Section Summary

Living things are made of different carbon-based macromolecules. The four covalent bonding positions of the carbon atom can give rise to a wide diversity of compounds with many functions, accounting for the importance of carbon in living things. Functional groups help explain why different macromolecules have different chemical properties.

Exercises

1. Each carbon molecule can bond with as many as________ other atom(s) or molecule(s).
    a. one
    b. two
    c. three
    d. four

2. Which of the following would be hydrophobic?
    a. methyl group
    b. carbonyl group
    c. hydroxyl group
    d. carboxyl group

3. Explain what a functional group is and why they are important.

Answers

1. (d)
2. (a)
3. Functional groups are groups of atoms that occur within molecules and confer specific chemical properties to those molecules. They usually attach to the carbon backbones of macromolecules via chemical bonding. Each of the four types of macromolecules, proteins, lipids, carbohydrates, and nucleic acids, has its own characteristic set of functional groups. These functional groups contribute significantly to their differing chemical properties and functions in living organisms.

Glossary

hydrocarbon: organic molecules consisting entirely of carbon and hydrogen

functional group: groups of atoms that occur within molecules and confer specific chemical properties to those molecules

hydrophilic: describes a substance that dissolves in water; “water-loving"

hydrophobic: describes a material that does not dissolve in water; “water-fearing"

isomers: molecules that share the same chemical formula but differ in the placement (structure) of their atoms and/or chemical bonds

organic molecule: any carbon-containing liquid, solid, or gas

3.2 Synthesis and Breakdown of Macromolecules

Learning objectives

By the end of this section, you will be able to:

- *Understand how macromolecules are synthesized (dehydration synthesis)*
- *Understand how macromolecules are broken down (hydrolysis reactions)*
- *Explain the difference between a monomer and a polymer*
- *Be able to define and explain all bolded terms*

As you've learned, biological important molecules are relatively large molecules that are necessary for life. Each biological important molecule is built from smaller organic molecules. There are four major biological important molecule classes (carbohydrates, lipids, proteins, and nucleic acids). Each is an important cell component and performs a wide variety of functions. Biological important molecules are organic, meaning they contain carbon. They often also contain hydrogen, oxygen, nitrogen, and additional minor elements.

Most biologically important molecules are made from single subunits, or building blocks, called **monomers**. The monomers combine using covalent bonds to form larger molecules known as **polymers**. When monomers combine, water is released as a by-product. This type of reaction is called a **dehydration synthesis**, a condensation reaction, which means "to put together while losing water" (Figure 3.6a). Conversely, the covalent bonds that hold the polymer together can also be broken if need be. When a **hydrolysis reaction** occurs, a water molecule is used to break a chemical bond (Figure 3.6b). We will look more closely at each type of reaction below.

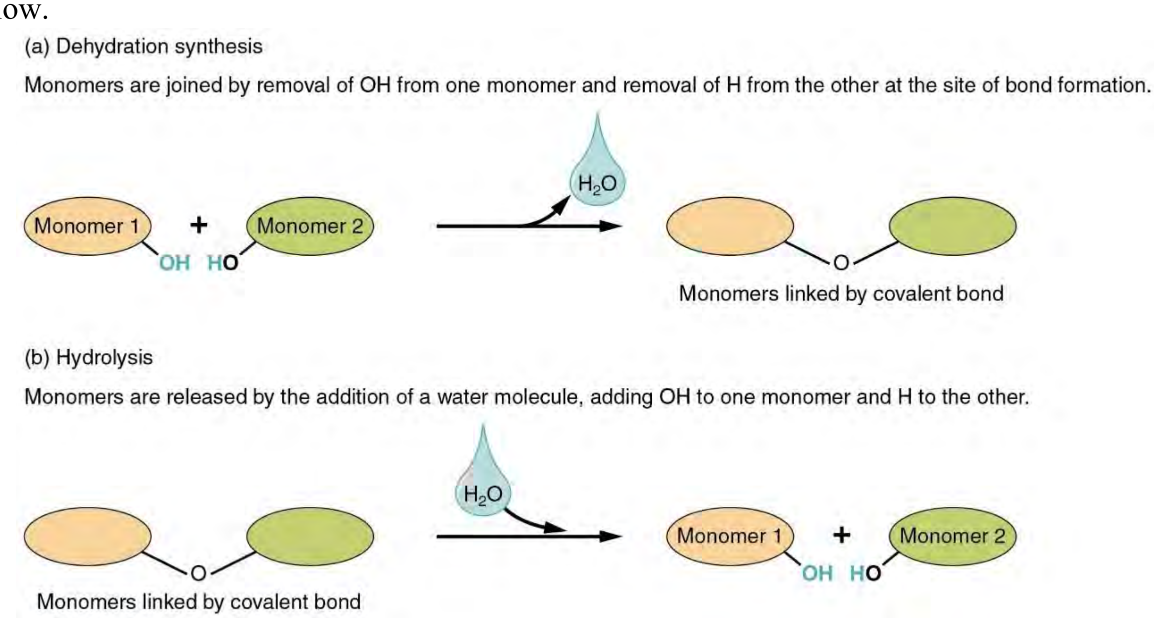

Figure 3.6 (a) In dehydration synthesis, two monomers are covalently bonded. (b) In a hydrolysis reaction, the covalent bond between two monomers is split apart. (credit: Betts et al./Anatomy and Physiology OpenStax)

Dehydration Synthesis

In a dehydration synthesis (Figure 3.7), the hydrogen of one monomer combines with the hydroxyl group of another monomer, forming a water molecule. At the same time, the monomers then come together and share electrons resulting in the formation of a covalent bond. As additional monomers are added, this growing chain forms a polymer. Different monomer types can combine in many configurations, giving rise to a diverse group of macromolecules. Alternatively, the same kind of monomers can also come together and form different polymers. For example, glucose monomers are the significant components of starch, glycogen, and cellulose.

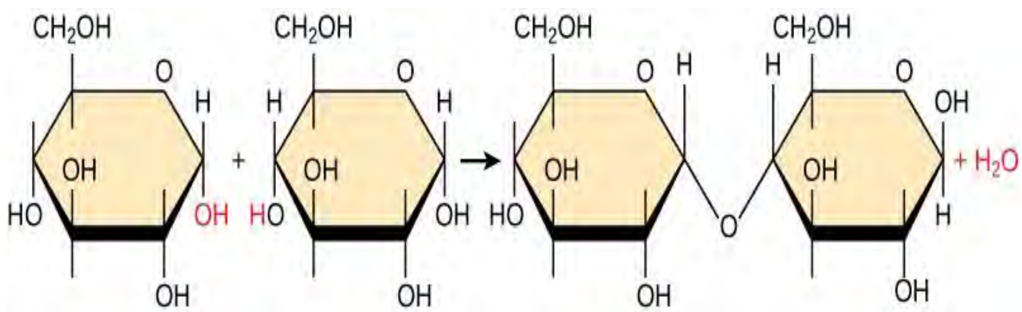

Figure 3.7 In the dehydration synthesis reaction above, two glucose molecules link to form the disaccharide maltose. In the process, it forms a water molecule. (credit: Clark et al./ Biology 2E OpenStax)

Hydrolysis

Polymers can be broken down into monomers during hydrolysis reactions. Hydrolysis reactions occur when a water molecule is used to break a chemical bond (Figure 3.8). During these reactions, the polymer breaks into two components: one part gains a hydrogen atom (H+), and the other gains a hydroxyl molecule (OH–). Both the hydrogen and hydroxyl ions are a result of splitting a water molecule.

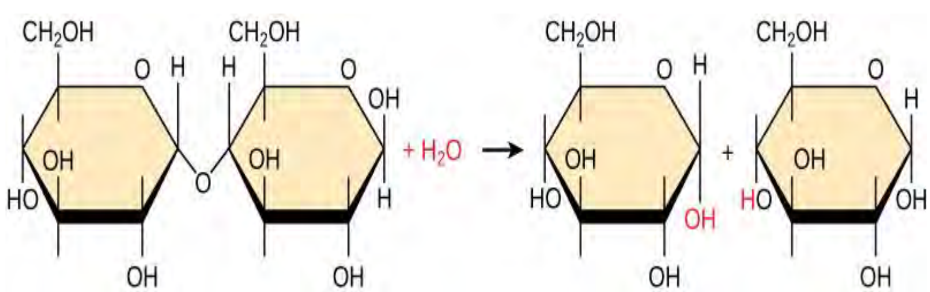

Figure 3.8 In the hydrolysis reaction above, the disaccharide maltose breaks down to form two glucose monomers by adding a water molecule. (credit: Clark et al./ Biology 2E OpenStax)

Dehydration synthesis and hydrolysis reactions can occur quickly with the help of molecules called enzymes. In dehydration reactions, enzymes help with the formation of new bonds, while enzymes used in hydrolysis reactions break bonds apart.