Cellular Transport
Section 8.3
Passive Transport: Osmosis

Pre-View 8.3

- **Hypertonic** – having a higher solute concentration in the solution outside the cell than inside the cell, causing the cell to shrink
- **Hypotonic** – having a lower solute concentration in the solution outside the cell than inside the cell, causing the cell to swell
- **Isotonic** – having equal solute concentrations inside and outside the cell
- **Osmosis** – the movement of water across a semi-permeable membrane
- **Osmotic pressure** – the pressure at which osmosis (the flow of water across a membrane) stops
- **Solute** – dissolved particles in a solution
- **Turgor pressure** – the pressure created by osmosis as water enters into a plant cell

Osmosis is also a type of passive transport since it does not use the cell's energy. Like diffusion, it moves molecules from a higher concentration to a lower concentration. So, you may be wondering what makes osmosis different from diffusion. There are two important things to remember about osmosis.

1. It is always the movement of *water* molecules.
2. It moves water molecules across a semi-permeable membrane through which the **solute** (dissolved particles) cannot cross. (Remember that *semi-permeable* membranes allow only some things to cross but not others.)

Osmosis occurs when the concentration of a solute (particles other than water) is greater on one side of a membrane than on the other side of the membrane, BUT the solute particles CANNOT diffuse through the membrane. If the solute particles could move through the membrane, they would do so by diffusion. If the solute particles cannot diffuse, water will move through the membrane in order to equalize the concentrations on each side of the membrane. The end result is that water molecules move through the membrane from an area of *higher water concentration* to an area of *lower water concentration* (figure 8-6).

Osmosis: The Movement of Water Through a Semi-Permeable Membrane

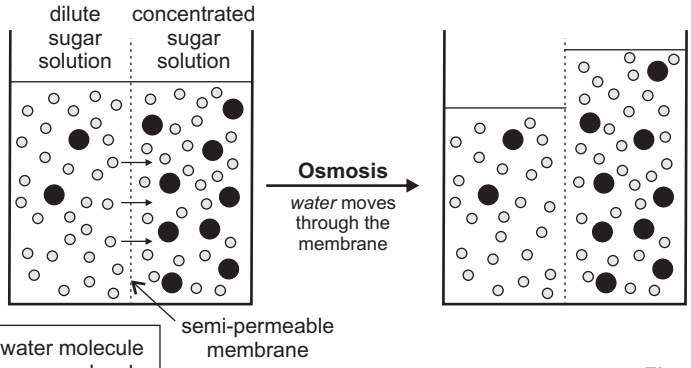


Fig. 8-6

As water passes to the other side of the membrane, pressure builds up as more and more water pushes against the membrane. For example, let's say water enters a cell by osmosis. As more and more water enters the cell, pressure will build up inside the cell as the water pushes against the inside of the cell membrane. Water will continue to pass through the membrane until the concentrations are equal across the membrane or until enough pressure is built up. At a certain pressure, called **osmotic pressure**, water stops flowing across the membrane and osmosis stops even if the concentrations are not equal on both sides of the membrane.

Light Independent Reactions/The Calvin Cycle

The second part of photosynthesis is the **Calvin cycle**, or the light independent reactions. The light independent stage takes place in the stroma, which is the watery fluid that surrounds the thylakoids. Since the stroma does not contain photosynthetic pigments, light is not needed for this stage of photosynthesis. Instead, the Calvin cycle uses the energy stored in the products of the light dependent reactions — ATP, hydrogen ions, and NADPH (an electron carrier coenzyme) — to drive this series of reactions. Along with carbon dioxide from the atmosphere, the ATP, NADPH, and hydrogen ions are used to form high energy sugars such as glucose. If more glucose is made than the plant can use for growth and development, then it is stored as complex carbohydrates, such as cellulose and starch.

Summary of the Calvin Cycle (Light Independent Stage of Photosynthesis)

- This stage does <u>not</u> require light.
- Carbon dioxide and hydrogen ions combine to form simple sugars.
- Simple sugars can be stored as complex carbohydrates, such as cellulose and starch.

$$\underset{\text{carbon dioxide}}{CO_2} + \underset{\text{hydrogen ions}}{H^+} \xrightarrow[\text{and ATP}]{\text{NADPH, enzymes,}} \underset{\text{glucose}}{C_6H_{12}O_6}$$

Plants use the glucose made in photosynthesis to get energy. They also convert the glucose to larger, more complex carbohydrates, such as starch and cellulose, that are needed for development and growth. If another organism eats a plant, the organism breaks the chemical bonds holding the carbohydrate molecules together (through the process of cellular respiration). The stored energy is then released for the organism's own use.

A summary of photosynthesis is given in figure 9-6.

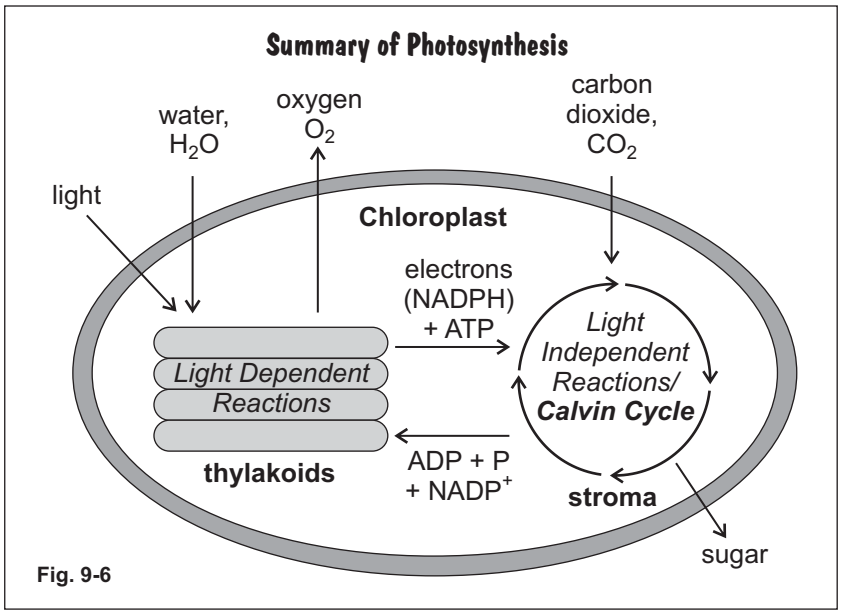
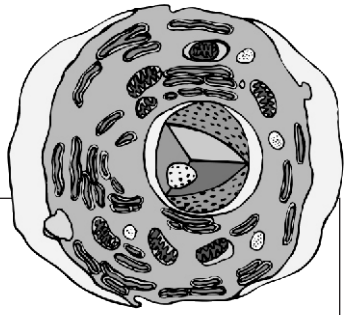


Fig. 9-6

Cellular Reproduction

Section 10.1
Cell Size and Cellular Division



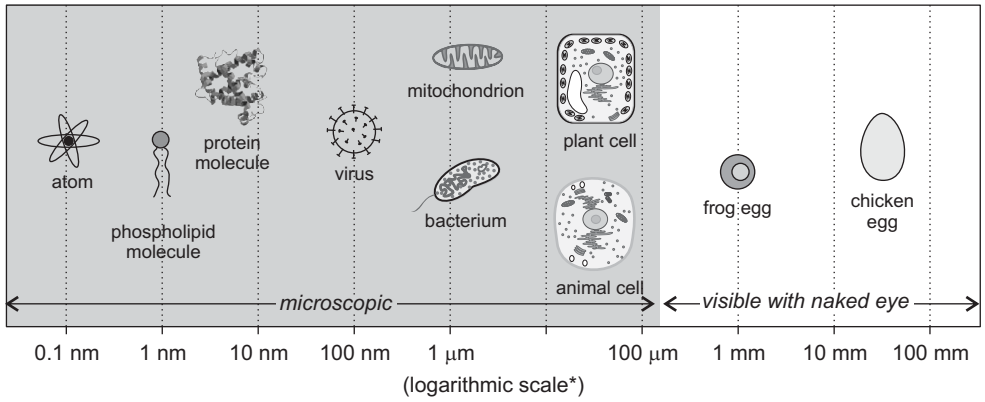
Pre-View 10.1

- **Cellular division** – the process by which cells multiply in number by growing and then dividing
- **Surface area to volume ratio** – a ratio calculated by dividing the surface area of a cell by the cell's volume; the larger the cell, the smaller the surface area to volume ratio

Relative Size of Biological Objects

Before Robert Hooke and Anton van Leeuwenhoek, no one had ever seen a living cell, cell wall, or any other cellular structures. Why not? Because cells are just too small to be seen by the naked eye. Visualizing cells takes specialized lenses like those found in the light microscopes that you use in your biology classroom. To view even smaller structures, including viruses and extremely small cellular organelles, electron microscopes are required. Take a look at figure 10-1 to see why it is impossible to see cells without a microscope. Cell sizes typically range from 1 μm to 100 μm. Prokaryotic (bacterial) cells can range from 1 to 5 μm in diameter, whereas eukaryotic cells are usually 10 to 100 μm in diameter (depending on the specific cell type).

Relative Sizes of Biological Objects



* On a logarithmic scale, each graduate mark is ten times greater than the one before it.

Fig. 10-1

Example 1: Using figure 10-1 above, approximately how many times larger is a bacteria cell than a virus? How many times larger is a plant cell than a virus?

Notice that the scale used in figure 10-1 is logarithmic. Each dashed line represents a value ten times greater than the line to its left. An object located 1 line to the right is 10 times larger. An object two lines to the right is 100 times larger.

The average virus is around 100 nm in diameter. A small bacteria cell is around 1 μm in diameter. Using the logarithmic scale, you can easily see that a bacterium cell is at least ten times larger than a virus.

Since each line represents a 10-fold increase in size, you can see that a plant cell is somewhere between 100 and 1000 times larger than a virus cell because they are more than two lines apart but less than three lines apart.

Suppose that you had a sentence made of 3 letter words (like codons):

THE RAT HID AND THE CAT SAT AND GOT FAT.

If we substituted a different letter for the letter R, words are still formed, but the sentence doesn't make sense:

substitution
THE PAT HID AND THE CAT SAT AND GOT FAT.

If we add a letter or delete a letter somewhere, it's even worse because all of the "words" after the insertion or deletion change:

insertion
THE RAT HIX DAN DTH ECA TSA TAN DGO TFA T

deletion
THE RAH IDA NDT HEC ATS ATA NDG OTF AT

Remember, amino acids make up polypeptide chains, polypeptide chains make up proteins, and proteins are a vital component of living materials and carry out vital cellular processes. Remember also that genes in the DNA are made up of nucleotide sequences that are "read" in groups of threes similar to the three-word sentences shown above. The sequence of the letters in the mRNA determines the amino acid that is added to the polypeptide chain. If one or more amino acids added to that polypeptide chain are wrong, the organism will not be able to build proteins with the correct structure. Look at figure 11-10 to review the different types of gene mutations and how they affect protein production. Notice that the amino acids that make up the protein can change when different gene mutations occur. Gene mutations are sometimes called **point mutations** because the mutation occurs at only one point in the DNA. Insertions or deletions of a single nucleotide are also called **frameshift mutations** because they shift how the codons are read and can result in different amino acids being added to the protein. (Note: Since some nucleotide sequences "code" for the same amino acid, not all gene mutations result in a different amino acid.) Both point mutations and frameshift mutations may also create a stop codon, which will stop protein synthesis. The resulting protein will be shorter than it is supposed to be.

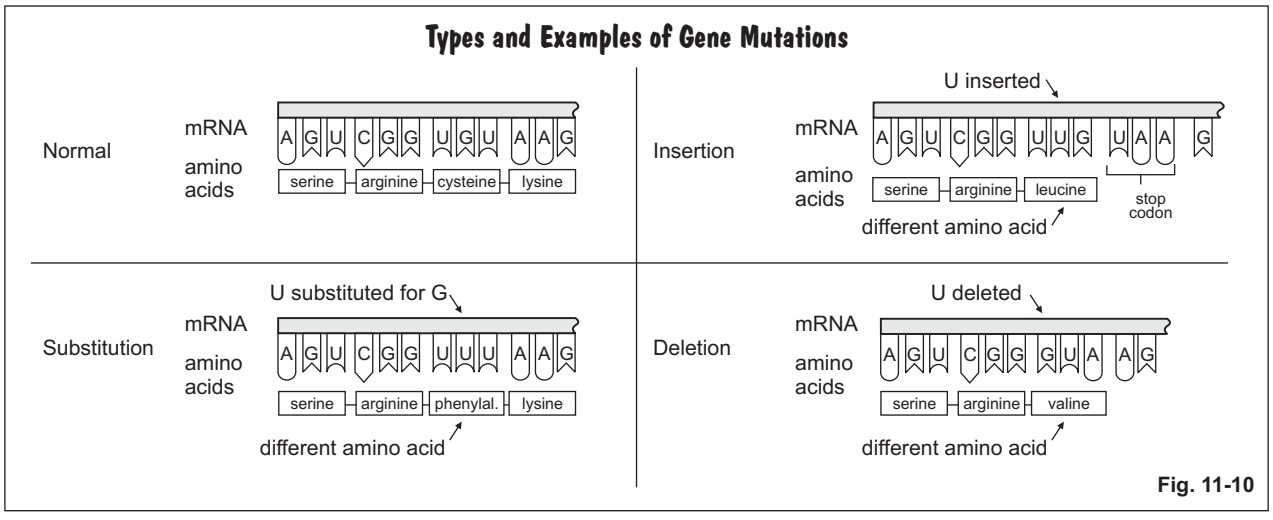


Fig. 11-10

Applied Genetics

Section 13.5
Pedigrees

Pre-View 13.5

- **Pedigree** – a diagram used by geneticists to chart a trait from one generation to another

Have you ever seen your family tree? You know — a family tree is a diagram that shows different generations and various members of your family. Geneticists use a diagram called a **pedigree** that is similar to a family tree to show genetic inheritance. Pedigrees can help geneticists determine if a trait is inherited, they can show how a trait is passed from one generation to the next, and they can help determine whether an allele for a trait is dominant or recessive.

Pedigrees always use certain symbols that you should know. Study the sample pedigree given below in figure 13-6.

Sample Pedigree of a Family with Color Blindness

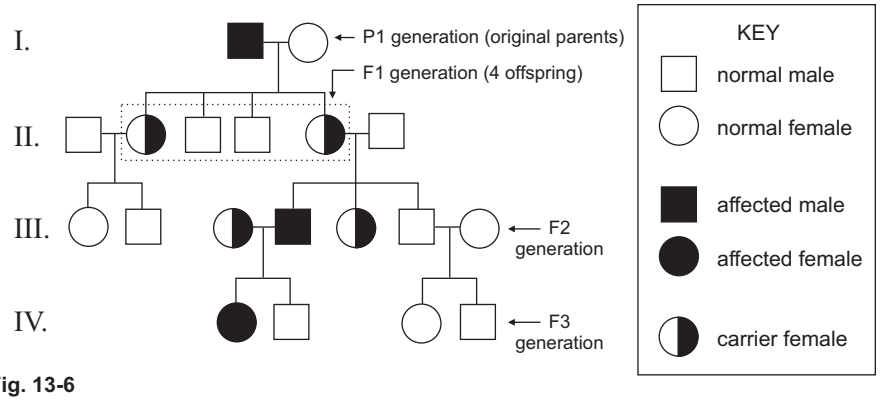


Fig. 13-6

Each horizontal row represents one generation, and the youngest generation is at the bottom. The rows are usually labeled with Roman numerals. Row I corresponds to the first generation (P1), row II corresponds to the children of the first generation and their spouses (F1), row III represents their grandchildren (F2), and so on. The horizontal line between a square and a circle represents parents. The vertical line between the parents that link to the next generation shows the offspring of the parents.

In the first generation (P1) of the sample above, the father is affected by color blindness, and the mother is normal. The parents have four children, 2 sons and 2 daughters (enclosed by the dotted line). Both sons are normal, but both daughters are carriers.

Example 1: In the pedigree given in figure 13-6, determine the genotypes of the parents in the first generation. The sons are normal, but the daughters are carriers. If the first generation parents had additional children, could the genotypes of sons and daughters be different?

We know that color blindness is an X-linked gene. Since the man in the P1 generation is affected, we know that his genotype is X^bY. The woman in the first generation is normal, so her genotype is X^BX^B. Use a Punnett square to see the possible genotypes of offspring.

	X^b	Y
X^B	X^BX^b	X^BY
X^B	X^BX^b	X^BY

From the Punnett square we can see that these parents will always have daughters that are carriers and sons that are normal.

Redi is often given credit as the first scientist to develop a controlled experiment. He may not have actually been the first person to use controls or to understand the need for a control group. However, his simple experiment successfully used a control group and two experimental groups to support his hypothesis. His experiment may have looked something like the illustrations in figure 14-1.

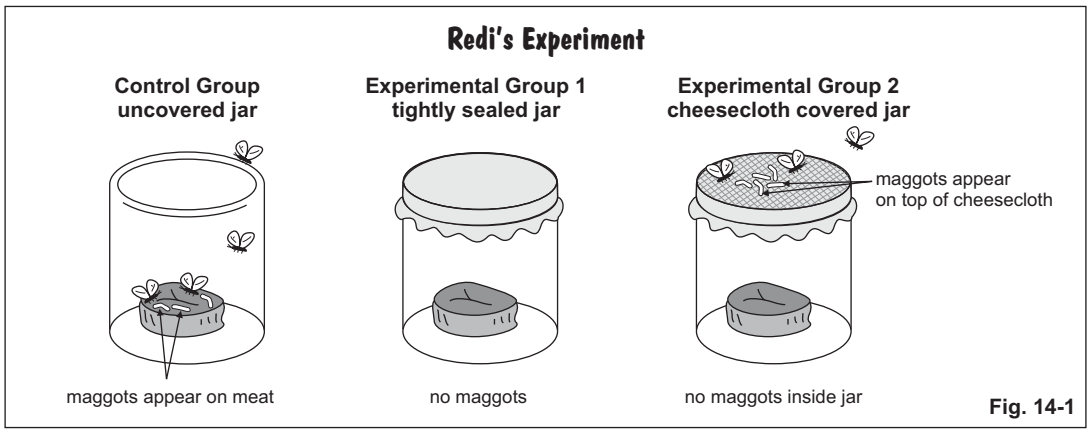


Fig. 14-1

John Needham (1713 – 1781) vs. Lazzaro Spallanzani (1729 – 1799)

As we observed from Redi's 1668 experiment, large organisms, such as maggots and flies, were not spontaneously generated. But questions still remained about the spontaneous generation of microorganisms. In the 1700s, some still believed that organisms unseen by the naked eye, microorganisms, were spontaneously generated.

John Needham was one of the scientists made famous by his *incorrect* assumption. In 1745 Needham attempted to prove spontaneous generation does occur with microscopic organisms. With the knowledge that heat killed living organisms, Needham boiled a nutrient-rich chicken broth, transferred the heated broth to a flask, covered it, and then allowed it to cool. Afterwards he maintained the broth at a constant temperature for some time. A thick, cloudy solution containing microorganisms resulted from his experiment. Needham believed this to be "proof" that the microorganisms were created by the broth.

Another scientist **Lazzaro Spallanzani** suspected that the microorganisms in Needham's experiment were coming from the air during the transfer to the flask, so he repeated Needham's experiment with a slight modification. Spallanzani placed the chicken broth in a flask, covered it, and removed air from the flask by creating a partial vacuum. He then boiled the broth and allowed the flask to cool with the covering and then waited. No growth occurred in Spallanzani's experiment, so he concluded that his experiment disproved spontaneous generation of microorganisms.

Not everyone was convinced of Spallanzani's conclusion. Many felt that air was the "vital force" for the microorganisms to appear and suggested that all his experiment proved was that spontaneous generation could not occur without air.

Louis Pasteur (1822 – 1895)

Another hundred years passed by before the French chemist **Louis Pasteur** finally settled the debate on spontaneous generation. He designed an experiment that disproved spontaneous generation once and for all! In 1859 Pasteur performed a variation of both Needham's and Spallanzani's experiments. He modified the flask by heating the neck and reshaping it to form an S. The newly designed *swan-necked* flask prevented dust and microbial contaminants from entering the broth while still allowing the exchange of air. Over a prolonged incubation, the flasks remained free of microbes. Microbes developed in the broth only if the swan-neck was broken to expose the broth to air or if the flask was tilted to allow broth to settle in the lowest point of the flask neck.