SECTION

2.3 Carbon-Based Molecules

FLORIDA STANDARDS
SC.912.L.18.1

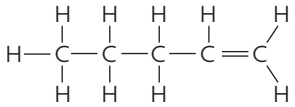
KEY CONCEPT Carbon-based molecules are the foundation of life.

Carbon atoms have unique bonding properties.

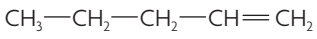
Most molecules that make up living things are based on carbon atoms. The structure of a carbon atom allows it to form up to four covalent bonds. It can bond to other carbons or to different atoms. As shown in the figure below, carbon-based molecules have three basic structures: straight chains, branched chains, and rings.

CARBON CHAINS AND RINGS

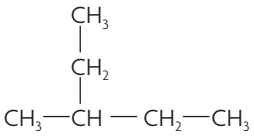
Straight chain



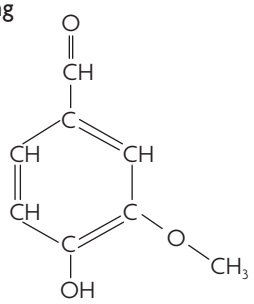
A simplified structure can also be shown as:



Branched chain



Ring



Each line represents a covalent bond. Each letter represents an atom. Notice that there are four bonds for every carbon atom (C). When a carbon (C) is attached to a hydrogen (H) sometimes there is no line drawn to represent the bond, but the bond is still there.

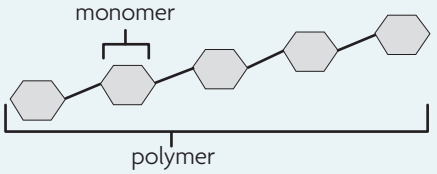
Think of a chain made up of connected loops, or links. Each link is a subunit that makes up the bigger chain. Many carbon-based molecules have subunits that make up a bigger molecule.

Each subunit is called a **monomer.** When monomers are linked together, they form molecules called polymers. A **polymer** is a large molecule made of many monomers bonded together. A polymer can also be called a macromolecule. *Macro-* means "large," so a macromolecule is a large molecule. The monomers that make up a polymer can all be the same, or they can be different, depending on the type of macromolecule.

VISUAL VOCAB

Each smaller molecule is a subunit called a **monomer.**

mono- = one
poly- = many



A **polymer** is a molecule that contains many monomers bonded together.

INSTANT REPLAY

How are polymers and monomers related?

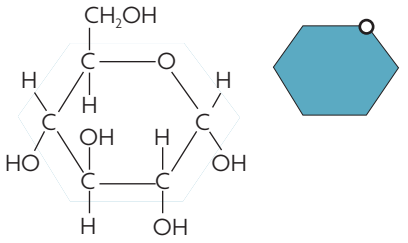
Four main types of carbon-based molecules are found in living things.

All organisms are made of four types of carbon-based molecules: carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates

Fruits and grains both contain large amounts of carbohydrates. **Carbohydrates** are molecules made of carbon, hydrogen, and oxygen. Sugars and starches are both types of carbohydrates. These carbohydrates can be broken down to produce energy in cells. Some carbohydrates are part of cell structure in plants.

The most basic carbohydrates are simple sugars. Many simple sugars have five or six carbon atoms. Fructose and glucose are both sugars that have six carbon atoms. The sugar that you might use in the kitchen is made of two sugar molecules bonded together.



Glucose is a six-carbon sugar. Glucose is often represented by a hexagon, a six-sided figure. Each point on the hexagon represents a carbon, except the point that has an O, for oxygen.

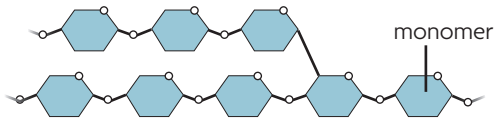
Many glucose molecules bonded together form polymers such as starch and cellulose. These polymers are called polysaccharides. Starches are carbohydrates made by plants. Starch can be broken down as a source of energy by plant and animal cells. Cellulose is also made by plants. Cellulose makes up cell walls, the tough outer covering of plant cells. The stringy fibers of vegetables like celery are made of cellulose. The structure of starch molecules is different from the structure of cellulose molecules. The different structures give them their different properties.

VOCABULARY

Poly- means "many." *Saccharide* means "sugar." A *polysaccharide* is a polymer made of many sugars.

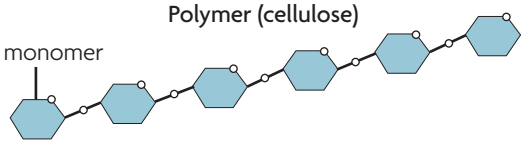
CARBOHYDRATE STRUCTURE

Polymer (starch)



Starch is a polymer of glucose monomers that often has a branched structure.

Polymer (cellulose)



Cellulose is a polymer of glucose monomers that has a straight, rigid structure.

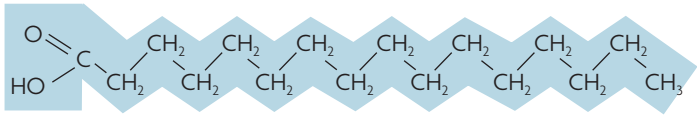
Lipids

Lipids are molecules that include fats, oils, and cholesterol. Lipids are nonpolar, so they do not dissolve in water. Like carbohydrates, most lipids are made of carbon, oxygen, and hydrogen atoms. Some lipids are broken down and used as energy in cells. Other lipids form part of the cell's structure.

Fats and lipids store large amounts of energy in organisms. Animal fats are found in foods such as meat and butter. Plant fats are found in nuts and oils, like olive oil or peanut oil. Fats and lipids are made of molecules called fatty acids. **Fatty acids** are chains of carbon atoms bonded to hydrogen atoms. In many lipids, the fatty acid chains are attached on one end to another molecule called glycerol. Because of the shape of the fatty acid chains, some fats are liquid at room temperature, like olive oil, and other fats are solid, like butter.

FATTY ACIDS

Fatty acid



Fatty acids are long chains of carbon atoms attached to hydrogen atoms.

Butter is made up of fatty acids.

All cell membranes are made mostly of another type of lipid, called a phospholipid (FAHS-foh-LIHP-ihd). A phospholipid has glycerol, two fatty acid "tails," and a phosphate group that forms the "head" of the molecule. The phosphate group includes phosphorous and oxygen atoms. This part of the molecule is polar, so it is attracted to water. The fatty acid end of the molecule is nonpolar, and is not attracted to water.

Cholesterol (kuh-LEHS-tuh-RAWL) is a lipid with a ring structure. Although high cholesterol is a health risk, your body needs a certain amount of cholesterol to function. Cholesterol is part of cell membranes. Cholesterol is also an important part of steroid hormones. Cholesterol-based steroids help your body respond to stress and also control sexual development and the reproductive system.

PHOSPHOLIPID STRUCTURE

Phospholipid

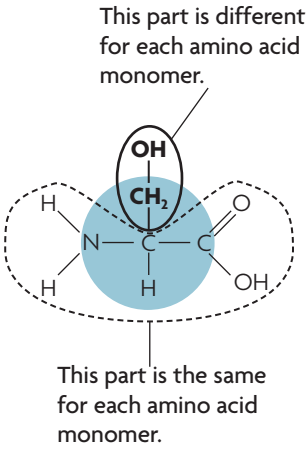
A phospholipid has nonpolar fatty acid "tails" and a polar "head" that contains a phosphate group.

Proteins

Proteins are the most varied of the carbon-based molecules in organisms. There are many different types of proteins. They are involved in many different body functions including movement, eyesight, and digestion.

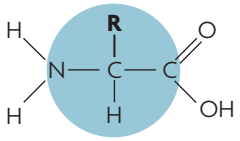
A **protein** is a polymer made of monomers called amino acids. **Amino acids** are molecules that contain carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. Organisms use 20 different amino acids to build different types of proteins. Your body can make 12 of the amino acids it needs. The other 8 amino acids come from the foods you eat, such as meat, beans, and nuts.

Look at the figure at right to see the amino acid called serine. All amino acids have part of their structure that is the same. Another part of their structure is different for each amino acid. The part that is different is called the side group, or R-group. Amino acids are bonded together to form proteins.

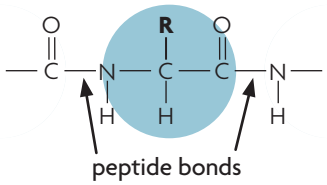


AMINO ACID AND PROTEIN STRUCTURE

All amino acids have a carbon atom bonded to a hydrogen atom, an amino group (NH_2), and a carboxyl group (COOH). Different amino acids have different side groups (**R**).

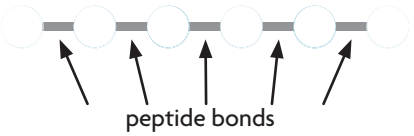


Monomer (amino acid)



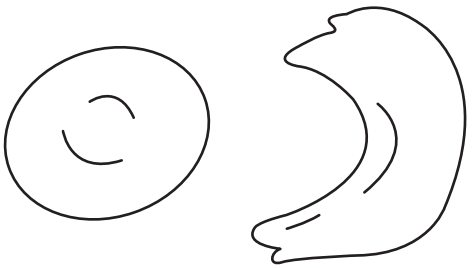
Peptide bonds form between the amino group of one amino acid and the carboxyl group of another amino acid.

Polymer (protein)



A polypeptide is a chain of precisely ordered amino acids linked by peptide bonds. A protein is made of one or more polypeptides.

Proteins are different based on the number and order of amino acids. A protein's function depends on the specific order of the amino acids, which affects the shape of the protein. The side groups of each amino acid can interact with each other and affect the protein's shape. For example, hydrogen bonds can form between different side groups.



Typically, red blood cells are shaped like a saucer (left). A change in just one amino acid in hemoglobin can cause cells to have the curved shape characteristic of sickle cell anemia.

Hemoglobin is the protein in your red blood cells that transports oxygen. Hemoglobin is made of 574 amino acids. Hydrogen bonds help make the structure of this protein. If just one of the amino acids in hemoglobin changes, the structure of the protein can change in a way that prevents the protein from working properly. A change in one amino acid in hemoglobin causes the disorder called sickle cell anemia.

Nucleic Acids

There are two general types of nucleic acids: DNA and RNA. **Nucleic acids** are polymers that are made up of monomers called nucleotides. A nucleotide is made up of a sugar, a phosphate group, and a nitrogen-containing molecule called a base. Nucleic acids contain the instructions to build proteins.

Nucleic acids are different from the other three macromolecules you read about. Carbohydrates, lipids, and proteins have many different structures and functions. Nucleic acids have just one function. They code for proteins. You will learn more about nucleic acids in Unit 3.

STANDARDS CHECK

What are four main types of macromolecules found in living things?

2.3 Vocabulary Check

monomer	protein
polymer	amino acid
carbohydrate	lipid
fatty acid	nucleic acid

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold.**

1. Name four types of macromolecules. _____

_____

2. A protein is made up of monomers called _____ .
3. The carbon chain that makes up part of a lipid is called a _____.
4. A six-carbon sugar is an example of a _____ that can join with other molecules to form a _____ such as starch or cellulose.

2.3 The Big Picture

1. What are three different shapes, or structures, of carbon-based molecules? _____
2. Complete the following chart.

MONOMER	POLYMER	EXAMPLE	FUNCTION
Glucose			
	Protein		
		DNA	

3. What is a phospholipid?

_____

4. Living things are sometimes called "carbon-based life forms." Do you think this is a good way to describe life? Explain your answer.

_____