**Section 7-1**

**The Discovery of the Cell**

Because there were no instruments to make cells visible, the existence of cells was unknown for most of human history. This changed with the invention of the microscope.

**Early Microscopes**

In 1665, Robert Hooke used an early compound microscope to look at a thin slice of cork, a plant material.

Cork looked like thousands of tiny, empty chambers. Hooke called these chambers “cells.”

**Cells** are the basic units of life.

At the same time, Anton van Leeuwenhoek used a single-lens microscope to observe pond water and other things. The microscope revealed a world of tiny living organisms.

**The Cell Theory**

In 1838, Matthias Schleiden concluded that all plants were made of cells.

In 1839, Theodor Schwann stated that all animals were made of cells.

In 1855, Rudolph Virchow concluded that new cells were created only from division of existing cells.

These discoveries led to the cell theory.

**The cell theory states:**

* + - **All living things are composed of cells.**
    - **Cells are the basic units of structure and function in living things.**
    - **New cells are produced from existing cells.**

**Exploring the Cell**

* New technologies allow researchers to study the structure and movement of living cells in great detail.
* **Electron Microscopes**
* Electron microscopes reveal details 1000 times smaller than those visible in light microscopes.
* Electron microscopy can be used to visualize only nonliving, preserved cells and tissues.
  + Transmission electron microscopes (TEMs)
* Used to study cell structures and large protein molecules;Specimens must be cut into ultra-thin slices
* Scanning electron microscopes (SEMs)
  + Produce three-dimensional images of cells; Specimens do not have to be cut into thin slices; observe single atoms. Images are produced by tracing surfaces of samples with a fine probe.

Scanning Probe Micrograph of DNA!!!!!!!!!

**Prokaryotes and Eukaryotes**

come in a variety of shapes and sizes.

All cells:

* + - * are surrounded by a barrier called a cell membrane.
      * at some point contain DNA.
  + Cells are classified into two categories, depending on whether they contain a nucleus.
  + The **nucleus** is a large membrane-enclosed structure that contains the cell's genetic material in the form of DNA.
  + The nucleus controls many of the cell's activities.
* **Prokaryotes** are cells that do not contain nuclei
  + **Prokaryotic cells have genetic material that is not contained in a nucleus.**
  + Prokaryotes do not have membrane-bound organelles.
  + Prokaryotic cells are generally smaller and simpler than eukaryotic cells.
  + Bacteria are prokaryotes.
* **Eukaryotes have cells that contain a nucleus in which their genetic material is separated from the rest of the cell.**
  + Eukaryotic cells are generally larger and more complex than prokaryotic cells.
  + Eukaryotic cells generally contain dozens of structures and internal membranes.
  + Many eukaryotic cells are highly specialized.
  + Plants, animals, fungi, and protists are eukaryotes.

**Section 7-2**

* **Eukaryotic Cell Structures (organelles)**
* Cell biologists divide the eukaryotic cell into two major parts: the nucleus and the cytoplasm. The **cytoplasm** is the portion of the cell outside the nucleus.
* **Nucleus** is the control center of the cell;contains nearly all the cell's DNA and with it the coded instructions for making proteins and other important molecules. It is surrounded by a **nuclear envelope** composed of two membranes. The envelope is dotted with nuclear pores, which allow material to move in and out of the nucleus. The granular material in the nucleus is called **chromatin**. Chromatin consists of DNA bound to protein. When a cell divides, chromatin condenses to form **chromosomes**. Chromosomes contain the genetic information that is passed from one generation of cells to the next.
* Most nuclei also contain a **nucleolus**. The nucleolus is where the assembly of ribosomes begins.
* **Ribosomes** are small particles of RNA and protein found throughout the cytoplasm. Proteins are assembled on ribosomes. Ribosomes produce proteins by following coded instructions that come from the nucleus. Cells that are active in protein synthesis are often packed with ribosomes.
* **Endoplasmic Reticulum** Eukaryotic cells contain an internal membrane system called the **endoplasmic reticulum**, or ER. The ER is where lipid components of the cell membrane are assembled, along with proteins and other materials that are exported from the cell. There are two types of ER—rough and smooth. Ribosomes are found on the surface of rough ER. The portion of the ER involved in protein synthesis is called rough endoplasmic reticulum, or rough ER. Rough ER is abundant in cells that produce large amounts of protein for export. **Smooth ER** does not have ribosomes on its surface. Smooth ER contains collections of enzymes that perform specialized tasks, such as synthesis of membrane lipids and detoxification of drugs.
* **Golgi Apparatus** Proteins produced in the rough ER move into the **Golgi apparatus**. The Golgi apparatus appears as a stack of closely apposed membranes. The Golgi apparatus modifies, sorts, and packages proteins and other materials from the endoplasmic reticulum for storage in the cell or secretion outside the cell. From the Golgi apparatus, proteins are then “shipped” to their final destinations throughout the cell or outside of the cell.
* **Lysosomes** are small organelles filled with enzymes; they break down lipids, carbohydrates, and proteins into small molecules that can be used by the rest of the cell. They also break down organelles that have outlived their usefulness.
* **Vacuoles** Some cells contain saclike structures called **vacuoles** that store materials such as water, salts, proteins, and carbohydrates. In many plant cells there is a single, large central vacuole filled with liquid. The pressure of the central vacuole allows plants to support heavy structures such as leaves and flowers. Vacuoles are also found in some unicellular organisms and in some animals. The paramecium contains a contractile vacuole that pumps excess water out of the cell.
* **Mitochondria**Nearly all eukaryotic cells contain **mitochondria**. Mitochondria convert the chemical energy stored in food into compounds that are more convenient for the cell to use (cellular respiration )
* Chemical equation for cellular respiration:

* **Chloroplasts** capture energy from sunlight and convert it into chemical energy in a process called photosynthesis. Plants and some other organisms contain chloroplasts.
* Chemical equation for photosynthesis:

**Cytoskeleton** Eukaryotic cells are given their shape and internal organization by the **cytoskeleton**. The cytoskeleton is a network of protein filaments that helps the cell to maintain its shape. The cytoskeleton is also involved in movement.

The cytoskeleton is made up of:

* + - **Microfilaments** are threadlike structures made up of the protein actin; form extensive networks in some cells.
    - **Microtubules** Microtubules are hollow structures made up of proteins known as tubulins. Microtubules: maintain cell shape; are important in cell division.

build projections from the cell surface—cilia and flagella—that enable some cells to swim rapidly through liquids.

* In animal cells, structures known as centrioles are formed from tubulin. **Centrioles** are located near the nucleus and help to organize cell division.

**Section 7-3 Cell boundaries**

All cells are surrounded by a thin, flexible barrier known as the **cell membrane**. The cell membrane regulates what enters and leaves the cell and also provides protection and support. The composition of nearly all cell membranes is a flexible double-layered sheet called a **lipid bilayer** that forms a barrier between the cell and its surroundings. Most cell membranes contain protein molecules embedded in the lipid bilayer, some of which have carbohydrate molecules attached to them.

Some cells also produce a strong supporting layer around the membrane known as a cell wall. The main function of the cell wall is to provide support and protection for the cell.

* Cell walls are found in plants, algae, fungi, and many prokaryotes and lie outside the cell membrane.
* Most cell walls are porous enough to allow water, oxygen, carbon dioxide, and certain other substances to pass through easily.

**Diffusion Through Cell Boundaries**

* Every living cell exists in a liquid environment.
* The cell membrane regulates movement of dissolved molecules from the liquid on one side of the membrane to the liquid on the other side.

**Measuring Concentration.** A solution is a mixture of two or more substances. The substances dissolved in the solution are called solutes. The **concentration** of a solution is the mass of solute in a given volume of solution, or mass/volume.

**Diffusion**

* Particles in a solution tend to move from an area where they are more concentrated to an area where they are less concentrated. This process is called **diffusion**.
* When the concentration of the solute is the same throughout a system, the system has reached **equilibrium**.
* Diffusion depends upon random particle movements. Therefore, substances diffuse across membranes without requiring the cell to use energy.

**Osmosis** is the diffusion of water through a selectively permeable membrane.

* Water moves from an area that is mostly water to an area that has less water.
* If you compare two solutions, the more concentrated solution is **hypertonic** (“above strength”). A hypertonic solution has less water.
* The more dilute solution is **hypotonic** (“below strength”). A hypotonic solution has more water. When concentrations of solutions are the same on both sides of a membrane, the solutions are **isotonic** (“same strength”).

Illustration of hypertonic, hypotonic and isotonic:

**Osmotic Pressure**

* Osmosis exerts a pressure known as osmotic pressure on the hypertonic side of a selectively permeable membrane.
* Because the cell is filled with salts, sugars, proteins, and other molecules, it will almost always be hypertonic to fresh water. If so, the osmotic pressure should produce a net movement of water into the cell. As a result, the volume of the cell will increase until the cell becomes swollen or bursts.
* Cells in large organisms are not in danger of bursting because they are bathed in fluids, such as blood, that are isotonic.
* Other cells are surrounded by tough cell walls that prevent the cells from expanding even under tremendous osmotic pressure.

**Facilitated Diffusion**

* Cell membranes have protein channels that act as carriers, making it easy for certain molecules to cross. The movement of specific molecules across cell membranes through protein channels is known as **facilitated diffusion**. Hundreds of different protein channels have been found that allow particular substances (like glucose) to cross different membranes. Although facilitated diffusion is fast and specific, it is still diffusion.
* Therefore, facilitated diffusion will only occur if there is a higher concentration of the particular molecules on one side of a cell membrane as compared to the other side.

**Active Transport**

* Sometimes cells move materials in the opposite direction from which the materials would normally move—that is against a concentration difference. This process is known as **active transport**. Active transport requires energy.
* In active transport, small molecules and ions are carried across membranes by proteins in the membrane.
* Energy use in these systems enables cells to concentrate substances in a particular location, even when diffusion might move them in the opposite direction.
* **Endocytosis and Exocytosis**
* Large molecules and even solid clumps of material may undergo active transport by means of the cell membrane.
* **Endocytosis** is the process of taking material into the cell by means of infoldings, or pockets, of the cell membrane. The pocket breaks loose from the outer portion of the cell membrane and forms a vacuole within the cytoplasm.
  + Two examples of endocytosis are:
    - Phagocytosis In **phagocytosis**, extensions of cytoplasm surround a particle, package it within a food vacuole and then the cell then engulfs it. This requires a considerable amount of energy.
    - Pinocytosis. In **pinocytosis**, tiny pockets form along the cell membrane, fill with liquid, and pinch off to form vacuoles within the cell.
    - **Exocytosis**
    - Many cells also release large amounts of material from the cell, in a process called exocytosis.
    - During **exocytosis**, the membrane of the vacuole surrounding the material fuses with the cell membrane, forcing the contents out of the cell

**Section 7-4 The Diversity of Cellular Life**

* The differences among living things arise from the ways in which cells are specialized to perform certain tasks and the ways in which cells associate with one another to form multicellular organisms.
* **Unicellular Organisms**
* Unicellular organisms are made up of only one cell and organisms dominate life on Earth.
* **Multicellular Organisms**
* Organisms that are made up of many cells are called multicellular. There is a great variety among multicellular organisms.
* **Cells throughout an organism can develop in different ways to perform different tasks.**
* This process is called **cell specialization.**
  + Red blood cells transport oxygen.
  + Cells in the pancreas produce proteins.
  + Muscle cells allow movement.
  + **Specialized Plant Cells** Plants exchange carbon dioxide, oxygen, water vapor, and other gases through tiny openings called **stomata** on the undersides of leaves. Highly specialized cells, known as **guard cells**, regulate this exchange.

**The levels of organization in a multicellular organism are:**

* + - **individual cells**
    - **a tissue** is a group of similar cells that perform a particular function.
    - **Organs** are groups of tissues that work together to perform a specific function.
    - A group of organs that work together to perform a specific function is called an **organ system**.

**Chapter 40 Infectious disease**

A **disease** is any change, other than an injury, that disrupts the normal functions of the body.

Disease-causing agents are called **pathogens**.

Diseases caused by pathogens are called **infectious diseases**.

Some diseases are produced by **bacteria, viruses, worms, protists, fungi or prions.** Others are caused by materials in the environment, such as **cigarette smoke.** Still others, such as hemophilia, are **inherited.**

**Section 40-1**

**Bacteria**

Most bacteria are helpful or harmless to humans. Bacteria that cause disease either:

* + - * break down tissues of the organism for food, or
      * release toxins that harm the body.

Bacterial diseases include Lyme disease, streptococcus infections, diphtheria, and botulism.

**Viruses**

* + - tiny particles made of DNA or RNA surrounded by a protein coat that invade and replicate within living cells.
    - attach to a cell’s surface, insert their genetic material, and take over many of the functions of the host cell.
    - Diseases caused by viruses include the AIDS, common cold, influenza, and smallpox**.**

**Worms**

* + - Flatworms and roundworms cause many human diseases.
    - Other parasitic worms include *Schistosoma*, tapeworms and hookworms.

**Protists**

Disease-causing protists are transported from person to person by:

* + - * mosquitoes (malaria)
      * insects (African sleeping sickness)
      * contaminated water supplies (amebic dysentery).

**Fungi**

Fungi can infect the outer layers of the skin on the feet (athlete’s foot) or the scalp (ringworm).

Other types of fungi infect the mouth, the throat, and even the fingernails and toenails

**Prions**

Prions are infectious proteins which cause some brain disease such as mad cow disease.

**Others diseases** (not infectious diseases) are caused by materials in the environment, such as **cigarette smoke.**

Still others, such as hemophilia, are **inherited.**

**The Germ Theory of Disease**

In the mid-nineteenth century, Louis Pasteur and Robert Koch concluded that infectious diseases were caused by **germs**. This idea is now known as the **germ theory of disease**.

**Koch's Postulates**

Robert Koch developed rules still used today to identify microorganisms that cause specific diseases.

These rules are known as **Koch's postulates**.

1. The pathogen should always be found in the body of a sick organism and should not be found 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.

**How Diseases Are Spread**

Some infectious diseases are spread from one person to another through coughing, sneezing, (airborne) or physical contact. Other infectious diseases are spread through contaminated water or food.

Still others are spread by infected animals. Some infectious diseases can be spread by direct physical contact. Some dangerous pathogens are spread by sexual contact.

Most diseases spread by indirect contact, such as through the air.

Some behaviors can help to control transmission of diseases spread by physical contact.

Cover your mouth when you sneeze or cough. Wash your hands thoroughly with soap and warm water often.

**Contaminated Food and Water**

Food poisoning is caused by eating food that has pathogens.

Bacteria are always present in uncooked meat. Bacteria grow quickly in warm, partially cooked food, so you should always cook food thoroughly. Contaminated water also causes disease, especially in areas with poor sanitation and untreated sewage.

**Animals also** spread infectious disease.

Animals that carry pathogens from person to person are called **vectors**.

Malaria, Lyme disease, West Nile virus, and rabies are diseases carried by vectors.

**Fighting Infectious Diseases**

**Antibiotics** are compounds that kill bacteria without harming the cells of the human or animal hosts. They work by interfering with cellular processes of microorganisms. Antibiotics have no effect on viruses. Antiviral drugs have been developed to fight certain viral diseases. **Over-the-Counter Drugs**

You can buy many medicines without a prescription.

Over-the-counter drugs treat only the symptoms of the disease, not the cause.

The best treatment for most infections includes lots of rest, a well-balanced diet, and plenty of fluids.

**Section 40-2.**

The immune system is the body's main defense against pathogens.

It recognizes, attacks, destroys, and “remembers” each type of pathogen that enters the body. **The immune system fights infection by producing cells that inactivate foreign substances or cells.**

This process is called **immunity.**

The immune system includes two general categories of defense mechanisms against infection:

* + - **Nonspecific Defenses** do not discriminate between one threat and another.
      * **First Line of Defense**
      * The first line of defense keeps pathogens out of the body.
      * This role is carried out by skin, mucus, sweat, and tears.
      * **Your body's most important nonspecific defense is the skin.**
      * When the skin is broken, pathogens can enter the body and multiply.
      * As they grow, they cause the symptoms of an infection, such as swelling, redness, and pain
      * Mucus, saliva, and tears, contain lysozyme—an enzyme that breaks down the cell walls of many bacteria.
      * In addition, oil and sweat glands in the skin produce an acidic environment that kills many bacteria.
      * Other nonspecific defenses include:
        + Mucus in the nose and throat helps to trap pathogens.
        + Cilia in the nose and throat push pathogens away from the lungs.
        + Stomach acid and digestive enzymes destroy pathogens.
      * **Second Line of Defense**
      * If pathogens enter the body, the inflammatory response is activated.
      * **The inflammatory response** is a nonspecific defense reaction to tissue damage caused by injury or infection.
        + When pathogens are detected, the immune system makes white blood cells, which fight the infection.
        + Blood vessels near the wound expand, and white blood cells move from the vessels to enter the infected tissues.
        + Many are phagocytes, which engulf and destroy bacteria.
        + The infected tissue may become swollen and painful.
        + The immune system releases chemicals that increase the core body temperature, causing a **fever**. This high temperature slows or stops the growth of pathogens. It also increases heart rate so white blood cells get to the site of infection faster.

**Specific Defenses**

* + - If a pathogen gets past the nonspecific defenses, the immune system reacts with a series of specific defenses. These defenses are called the **immune response**.
    - Any substance, such as a virus or bacterium, that triggers this response is known as an **antigen**.
    - The cells of the immune system that recognize specific antigens are:
      * B lymphocytes (B cells)
      * T lymphocytes (T cells)
    - B cells defend the body against antigens and pathogens in body fluids (blood,etc). This process is called **humoral immunity**.
      * **Humoral Immunity**produces antibodies.
      * An **antibody** is a protein that recognizes and binds to an antigen.
      * An antibody is shaped like the letter “Y” and has two identical antigen-binding sites. Small differences in amino acids affect shapes of binding sites. Different shapes allow antibodies to recognize a variety of antigens with complementary shapes. Plasma cells release antibodies.
      * Antibodies are carried in the bloodstream to attack the pathogen.
      * As the antibodies overcome the infection, the plasma cells die out and stop producing antibodies.
      * Once the body has been exposed to a pathogen, millions of memory B cells remain capable of producing antibodies specific to that pathogen.
      * These memory B cells greatly reduce the chance that the disease could develop a second time. If the same antigen enters the body a second time, a secondary response occurs. The memory B cells divide rapidly, forming new plasma cells. The plasma cells produce the specific antibodies needed to destroy the pathogen.
    - T cells defend the body against abnormal cells and pathogens inside living cells. This process is called **cell-mediated immunity**. **Cell-Mediated Immunity** is the response against abnormal cells and pathogens.
    - When viruses or other pathogens get inside living cells, antibodies alone cannot destroy them. T cells divide and differentiate into different types

**Transplants**

* Killer T cells make acceptance of organ transplants difficult.
* Cells have marker proteins on their surfaces that allow the immune system to recognize them.
* The immune system would recognize a transported organ as foreign and attack it. This is known as rejection. To prevent organ rejection, doctors find a donor whose cell markers are nearly identical to cell markers of the recipient. Recipients must take drugs to suppress the cell-mediated immune response.

**Acquired Immunity**

**Active Immunity**

Injection of a weakened or mild form of a pathogen to produce immunity is known as a **vaccination**.

Vaccines stimulate the immune system to create millions of plasma cells ready to produce specific types of antibodies. Immunity produced by the body's reaction to a vaccine is known as **active immunity**.

Active immunity may develop:

* + - after exposure to an antigen (fighting an infection).
    - from deliberate exposure to an antigen (vaccine).

Today, over 20 serious human diseases can be prevented by vaccination.

**Passive Immunity**

The body can also be temporarily protected against disease.

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

Passive immunity is temporary because eventually the body destroys the foreign antibodies. Passive immunity can develop naturally or by deliberate exposure.

Natural immunity occurs when antibodies produced by the mother are passed to the fetus during development or in early infancy through breast milk.

Passive immunity also occurs when antibodies are administered to fight infection or prevent disease.