Name _____ Class _____ Date _____

CHAPTER 6 The Structure of Matter

SECTION 4

Organic and Biochemical Compounds

KEY IDEAS

As you read this section, keep these questions in mind:

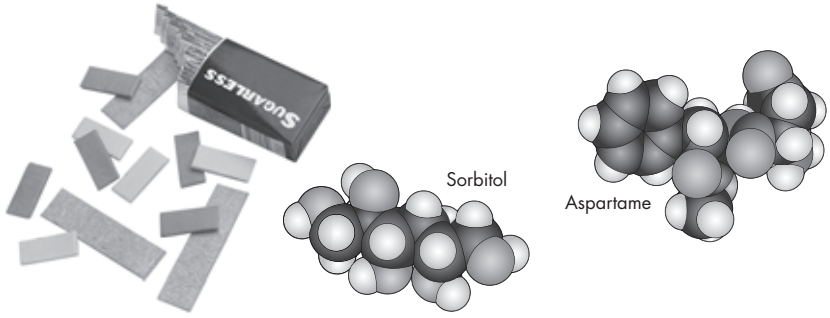
- What is an organic compound?
- What is a polymer?
- What organic compounds are essential to life?

What Are Organic Compounds?

What do you think of when you hear the word *organic*? Many people think of living things or a way of growing food. Scientists use the word organic to describe a type of compound. An **organic compound** is a covalently bonded compound that contains carbon. Most organic compounds also contain hydrogen. Many organic compounds contain oxygen, nitrogen, phosphorus, and sulfur. ☑

READING TOOLBOX

Summarize As you read this section, make a table that lists each type of organic compound and its main characteristics.



Many familiar substances contain organic compounds. For example, the sweeteners sorbitol, $C_6H_{14}O_6$, and aspartame, $C_{14}H_{18}N_2O_5$, are found in sugarless chewing gum.

READING CHECK

1. Identify What kind of bonds exists between atoms in an organic compound?

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A carbon atom can form four covalent bonds. It forms a single bond by sharing one valence electron with another atom. A carbon atom forms a double bond if it shares two of its electrons with another atom. A carbon atom forms a triple bond if it shares three of its electrons. A carbon atom cannot form more than four total bonds at one time.

Critical Thinking

2. Apply Concepts If two carbon atoms are joined by a triple bond, how many other atoms can each carbon atom bond with?

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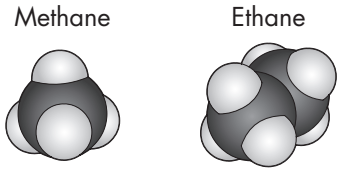
_____

What Is an Alkane?

When a compound is made of only carbon and hydrogen atoms, it is called a *hydrocarbon*. *Alkanes* are hydrocarbons that have only single covalent bonds. Methane, CH_4, is the simplest alkane. It forms when living matter, such as plants, decay. Methane is also a component of the gas used in stoves.



Methane and ethane are the two simplest hydrocarbons.

Methane has only C—H single bonds. However, all other alkanes have one or more C—C single bonds. Molecular models of methane and ethane, C_2H_6, are shown above.

The carbon atoms in methane, ethane, and propane are all bonded in a single line. There are no other arrangements possible for these three hydrocarbons. When an alkane's carbon atoms are bonded in a straight line, it is called a *normal alkane* (*n*-alkane). Several normal alkanes are shown in the table below. ☑

READING CHECK

3. Define What is a normal alkane?

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***n*-Alkane**	**Molecular formula**	**Condensed structural formula**
Methane	CH_4	CH_4
Ethane	C_2H_6	CH_3CH_3
Propane	C_3H_8	$CH_3CH_2CH_3$
Butane	C_4H_{10}	$CH_3(CH_2)_2CH_3$
Pentane	C_5H_{12}	$CH_3(CH_2)_3CH_3$
Hexane	C_6H_{14}	$CH_3(CH_2)_4CH_3$
Heptane	C_7H_{16}	$CH_3(CH_2)_5CH_3$
Octane	C_8H_{18}	$CH_3(CH_2)_6CH_3$
Nonane	C_9H_{20}	$CH_3(CH_2)_7CH_3$
Decane	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$

Carbon atoms in an alkane that has more than three carbon atoms can have more than one possible arrangement. Carbon atom chains may have branches or form rings. The figure on the next page shows several ways that six carbon atoms can be arranged.

Math Skills

4. Calculate If a normal alkane contains 15 carbon atoms, how many hydrogen atoms does it contain?

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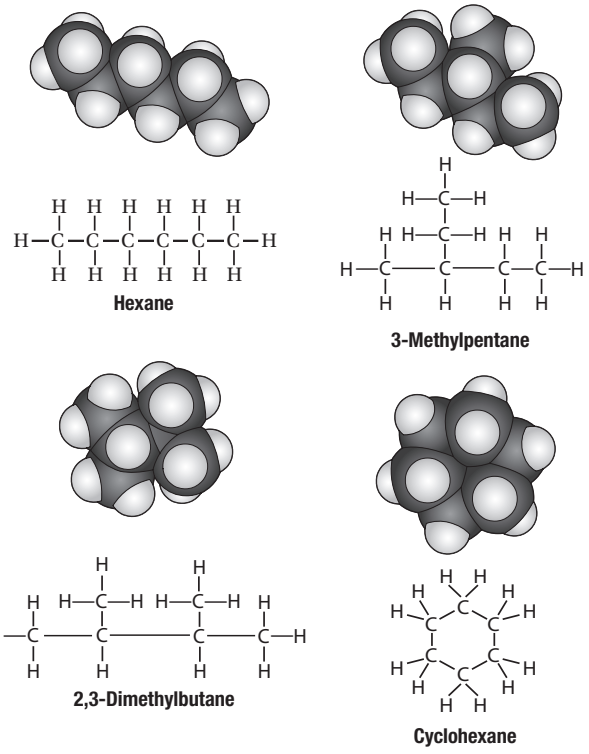
Except for *cyclic alkanes*, or alkanes that form rings, the chemical formula for alkanes follows a special pattern:

$$C_nH_{2n+2}$$

Some alkanes may share a chemical formula. For example, all of the six-carbon alkanes on the next page, except cyclohexane, have the chemical formula C_6H_{14}, or $(C_6H_{2(6)+2})$.

Some Six-Carbon Alkanes



LOOKING CLOSER

5. Compare All of these alkanes, except cyclohexane, have the same chemical formula. Why, then, are these three different compounds?

6. Identify What is the chemical formula for cyclohexane?

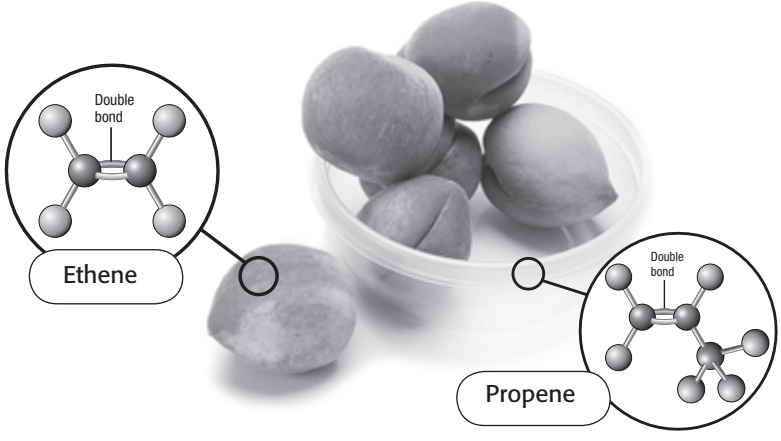
What Are Alkenes?

Alkenes are hydrocarbons with a double bond between at least two carbon atoms. A double bond is represented by two lines between the two carbon atoms, C═C. Alkenes are named by replacing the *-ane* ending used for alkanes with *-ene*.

The simplest alkene is ethene (also called ethylene), C_2H_4. Ethene forms when fruit ripens. Propene (propylene), C_3H_6, is used in some plastics.

Critical Thinking

7. Infer Can an alkene contain single bonds between carbon atoms? Explain your answer.



The peaches in the plastic bowl release ethene gas as they ripen. The plastic that forms the bowl was made by joining propene molecules.

Critical Thinking

8. Compare How does the structure of methanol differ from the structure of methane?

What Are Alcohols?

Alcohols are organic compounds that contain a hydroxyl, –OH, group. Methanol, CH_3OH, and ethanol, CH_3CH_2OH, are the simplest alcohols. Notice that the names of these alcohols ends in *-ol*. The names of most alcohols end in *-ol*.

Like water molecules, alcohol molecules attract one another due to hydrogen bonding. Hydrogen bonds form between the oxygen atom of one alcohol molecule and the hydrogen atom of another molecule. Because of these attractions, alcohols are generally liquids at room temperature. Alcohols have higher boiling points than alkanes of a similar size do. ☑

READING CHECK

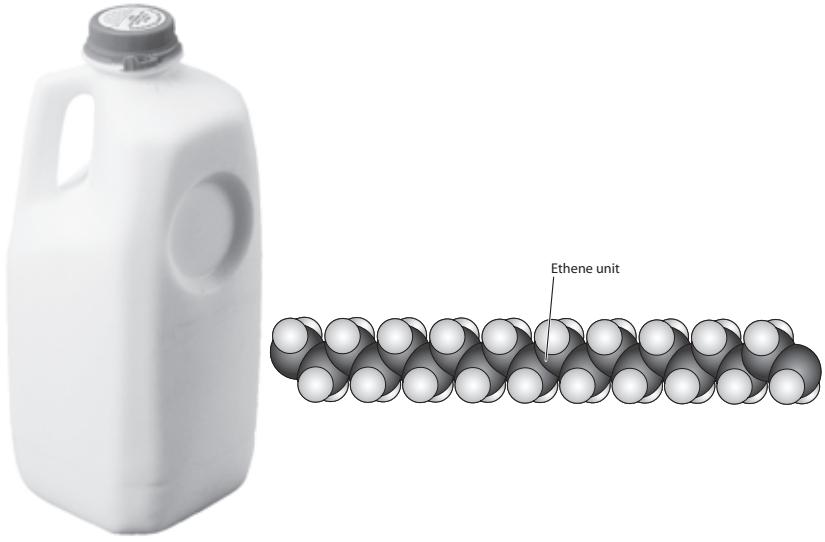
9. Explain Why do alcohols have higher boiling points than alkanes of similar sizes do?

What Are Polymers?

A **polymer** is a large molecule made of a chain of smaller, repeating molecules. Many natural products are made up of polymers. Rubber, wood, cotton, wool, starch, protein, and DNA are all natural polymers.

Human-made polymers are usually plastics, such as the milk jug shown in the figure below, or fibers, such as nylon. Most plastics are flexible and easily molded, and fibers form long, thin strands.

Polypropene (polypropylene) can be used to make both plastics and fibers. Polypropene is molded to make plastic containers, some car parts, and appliances. It is also used to make carpets and artificial turf for athletic fields.



This plastic milk jug is made of polyethene. Polyethene is a polymer made of repeating units of ethene.

MONOMERS

The name polyethene (also called polyethylene or polythene) tells you the basic structure of the polymer. Ethene is an alkene that has the chemical formula C_2H_4. Poly means "many." Thus, polyethene means "many ethenes."

Polyethene is a polymer made up of monomers of ethene. A *monomer* is a repeating unit that makes up a polymer.

Critical Thinking

10. Infer What does the name *polystyrene* tell you about the structure of the compound?

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_____

POLYMER PROPERTIES

The way polymer chains join together to form substances determines the properties of the substance. The arrangement of polymer chains in some substances makes the substance flexible. For example, you can crush or dent a milk jug because the plastic is flexible. However, the plastic is not elastic, so it will not return to its original shape.

The arrangement of polymer chains in other substances makes the polymer elastic. For example, rubber bands are made up of elastic polymers. As long as you do not stretch a rubber band too far, it can return to its original shape.

What Are Biochemical Compounds?

Biochemical compounds are organic compounds that can be made by living things. Biochemicals are essential to life. They include carbohydrates, proteins, and DNA. Each of these biochemicals is a polymer. ☑

READING CHECK

11. List What are three biochemical polymers?

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Carbohydrates give athletes plenty of quick energy. The athletes also need plenty of protein in their diets to help build up their muscles.

CARBOHYDRATES

Carbohydrates are biochemical compounds made up of carbon, hydrogen, and oxygen. Some carbohydrates, such as sugars, are small molecules. However, many carbohydrates are large molecules made of chains of sugars. For example, starch is made of glucose monomers. Potatoes and pasta are some foods that contain starch. ☑

READING CHECK

12. List What three elements make up a carbohydrate?

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When you eat starchy foods, enzymes in your body break down the carbohydrate polymers into their monomers. Your body uses enzymes to break down starches so that your cells can use the molecules of glucose.

Your cells use glucose for energy. However, your body can store extra glucose as glycogen. Glycogen is another polymer made up of glucose molecules. When you need energy later, your body breaks down glycogen into glucose monomers that your cells can use.

PROTEINS

Proteins are organic compounds made of chains of amino acids. **Amino acids** are smaller molecules made of carbon, hydrogen, oxygen, and nitrogen. Some amino acids contain sulfur. Each protein is made of a specific combination and number of amino acids. The sequence of amino acids in a protein determines the protein's structure and function. ☑

READING CHECK

13. Identify What monomers make up proteins?

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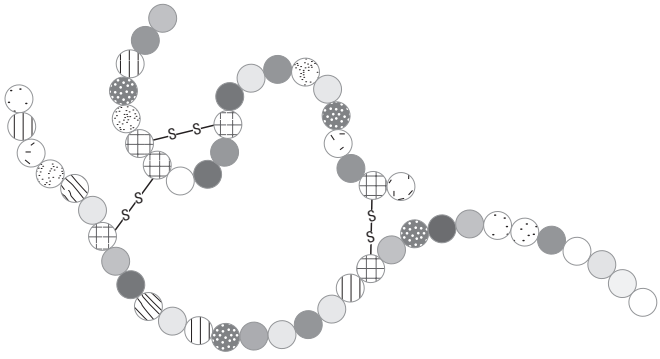
Foods that contain proteins include cheeses and meats. When you eat foods that contain protein, your body breaks down the protein into individual amino acids. Your cells use the amino acids to make other proteins that your body needs.



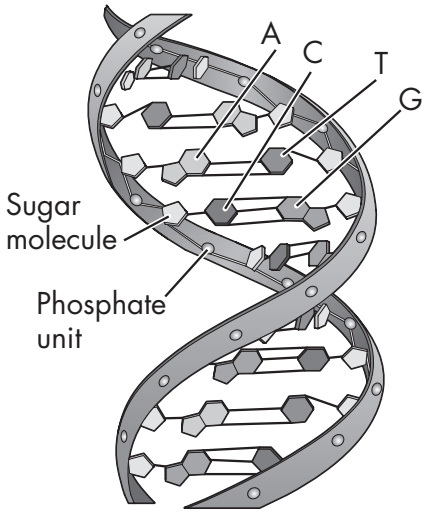
Proteins are made up of monomers called amino acids. Each ball in the chain represents an amino acid. Different chains may be linked together by sulfur ions. These links are called disulfide bridges.

DNA

All of your genes are made of DNA molecules. *DNA* is a long molecule made of carbon, hydrogen, oxygen, nitrogen, and phosphorus. DNA is made up of monomers called *nucleotides*. Each nucleotide has one of four bases: adenine, thymine, guanine, and cytosine. ☑

The figure below shows the complex structure of DNA. The shape of a DNA molecule is a double helix. A double helix looks like a twisted ladder.

Two chains of nucleotides form the strands of DNA. The strands are held together by attractions between bases on opposite strands.



In DNA, cytosine, C, always pairs with guanine, G. Adenine, A, always pairs with thymine, T.

DNA carries the instructions for making proteins. Each group of three bases along a strand of DNA represents a specific amino acid. The sequence of bases in DNA determines the sequence of amino acids in proteins. ☑

Almost every cell in your body contains a copy of your DNA. When a cell divides, DNA strands separate and a copy is made from the old strands.

READING CHECK

14. Identify What monomers make up DNA?

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READING CHECK

15. Identify Relationships How is the sequence of bases in DNA related to the sequence of amino acids in proteins?

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Name _____ Class _____ Date _____

Section 4 Review

SECTION VOCABULARY

amino acid a compound of a class of simple organic compounds that contain a carboxyl group and an amino group and that combine to form proteins

carbohydrate a class of molecules that includes sugars, starches, and fiber; contains carbon, hydrogen, and oxygen

organic compound a covalently bonded compound that contains carbon, excluding carbonates and oxides

polymer a large molecule that is formed by more than five monomers, or small units

protein an organic compound that is made of one or more chains of amino acids and that is a principal component of all cells

1. **Apply Concepts** A particular alkane and a particular alkene have the same number of carbon atoms joined in a chain. Which compound contains more hydrogen atoms? Explain your answer.

2. **Identify** Complete the table below to identify each compound as an alkane, an alkene, or an alcohol based on its name.

Compound	Alkane, alkene, or alcohol?
2-methylpentane	
3-methyloctane	
1-nonene	
2-butanol	
3-heptene	
cyclohexanol	

3. **Identify** Which of the following compounds is an alkane: CH_2O, C_6H_{14}, or C_3H_4? Explain your answer.

4. **Analyze Patterns** Alkynes are hydrocarbons that have triple bonds between at least two carbons. What is the name of the compound that has the chemical formula C_3H_4?

5. **Identify Relationships** What is the relationship between monomers and polymers?