The Immune System and Disease

Chapter 40
What is Disease?

• A disease is any change, other than injury, that disrupts the normal function of the body.
• What are major agents of disease other than environment or genetics?
  – Viruses, Bacteria, Protists, Fungi, and Worms.
• How are they spread?
  – Physical Contact, Contaminated food and water, infected animals
• In the past, people thought diseases were the result of curses, evil spirits or night vapors!
• It was until the 1850s when Louis Pasteur and Robert Koch found that diseases were caused by microorganisms called “germs.”
  – Their idea is now called the Germ Theory of Disease.
How do we defend against disease?

• We learned earlier there are antibiotics (bacteria) and vaccines (viruses) available.
• However, our body has its own set of defenses, called the Immune system.
• The function of the immune system is to fight infection through the production of cells that inactivate foreign substances or cells. This process is called immunity.
  -- There are two major types of defenses, nonspecific defense and specific defense.
    • Nonspecific is like the fortress walls to keep stuff out!
    • Specific is like the security guards that tracks down harmful pathogens that happen to break in and get them out.
Koch’s Postulates

- Series of rules used to identify the microorganism that causes a specific disease. (Still used today!)
- They are important because identifying the pathogen that causes a disease in the first step in preventing or curing the ailments that they produce.

1. The pathogen should always be found in the body of a **sick** organism and not in a **healthy** one.
2. The pathogen must be isolated and grown in the laboratory in pure **culture**.
3. When the cultured pathogens are placed in a new host, they should cause the same **disease** that infected the original host.
4. The injected pathogen should be isolated from the second host. It should be **identical** to the original pathogen.
Non-specific Defenses:  
First Line of Defense

• Skin, mucus, sweat and tears.
• Most important? **SKIN**! Many pathogens cannot penetrate past the skin.  
  – Note: Largest organ of the body!
• **Secretions of the body** (mucus, saliva and tears) contain **lysozyme** an enzyme that breaks down the cell walls of many bacteria.
• **Oil and sweat glands** in the skin produce an acidic environment that kills many bacteria.
• Pathogens can also enter your body through your mouth and nose, where mucus and traps them and **cilia** push pathogens away from your lungs.
• **Stomach acid and digestive enzymes** destroy many pathogens that make their way into your stomach.
Non-specific Defenses: Second Line of Defense

• If pathogens do make their way past this first line of defense, they begin to multiply quickly and release toxins.
• Then the second line of defense is activated, the **inflammatory response**.
• The **inflammatory response** is a nonspecific defense reaction to tissue damage caused by injury or infection.
  – White blood cells are released.
  – Blood vessels near the wound expand to let the WBCs have access to the pathogens.
  – Many of these are called **phagocytes** that engulf and destroy the pathogen.
  – Body temperature rises, called a **fever**. This helps slow or destroy the pathogen.
  – Heart rate **increases** to pump blood (WBCs) faster.
  – When viruses are detected, cells release **interferon**, proteins that block the synthesis of viral proteins and buys the body time to respond to the attack.
Specific Defenses

- If a pathogen is able to get past these types of non-specific defenses, the body beings a full **immune response** using specific defenses.

- A substance that triggers this is called an **antigen**.

- There are two types of cells released for two separate activities:
  - B Lymphocytes (B cells) – Humoral Immunity
  - T Lymphocytes (T cells) – Cell-mediated Immunity
Some immune cells are activated to produce antibodies (such as IgE) against the food toxin.
Specific Defense: Humoral Immunity

- When a pathogen invades the body, its antigens are recognized by a small fraction of the body’s B cells that grow and divide rapidly. They produce plasma cells and memory B cells.

- Plasma Cells release antibodies. Antibodies are proteins that recognize and bind to antigens.
  - Antibodies have a Y shape and small differences in the amino acid sequences that affect the shape of their binding sites.
  - This allows for them to recognize a variety of antigens.
  - It is estimated that a healthy adult can produce over 100 million different types of antibodies!

Once the body has been exposed to an antigen, millions of memory B cells remain to create more antibodies specific to that antigen. If the body is exposed a second time, a secondary response occurs which is must faster to produce plasma cells and antibodies.
Specific Defense: Cell-Mediated Immunity

• The body’s primary defense against its own cells when they have become cancerous or virally infected is known as cell-mediated immunity. It is also used when fighting infection caused by protists or fungi.

• T cells divide and differentiate into killer T cells (cytotoxic T cells), suppressor T cells, helper T cells, and memory T cells.
  – Killer T cells track down and destroy.
  – Suppressor T cells release substances that shut down the killer T cells once the infection is under control.
  – Helper T cells produce memory T cells.
  – Memory T cells will cause a secondary response if infected with the same pathogen again.
Acquired Immunity

• More than 200 years ago, Edward Jenner wanted to know if it might be possible to produce immunity against smallpox.
• Jenner knew of a similar disease called Cowpox contracted by milkmaids.
• He wondered if infecting people with cowpox will protect them against smallpox?
• He tried this on a boy named Jamie Phipps, and it worked! This is the first known record of a vaccination.
Active Immunity

• The injection of a weakened or mild form of a pathogen to produce immunity is known as vaccination.
  – *Vacca* is the latin word for Cow reflecting Jenner’s experiment 200 years ago!
  – More than 20 serious human diseases can be prevented by vaccination.

• The type of immunity produced by the body’s reaction to a vaccination is called active immunity.
  – It can also come naturally from exposure to an antigen (fighting an infection.)
Passive Immunity

• If antibodies are produced by other animals against a pathogen are injected into the bloodstream, the antibodies produce a passive immunity against the pathogen.

• Passive immunity lasts only a short time because eventually the body destroys the foreign antibodies.
  • It can also come from an infant breast feeding (mothers milk contains essential antibodies). It protects the child in the few first months of its life or until no longer breast fed.
  • Also if you are immunized before a trip to a developing country with tropical diseases, you may be immunized before you leave. This immunity goes away over time.
Immune System Disorders

- The most common overreaction of the immune system is to antigens are known as **allergies**.
  - Include pollen, bee stings, dust, mold, etc
- When allergy-causing antigens enter the body, they attach themselves to **mast cells**. Mast cells are specialized immune system cells that initiate the inflammatory response. The cells then release chemicals known as **histamines**.
- Histamines increase the blood flow and fluids to the area and increase mucus production, causing typical symptoms.
  - There are many antihistamines you can take to reduce symptoms of watery eyes, runny nose, etc.
- Severe allergic reactions may cause a dangerous condition known as **asthma**. Asthma is a chronic respiratory disease in which the air passages become narrower and/or inflamed.
Autoimmune Diseases

- The immune system could not defend your body against a host of invading pathogens unless it was able to distinguish pathogens from the cells and tissues that are a part of your own body. It needs to determine what is “self” and “non-self.”

- When the immune system makes a mistake and attacks the body’s own cells, it produces an autoimmune disease. The immune system creates “antiself” antibodies.

Examples: Type I diabetes, Multiple Sclerosis (MS), Lupis, Rheumatoid arthritis
AIDS: an Immunodeficiency Disease

- HIV is a virus that destroys helper T cells. As a result, the number of helper T cells decreases and the immune response breaks down causing a condition called AIDS.

- HIV is very devastating because it evades the immune system (evolves very rapidly) and then destroys it preventing the body from being able to defend against other pathogens.

- AIDS stands for: Acquired immune deficiency syndrome
1. The gp120 glycoprotein on the surface of HIV attaches to CD4 and one of two coreceptors on the surface of a CD4+ cell.

2. The viral contents enter the cell by endocytosis.

3. Reverse transcriptase catalyzes, first, the synthesis of a DNA copy of the viral RNA, and, second, the synthesis of a second DNA strand complementary to the first one.

4. The double-stranded DNA is then incorporated into the host cell's DNA.

5. Transcription of the DNA results in the production of RNA. This RNA can serve as the genome for new viruses and can be translated to produce viral proteins.

6. Complete HIV particles are assembled. In macrophages, HIV buds out of the cell without rupturing the cell. In T cells, HIV exits the cell by rupturing it, effectively killing the cell.

Viral exiting by budding in macrophages

Viral exit by cell lysis in T cells