The Immune System

Host and Invaders

- Pathogens are disease-causing agents and can be found on almost any surface we touch
- **Host**- organism invaded
- **Pathogens**- organism that invades, include viruses, bacteria, protists, fungi, and multicellular animals

First Line of Defense: Innate Immune Response

- Protects against infection with no specificity
- Non-specific or innate immune response:
  - Note: the book uses the term “innate immune response” incorrectly. The innate immune response is both external and internal, not just internal?!

External Innate Response

- Includes the:
  - Skin
  - Mucus
  - Cilia
  - Probiotic bacteria
  - Tears

External Innate Response: Physical and Chemical Barriers

- Physical and chemical barriers are the first line of defense against invading pathogens
- Physical barriers act to block entry to the body
- Chemical defenses, such as enzymes, work to keep the invaders from attaching to or growing on body surfaces
Linings that separate the inside from the outside in the lungs, digestive system, reproductive system, and skin keep most pathogens out.
- Acidic pH of the skin
- Salty secretions from skin glands

Once a pathogen passes the external defense systems, the body must distinguish foreign invaders (nonself) from our own cells.
As soon as the body detects cells or molecules that do not belong, a nonspecific response is deployed taking measures to eliminate the pathogens and nonself substances.

The defense cells, proteins, and other molecules of the innate immune system are the second line of defense and fight an invading organism, virus, or other substance perceived as non-self.
The innate immune system does not provide long-lasting protection against pathogens.
It is found in both invertebrates and vertebrates.

Includes:
- Inflammation
- Mast cells (in connective tissue and in the mucous membranes)
- Phagocytes (eating cells)
- Neutrophils (release toxins for bacteria and fungus)

White blood cells called phagocytes, destroy invading cellular organisms by engulfing their target in a process called phagocytosis.
The engulfed pathogen is confined to a membrane-enclosed compartment, where it is chemically broken down or walled off from other cells.
Individual phagocytes die when they are full of pathogens.

Shields an injury site from potential pathogens.
Cleans up damaged tissues and prevents entry or spread of a pathogen.
Direct injury or activation by chemical signals stimulates mast cells to release histamine and other alarm signals, including cytokines.
Histamine increases blood flow by dilating blood vessels and makes the capillary walls more porous to allow other immune cells to infiltrate the area. Histamines can also irritate nerve endings, leading to itching or pain.

**Innate Response: Inflammation**

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**Innate Response: Blood Clots**

- Clotting reduces blood loss and restores the integrity of external defense barriers.
- Platelets are sticky cell fragments that circulate in the blood and interlink with the clotting proteins to form a gel-like mesh that traps blood cells.

**Innate Response: Fever**

- Cytokines and histamines trigger the release of prostaglandins to stimulate the hypothalamus and raise the body temperature, resulting in a fever.
- Fevers are beneficial because they limit the growth of many pathogens, enhance phagocytosis, and speed the repair of damaged tissues.

**Adaptive Immune Response**

- If the innate immune responses fail, vertebrates have a layer of defense known as the adaptive immune system:
  - Response is highly specific for a particular pathogen.
  - Slower than the innate immune systems.

**Adaptive Immune Response**

- The adaptive immune system has two features:
  - Antibody-mediated immunity: uses anti-pathogen proteins called antibodies.
  - Cell-mediated immunity: destroys cells harboring pathogens and other substances that are sensed as foreign by the body.

**The Lymphatic System Supports Immunity**

- Defensive proteins and white blood cells are collected, along with the interstitial fluid, in the lymphatic ducts, a network of tubes that returns the interstitial fluid to the circulatory system.
- Lymph nodes are located along the lymphatic ducts and contain large numbers of white blood cells, such as lymphocytes, that trap bacteria, viruses, and foreign proteins.
- Lymphatic ducts, lymph nodes, and organs such as the spleen make up the lymphatic system.
**B and T Lymphocytes**

- B and T lymphocytes specifically fight pathogens.
- B lymphocytes mature in the bone marrow, while T lymphocytes migrate from the bone to mature in the thymus.
- Large numbers of mature B cells and T cells are found in the lymph nodes and other organs of the lymphatic system.

**Antigens**

- B or T cells specialize in recognizing specific antigens, one or more molecules displayed on the surface of a particular pathogen or foreign substance.

**B and T Lymphocytes Recognize Pathogens**

- Each lymphocyte is individually specialized to recognize and bind with only its corresponding antigen.
- Once a specific antigen has been detected, each activated lymphocyte divides rapidly to make many identical copies in a process called clonal selection.

**B Cells Produce Antibodies**

- B cells produce antibodies, proteins that specifically bind to and tag pathogenic cells.
- This deploys the antibody-mediated immunity, which specifically targets the antigen on an invading pathogen.

**B Cells Produce Antibodies**

- Antibodies increase the ease with which macrophages and neutrophils can bind to and destroy invaders as well as bind to and neutralize small foreign molecules, such as toxins.

**T Cells Target Infected or Abnormal Cells**

- Immunity involving the action of T cells is called cell-mediated immunity because the T cell receptor proteins bind to their target antigens, becoming attached to the target cell targeting it for destruction.
T Cells Target Infected or Abnormal Cells

• **Cytotoxic T cells** destroy the body’s own cells that are damaged, exhibit the cell surface signature of a cancer, or have been infected by viruses

The First Infection Produces a Slower, Milder Immune Response

• The first exposure to a particular antigen sets into motion the **primary immune response** of adaptive immunity
• A majority of the cloned lymphocytes become **effector cells**, cells that are ready to engage the antigen-bearing pathogen, tumor cell, or foreign substance
• A small number of the cloned lymphocytes become **memory cells**, which are held in reserve to provide a rapid response to a repeat invasion by the same foreign particle

Subsequent Exposures Provoke a Faster, Stronger Response

• The immune cells’ memory is what enables us to become immune to further attacks by the same strain in the future
• **Immune memory** remembers a first encounter with a specific strain of pathogen and mobilizes a quick, targeted, response to a repeat infection by the same strain

Immunity May Be Active

• **Active immunity** to a particular pathogen occurs when the antibodies are produced by our own bodies
  • We can also acquire active immunity when we receive a **vaccine** consisting of antigen-containing preparations
  • **Booster shots** are repeat vaccinations that restore immunity by raising antibody concentrations and memory B cell numbers through fresh exposure to the antigens

Immunity May Be Passive

• **Passive immunity** occurs when we receive antibodies that were not made by our own bodies
  • A nursing baby receives passive immunity to a broad range of potential pathogens from its mother
  • Passive immunity produces no memory cells and therefore wears off over time
  • Passive immunity can also be delivered artificially, by injection of a concentrated dose of premade antibodies

Videos:

• [https://www.youtube.com/watch?v=Rpj0emEGShQ](https://www.youtube.com/watch?v=Rpj0emEGShQ)