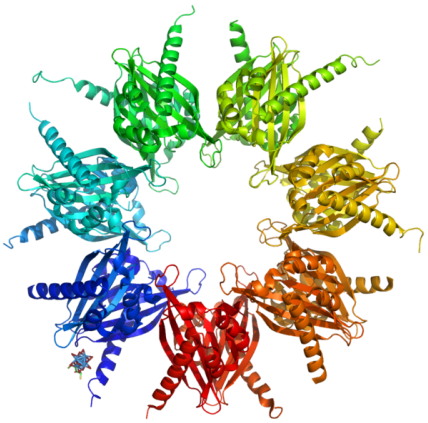
Chapter 2

The Chemistry of Life Worksheets



(Opening image courtesy of David Iberri, http://en.wikipedia.org/wiki/File:CaMKII.png, and under the Creative Commons license CC-BY-SA 3.0.)

- **Lesson 2.1: Matter and Organic Compounds**
- **Lesson 2.2: Biochemical Reactions**
- **Lesson 2.3: Water, Acids, and Bases**

2.1 Matter and Organic Compounds

Lesson 2.1: True or False

Name_____ **Class**_____ **Date**_____

Write true if the statement is true or false if the statement is false.

_____ 1. An atom is smaller than an element.

_____ 2. Organic compounds are found in living organisms.

_____ 3. Proteins are made out of amino acids.

_____ 4. Proteins speed up chemical reactions.

_____ 5. The DNA code carries instructions for the correct sequence of nucleic acids in a protein

_____ 6. Sugars and phosphate groups form the middle of a nucleic acid chain.

_____ 7. DNA (and RNA) is made out of nucleotides.

_____ 8. A protein consists of one or more polypeptide chains.

_____ 9. Lipids include fats, oils, and sugars.

_____ 10. Carbohydrates are the most common type of organic compound.

_____ 11. Peanut oil is an unsaturated fatty acid.

_____ 12. Cytosine and adenine are complementary bases in DNA.

_____ 13. A double helix is like a spiral staircase.

_____ 14. Phospholipids form cell membranes.

_____ 15. Carbohydrates are made out of monosaccharides.

Lesson 2.1: Critical Reading

Name_____ **Class**_____ **Date**_____

Read these passages from the text and answer the questions that follow.

The Significance of Carbon

A compound found mainly in living things is known as an **organic compound**. Organic compounds make up the cells and other structures of organisms and carry out life processes. Carbon is the main element in organic compounds, so carbon is essential to life on Earth. Without carbon, life as we know it could not exist. Why is carbon so basic to life? The reason is carbon's ability to form stable bonds with many elements, including itself. This property allows carbon to form a huge variety of very large and complex molecules. In fact, there are nearly 10 million carbon-based compounds in living things! However, the millions of organic compounds can be grouped into just four major types: carbohydrates, lipids, proteins, and nucleic acids. You can compare the four types in **Table** 2.1. Each type is also described below.

Table 2.1: **Types of Organic Compounds**

Type of Compound	Examples	Elements	Functions
Carbohydrates	sugars, starches	carbon, hydrogen, oxygen	provides energy to cells, stores energy, forms body structures
Lipids	fats, oils	carbon, hydrogen, oxygen	stores energy, forms cell membranes, carries messages
Proteins	enzymes, antibodies	carbon, hydrogen, oxygen, nitrogen, sulfur	helps cells keep their shape, makes up muscles, speeds up chemical reactions, carries messages and materials
Nucleic Acids	DNA, RNA	carbon, hydrogen, oxygen, nitrogen, phosphorus	contains instructions for proteins, passes instructions from parents to offspring, helps make proteins

Carbohydrates

Carbohydrates are the most common type of organic compound. A **carbohydrate** is an organic compound such as sugar or starch, and is used to store energy. Like most organic compounds, carbohydrates are built of small, repeating units that form bonds with each other to make a larger molecule. In the case of carbohydrates, the small, repeating units are called monosaccharides.

Lipids

A **lipid** is an organic compound such as fat or oil. Organisms use lipids to store energy, but lipids have other important roles as well. Lipids consist of repeating units called fatty acids. There are two types of fatty acids: saturated fatty acids and unsaturated fatty acids.

Proteins

A **protein** is an organic compound made up of small molecules called **amino acids**. There are 20 different amino acids commonly found in the proteins of living things. Small proteins may contain just a few hundred

amino acids, whereas large proteins may contain thousands of amino acids.

Nucleic Acids

A **nucleic acid** is an organic compound, such as DNA or RNA, that is built of small units called nucleotides. Many nucleotides bind together to form a chain called a **polynucleotide**. The nucleic acid **DNA** (deoxyribonucleic acid) consists of two polynucleotide chains. The nucleic acid **RNA** (ribonucleic acid) consists of just one polynucleotide chain.

Questions

1. List two functions of organic compounds.

2. Which two categories of organic compounds store energy? Which of these organic compounds is more common?

3. What is a main difference between DNA and RNA?

4. Describe a difference between large and small proteins.

5. Why is carbon considered the essential element of life?

Lesson 2.1: Multiple Choice

Name_____ **Class**_____ **Date**_____

Circle the letter of the correct choice.

1. Water (H_2O) is a(n)
   (a) element.
   (b) atom.
   (c) compound.
   (d) carbohydrate.
2. A process that changes some chemical substances into others is a
   (a) chemical bond.
   (b) chemical reaction.
   (c) chemical equation.
   (d) chemical formula.
3. The main difference between saturated and unsaturated fatty acids is
   (a) the amount of energy found in the fatty acid.
   (b) saturated fatty acids are liquids.
   (c) unsaturated fatty acids can be packed together very tightly.
   (d) the number of hydrogen atoms bonded to the carbon atoms.
4. The function of proteins can include
   (a) helping cells keep their shape.
   (b) helping to destroy foreign substances.
   (c) speeding up biochemical reactions.
   (d) all of the above
5. The characteristics of DNA includes which of the following?
   (a) DNA is made of nucleotides consisting of a sugar, a phosphate group, and a carbon base.
   (b) DNA is made of a single polynucleotide chain, which winds into a double helix.
   (c) DNA is how inherited characteristics are passed from one generation to the next.
   (d) all of the above
6. Which category of organic compound is the major component of cell membranes?
   (a) carbohydrate
   (b) lipid
   (c) protein
   (d) nucleic acid
7. The cell wall of plants is made out of
   (a) starch.
   (b) glycogen.
   (c) cellulose.
   (d) chitin.
8. The main element of organic compounds is
   (a) hydrogen.
   (b) oxygen.
   (c) nitrogen.
   (d) carbon.

Lesson 2.1: Vocabulary I

Name_____ **Class**_____ **Date**_____

Match the vocabulary word with the proper definition.

Definitions

_____ 1. an organic compound that stores energy, forms cell membranes, carries messages

_____ 2. an organic compound that contains instructions for proteins

_____ 3. an organic compound that provides energy to cells, stores energy, forms body structures

_____ 4. an organic compound that helps cells keep their shape

_____ 5. a pure substance, like carbon

_____ 6. may contain just a few simple sugars or thousands

_____ 7. subunit that make up proteins

_____ 8. subunit used to make nucleic acids

_____ 9. lipid in which carbon atoms are bonded to as many hydrogen atoms as possible

_____ 10. lipid in which carbon atoms are bonded to groups of atoms other then hydrogen

_____ 11. the major component of cell membranes

_____ 12. anything that takes up space and has mass

Terms

a. amino acid

b. carbohydrate

c. DNA

d. element

e. lipid

f. matter

g. nucleotide

h. phospholipid

i. polysaccharide

j. protein

k. saturated fatty acid

l. unsaturated fatty acid

Lesson 2.1: Vocabulary II

Name_____ **Class**_____ **Date**_____

Fill in the blank with the appropriate term.

1. A substance that consists of two or more elements is a _____.
2. The information in _____ is passed from parents to offspring when organisms reproduce.
3. _____ are proteins which bind to foreign substances such as bacteria and target them for destruction.
4. _____ compounds make up the cells and other structures of organisms and carry out _____ processes.
5. _____ is the monosaccharide used for energy by the cells of most organisms.
6. _____ are the most common type of organic compound.
7. _____ is a protein that binds with oxygen molecules.
8. The shape of DNA is that of a _____.
9. _____ is used by plants to store energy.
10. _____ is used by plants to form rigid walls around cells.
11. DNA contains _____ instructions for proteins, and _____ helps assemble the proteins.
12. Matter is anything that takes up space and has _____.

Lesson 2.1: Critical Writing

Name_____ **Class**_____ **Date**_____

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Describe the main functions of each of the four classes of organic compounds.

2.2 Biochemical Reactions

Lesson 2.2: True or False

Name_____ **Class**_____ **Date**_____

Write true if the statement is true or false if the statement is false.

_____ 1. A substance that forms as a result of a chemical reaction is called a reactant.

_____ 2. Only some chemical reactions need energy to get started.

_____ 3. Biochemical reactions take place inside the cells.

_____ 4. A chemical reaction that releases heat is an exothermic reaction.

_____ 5. Most biochemical reactions need help to get started.

_____ 6. Anabolic reactions give off energy.

_____ 7. Metabolism is the sum of all the biochemical reactions in an organism.

_____ 8. In a chemical reaction, the quantity of an element may change.

_____ 9. During a chemical reaction, some bonds break and new bonds form.

_____ 10. Activation energy is the energy needed to start a chemical reaction.

_____ 11. An enzyme speeds up the reaction by lowering the activation energy.

_____ 12. In a chemical reaction, the number of atoms on one side of the arrow may differ from the number of atoms on the other side.

_____ 13. Matter is always conserved.

_____ 14. Understanding chemistry is needed to understand fully the processes within the cell.

_____ 15. In a chemical reaction, the quantity of each element does not change.

Lesson 2.2: Critical Reading

Name_____ **Class**_____ **Date**_____

Read these passages from the text and answer the questions that follow.

Biochemical Reactions and Enzymes

Biochemical reactions are chemical reactions that take place inside the cells of living things. Biochemistry is a relatively new field that emerged at the interface of biology and chemistry. Its emergence shows that knowledge of chemistry as well as biology is needed to understand fully the life processes of organisms at the level of the cell. The sum of all the biochemical reactions in an organism is called **metabolism**. It includes both exothermic and endothermic reactions.

Types of Biochemical Reactions

Exothermic reactions in organisms are called **catabolic reactions**. These reactions break down molecules into smaller units and release energy. An example of a catabolic reaction is the breakdown of glucose, which releases energy that cells need to carry out life processes. Endothermic reactions in organisms are called **anabolic reactions**. These reactions build up bigger molecules from smaller ones. An example of an anabolic reaction is the joining of amino acids to form a protein. Which type of reactions — catabolic or anabolic — do you think occur when your body digests food?

Enzymes

Most biochemical reactions in organisms need help in order to take place. Why is this the case? For one thing, temperatures are usually too low inside living things for biochemical reactions to occur quickly enough to maintain life. The concentrations of reactants may also be too low for them to come together and react. Where do the biochemical reactions get the help they need to proceed? The help comes from enzymes.

An **enzyme** is a protein that speeds up a biochemical reaction. An enzyme works by reducing the amount of activation energy needed to start the reaction. Less activation energy is needed when the correct enzyme is present than when it is not present.

Enzymes are involved in most biochemical reactions, and they do their job extremely well. A typical biochemical reaction could take several days to occur without an enzyme. With the proper enzyme, the same reaction can occur in just a split second! Without enzymes to speed up biochemical reactions, most organisms could not survive. The activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings. Some enzymes work best at an acidic pH, while others work best in neutral environments.

Questions

1. What is an enzyme?

2. How are biochemistry and metabolism related?

3. Which type of reactions — catabolic or anabolic — do you think occur when your body digests food?

4. How do enzymes work?

5. What is activation energy?

Lesson 2.2: Multiple Choice

Name_____ **Class**_____ **Date**_____

Circle the letter of the correct choice.

1. Reactants in the burning of methane include
   (a) CH_4 and $2O_2$.
   (b) CO_2 and $2H_2O$.
   (c) CH_4 and CO_2.
   (d) CO_2 and $2O_2$.
2. Activities of enzymes depend on
   (a) pH.
   (b) temperature.
   (c) ionic conditions.
   (d) all of the above
3. An enzyme is a _____.
   (a) carbohydrate
   (b) lipid
   (c) protein
   (d) nucleic acid
4. Reactions that take place inside cells are
   (a) cellular reactions.
   (b) enzyme reactions.
   (c) metabolic reactions.
   (d) biochemical reactions.
5. What is the main difference between an endothermic reaction and an exothermic reaction?
   (a) An endothermic reaction gives off energy and an exothermic reaction absorbs energy.
   (b) An exothermic reaction gives off energy and an endothermic reaction absorbs energy.
   (c) An endothermic reaction does not need activation energy.
   (d) Only endothermic reactions involve enzymes.
6. Another name for a "biological catalyst" could be a(n)
   (a) enzyme.
   (b) reactant.
   (c) activator.
   (d) metabolism.
7. The joining of amino acids to form a protein is a(n)
   (a) anabolic reaction.
   (b) catabolic reaction.
   (c) amino acid reaction.
   (d) polypeptide reaction.
8. The "push" needed to start a chemical reaction is the
   (a) enzymatic energy.
   (b) endothermic energy.
   (c) activation energy.
   (d) reactant energy.

Lesson 2.2: Vocabulary I

Name_____ **Class**_____ **Date**_____

Match the vocabulary word with the proper definition.

Definitions

_____ 1. represents a chemical reaction

_____ 2. a protein that speeds up a biochemical reaction

_____ 3. a substance that forms as a result of a chemical reaction

_____ 4. a substance that starts a chemical reaction

_____ 5. sum of all the biochemical reactions in an organism

_____ 6. a process that changes some chemical substances into others

_____ 7. exothermic reactions in organisms

_____ 8. endothermic reactions in organisms

_____ 9. chemical reactions that take place inside the cells of living things

_____ 10. a chemical reaction that releases energy

_____ 11. a chemical reaction that absorbs energy

_____ 12. the energy needed to start a chemical reaction

Terms

a. activation energy

b. anabolic reaction

c. biochemical reaction

d. catabolic reaction

e. chemical equation

f. chemical reaction

g. enzyme

h. endothermic

i. exothermic

j. metabolism

k. product

l. reactant

Lesson 2.2: Vocabulary II

Name_____ **Class**_____ **Date**_____

Fill in the blank with the appropriate term.

1. Biochemical reactions are chemical reactions that take place inside the _____ of living things.

2. During a chemical reaction, the _____ are used up to create the products.

3. All chemical reactions need _____ to get started.

4. _____ reactions in organisms are called catabolic reactions.

5. _____ energy provides the push needed to start a chemical reaction.

6. Your _____ includes both exothermic and endothermic reactions.

7. A chemical reaction involves the breaking and forming of _____.

8. In a chemical reaction, all matter is _____.

9. Energy can be released during a chemical reaction in the form of _____ and light.

10. In a chemical reaction, there is the same amount of each _____ in the products as there was in the reactants.

11. An _____ reaction builds up bigger molecules from smaller ones.

12. An _____ works by reducing the amount of activation energy needed to start the reaction.

Lesson 2.2: Critical Writing

Name_____ **Class**_____ **Date**_____

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Describe the roles of enzymes in biochemical reactions. Use specifics in discussing how enzymes work. Provide an example of a biochemical reaction involving an enzyme.

2.3 Water, Acids, and Bases

Lesson 2.3: True or False

Name_____ **Class**_____ **Date**_____

Write true if the statement is true or false if the statement is false.

_____ 1. Water is a chemical.

_____ 2. The hydrogen atoms in a water molecule attract electrons more strongly than the oxygen atom does.

_____ 3. Hydrogen bonds are very strong bonds.

_____ 4. Water is a reactant in photosynthesis.

_____ 5. Enzymes in the small intestine need an acidic environment in order to work.

_____ 6. Pure water has a pH of 7.

_____ 7. Lemon juice is a stronger acid than orange juice.

_____ 8. An ion is an electrically charged atom or molecule.

_____ 9. The stomach is a very acidic environment.

_____ 10. Water is released during cellular respiration.

_____ 11. Soap is very acidic.

_____ 12. Hydrogen bonds cause water to have a relatively high boiling point of 100°F.

_____ 13. Acids have a pH lower than 7.

_____ 14. Bases have a pH lower than 7.

_____ 15. A water molecule has positive and negative parts to it.

Lesson 2.3: Critical Reading

Name_____ **Class**_____ **Date**_____

Read these passages from the text and answer the questions that follow.

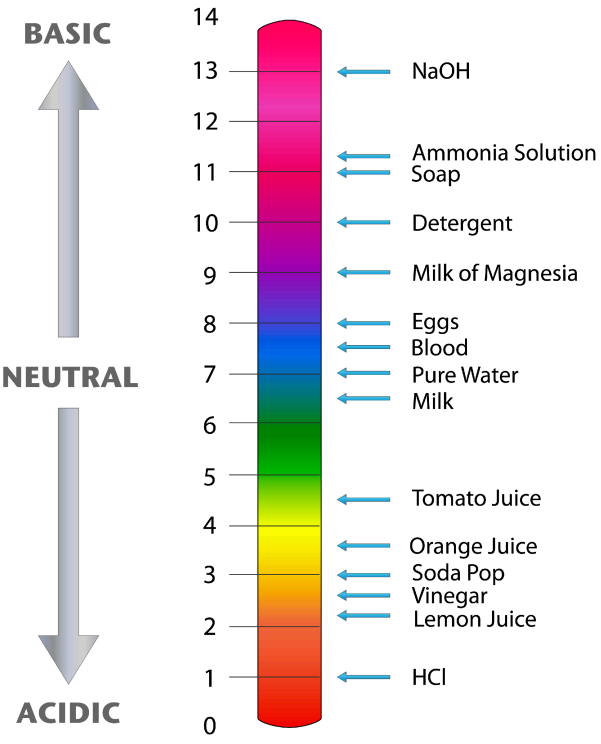
Acids and Bases

Water is the main ingredient of many solutions. A **solution** is a mixture of two or more substances that has the same composition throughout. Some solutions are acids and some are bases. To understand acids and bases, you need to know more about pure water. In pure water (such as distilled water), a tiny fraction of water molecules naturally break down to form ions. An ion is an electrically charged atom or molecule. The breakdown of water is represented by the chemical equation

$$2H_2O \rightarrow H_3O^+ + OH^-$$

The products of this reaction are a hydronium ion (H_3O^+) and a hydroxide ion (OH^-). The hydroxide ion, which has a negative charge, forms when a water molecule gives up a positively charged hydrogen ion (H^+). The hydronium ion, which has positive charge, forms when another water molecule accepts the hydrogen ion.

Acidity and pH The concentration of hydronium ions in a solution is known as acidity. In pure water, the concentration of hydronium ions is very low; only about 1 in 10 million water molecules naturally breaks down to form a hydronium ion. As a result, pure water is essentially neutral. Acidity is measured on a scale called **pH**, as shown in the figure below. Pure water has a pH of 7, so the point of neutrality on the pH scale is 7.



pH Scale. The pH scale ranges from 0 to 14, with 7 being the point of neutrality. What is the pH of lemon juice? Of milk? *(Image courtesy of Edward Stevens, modified by CK-12 Foundation, and under the Creative Commons license CC-BY-SA 3.0.)*

Acids and Bases in Organisms

Acids and bases are important in living things because most enzymes can do their job only at a certain

level of acidity. Cells secrete acids and bases to maintain the proper pH for enzymes to work. For example, every time you digest food, acids and bases are at work in your digestive system. Consider the enzyme pepsin, which helps break down proteins in the stomach. Pepsin needs an acidic environment to do its job, and the stomach secretes a strong acid that allows pepsin to work. However, when stomach contents enter the small intestine, the acid must be neutralized. This is because enzymes in the small intestine need a basic environment in order to work. An organ called the pancreas secretes a strong base into the small intestine, and this base neutralizes the acid.

Water and Life

The human body is about 70% water (not counting the water in body fat, which varies from person to person). The body needs all this water to function normally. Just why is so much water required by human beings and other organisms? Water can dissolve many substances that organisms need, and it is necessary for many biochemical reactions. The examples below are among the most important biochemical processes that occur in living things, but they are just two of many ways that water is involved in biochemical reactions.

- Photosynthesis — In this process, cells use the energy in sunlight to change carbon dioxide and water to glucose and oxygen. The reactions of photosynthesis can be represented by the chemical equation

$6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6O_2$

- Cellular respiration — In this process, cells break down glucose in the presence of oxygen and release carbon dioxide, water, and energy. The reactions of cellular respiration can be represented by the chemical equation

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$

Water is involved in many other biochemical reactions. As a result, just about all life processes depend on water. Clearly, life as we know it could not exist without water.

Questions

1. Describe the best environment for the enzyme pepsin.

2. Why is water so important for life?

3. Which is a stronger acid: lemon juice or soda pop? Why?

4. What is a hydronium ion? How does one form?

5. In terms of water, what is one main difference between photosynthesis and cellular respiration?

Lesson 2.3: Multiple Choice

Name_____ **Class**_____ **Date**_____

Circle the letter of the correct choice.

1. Earth is sometimes called the
   (a) "water planet," because almost 75% of its surface is covered with water.
   (b) "oxygen planet," because oxygen is necessary for life.
   (c) "carbon planet," because carbon is the central element in organic compounds.
   (d) all of the above.
2. The oxygen in a water molecule
   (a) attracts electrons more strongly than the hydrogen atoms.
   (b) has a slight negative charge.
   (c) binds to a hydrogen of another water molecule through a hydrogen bond.
   (d) all of the above
3. Which of the following is an example of a solution?
   (a) a pepperoni pizza
   (b) a box of Lucky Charms cereal
   (c) a glass of orange juice
   (d) a hot fudge sundae
4. Which is the strongest acid?
   (a) vinegar
   (b) soda pop
   (c) orange juice
   (d) lemon juice
5. A solution with a lower concentration of hydronium ions than pure water
   (a) can have a pH of 6.5.
   (b) is a base.
   (c) can taste sweet.
   (d) all of the above
6. How do hydrogen bonds affect water's properties?
   (a) Hydrogen bonds explain why water molecules stick together.
   (b) Hydrogen bonds cause water to have a relatively high boiling point.
   (c) Hydrogen bonds also cause water to expand when it freezes.
   (d) all of the above
7. Where is most of the freshwater found?
   (a) as ground water
   (b) in icecaps, glaciers and inland seas
   (c) in the oceans
   (d) in other areas

Lesson 2.3: Vocabulary I

Name_____ **Class**_____ **Date**_____

Match the vocabulary word with the proper definition.

Definitions

_____ 1. for water, 212°F or 100°C

_____ 2. a range from 0 to 14

_____ 3. has a pH less than 7

_____ 4. has a pH more than 7

_____ 5. photosynthesis

_____ 6. OH^-

_____ 7. a measure of the acidity of a solution

_____ 8. has the same composition throughout

_____ 9. needs an acidic environment to work

_____ 10. an organ that secretes a strong base into the small intestine

_____ 11. a difference in electrical charge within the same molecule

_____ 12. holds water molecules together

Terms

a. acid

b. base

c. boiling point

d. hydrogen bond

e. hydroxide ion

f. pancreas

g. pepsin

h. pH

i. pH scale

j. polarity

k. solution

l. $6CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6O_2$

Lesson 2.3: Vocabulary II

Name_____ **Class**_____ **Date**_____

Fill in the blank with the appropriate term.

1. Water's _____ gives it unique properties that help explain why it is vital to all living organisms.
2. In water, the _____ atom attracts electrons more strongly than the _____-atoms do.
3. Ice floats on water because ice has a _____ density.
4. A mixture of two or more substances with the same composition throughout is a _____.
5. pH is a measure of the _____ of a solution.
6. A(n) _____ has a pH lower than 7.
7. Water molecules are held together by _____ bonds.
8. _____ is a difference in electrical charge between different parts of the same molecule.
9. 100°C is water's _____ point.
10. Water is essentially neutral, with a pH of _____.
11. _____ is slightly basic with a pH just above 7.
12. In a water molecule, the hydrogen atoms have a _____ charge.

Lesson 2.3: Critical Writing

Name_____ **Class**_____ **Date**_____

Thoroughly answer the question below. Use appropriate academic vocabulary and clear and complete sentences.

Using specifics in describing the structure of the water molecule, and discuss why water is referred to as a "polar molecule."