrow.

Margination. Neutrophils cling to capillary wall.

Diapedesis. Neutrophils flatten and squeeze out of capillaries.

Chemotaxis. Neutrophils follow chemical trail.

Inflammatory chemicals diffusing from the inflamed site act as chemotactic agents.

1. Leukocytosis. Neutrophils enter blood from bone marrow.
Tissue injury

- Release of chemical mediators (histamine, complement, kinins, prostaglandins, etc.)
  - Vasodilation of arterioles
  - Increased capillary permeability
  - Local hyperemia (increased blood flow to area)
  - Leaked protein-rich fluid in tissue spaces
  - Leaked clotting proteins form interstitial clots that wall off area to prevent injury to surrounding tissue
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- Attract neutrophils, monocytes, and lymphocytes to area (chemotaxis)
  - Margination (leukocytes cling to capillary walls)
  - Diapedesis (leukocytes pass through capillary walls)

- Release of leukocytosis-inducing factor
  - Leukocytes migrate to injured area

- Leukocytosis (increased numbers of white blood cells in bloodstream)

- Possible temporary limitation of joint movement

- Healing
  - Area cleared of debris

- Local hyperemia (increased blood flow to area)
  - Leaked protein-rich fluid in tissue spaces
  - Leaked clotting proteins form interstitial clots that wall off area to prevent injury to surrounding tissue

- Pain, Swelling

- Locally increased temperature increases metabolic rate of cells
  - Heat, Redness

- Innate defenses → Internal defenses
Adaptive defenses → Humoral immunity

Antigen-antibody complex

- Inactivates by
  - Neutralization: (masks dangerous parts of bacterial exotoxins; viruses)
  - Agglutination: (cell-bound antigens)
  - Precipitation: (soluble antigens)

- Fixes and activates
  - Complement

Enhances
- Phagocytosis
- Inflammation: Histamine release, Chemotaxis
- Cell lysis

Neutralization: (masks dangerous parts of bacterial exotoxins; viruses)
Agglutination: (cell-bound antigens)
Precipitation: (soluble antigens)
Complement
Phagocytosis
Inflammation: Histamine release, Chemotaxis
Cell lysis

Figure 21.15
**Classical pathway**

Antigen-antibody complex +

- C1
- C4
- C2 complex

**Opsonization:**

coats pathogen surfaces, which enhances phagocytosis

**Alternative pathway**

Spontaneous activation +

- Stabilizing factors (B, D, and P)
- No inhibitors on pathogen surface

**Enhances inflammation:**

stimulates histamine release, increases blood vessel permeability, attracts phagocytes by chemotaxis, etc.

Insertion of MAC and cell lysis (holes in target cell’s membrane)

- Pore
- Complement proteins (C5b–C9)
- Membrane of target cell

Figure 21.6
Innate response

• Interferon
  • Production stimulated by viral infection
  • Promotes protein synthesis in healthy cells
  • Activates macrophages and NK cells
Virus
Viral nucleic acid

1. Virus enters cell.
2. Interferon genes switch on.

Host cell 1
Infected by virus; makes interferon; is killed by virus

Host cell 2
Binds interferon from cell 1; interferon induces synthesis of protective proteins

New viruses
Antiviral proteins block viral reproduction.

Interferon binding stimulates cell to turn on genes for antiviral proteins.
Innate response

- Fever

  - Functions
    - Inhibits bacterial reproduction
    - Improves lymphocyte activity

  - Activation
    - Endogenous pyrogens
      - Production related to prostaglandins, also stimulate pain receptors
      - Aspirin interferes with prostaglandin formation
Innate defenses

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Adaptive defenses

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Cellular immunity
- T cells