

# 2

## The Chemistry and Energy of Life

### Chapter Outline

- 2.1 – Atomic Structure Is the Basis for Life's Chemistry
- 2.2 – Atoms Interact and Form Molecules
- 2.3 – Carbohydrates Consist of Sugar Molecules
- 2.4 – Lipids Are Hydrophobic Molecules
- 2.5 – Biochemical Changes Involve Energy

Living organisms, such as birds and fish, are made up of cells—collections of molecules that work together. Interacting atoms make up the molecules, and it is necessary for you to understand a few details about atoms and molecules if you are going to be able to understand life. All life exists at the expense of its surrounding environment and is dependent on biochemical transformations of matter. These transformations occur within the laws of thermodynamics, specifying that energy is neither created nor destroyed and that disorder (entropy) increases during transformations.

Chapter 2 continues the consideration of **Big Idea 1**. Specific parts of the AP Biology curriculum that are covered in Chapter 2 include:

- **1.D.2:** Scientific evidence from many different disciplines supports models of the origin of life.

This chapter also begins your exploration of **Big Idea 2**, wherein you examine energy use by cells as you

begin to catalogue the molecular building blocks of life processes. Included are:

- **2.A.1:** All living systems require constant input of free energy.
- **2.A.3:** Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.

The chapter introduces **Big Idea 4:** Biological systems interact, and these systems and their interactions possess complex properties. Specifically, it addresses:

- **4.A.1:** The subcomponents of biological molecules and their sequence determine the properties of that molecule.
- **4.B.1:** Interactions between molecules affect their structure and function.
- **4.C.1:** Variation in molecular units provides cells with a wider range of functions.

### Chapter Review

**Concept 2.1** reviews some details about atomic structure in order to understand how molecules function in living organisms.

1. For each of the following, provide the number of electrons, protons, and neutrons, and the atomic number in its elemental form. Look for the information in your textbook or on a periodic table of the elements.

	electrons	protons	neutrons	atomic number
a. hydrogen	_____	_____	_____	_____
b. carbon	_____	_____	_____	_____
c. oxygen	_____	_____	_____	_____
d. phosphorus	_____	_____	_____	_____

**Concept 2.2** explains how molecules result from interactions between atoms.

2. Arrange the following atomic interactions from strongest to weakest: van der Waals forces, covalent bonds, hydrogen bonds, ionic bonds.

\_\_\_\_\_ > \_\_\_\_\_ > \_\_\_\_\_ > \_\_\_\_\_

3. Define *cation*.

\_\_\_\_\_

\_\_\_\_\_

4. Define *anion*.

\_\_\_\_\_

\_\_\_\_\_

5. Using sodium chloride as an example, explain how electron imbalances cause atoms to interact with one another.

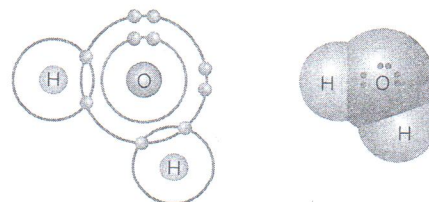
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. Name the molecule shown by the two models at the right.

\_\_\_\_\_



Explain how the electrons of these atoms are affected by their atomic interaction, and describe what this does to the distribution of charge around the molecule.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. Drawings (A) and (B) are shown at different magnifications. They represent three molecules, two of which are interacting with each other and a third that is interacting with itself. Explain the interactions in each. Then explain why you think (A) and (B) have either the same number of atoms or a different number of atoms.

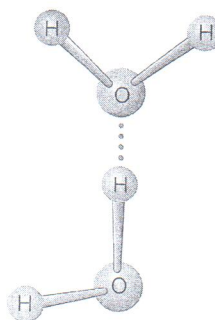
a. Interactions in (A) \_\_\_\_\_

\_\_\_\_\_

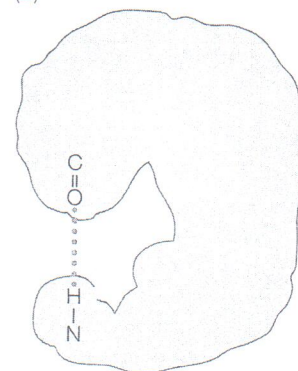
\_\_\_\_\_

\_\_\_\_\_

(A)



(B)





b. Interactions in (B) \_\_\_\_\_

\_\_\_\_\_

c. (A) and (B) have (the same/a different) number of atoms because \_\_\_\_\_

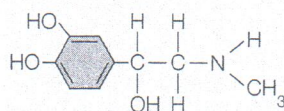
\_\_\_\_\_

d. More atoms are represented in drawing \_\_\_\_\_ because \_\_\_\_\_

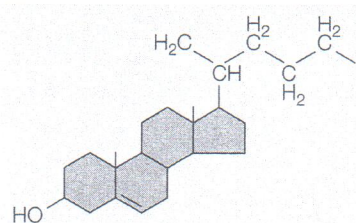
\_\_\_\_\_

8. The two chemicals at the right are found in the body and differ in their solubility in water. One is quite soluble, and the other is much less soluble. Explain this by completing the sentences below.

(A)



(B)



a. Choice \_\_\_\_\_ is more water-soluble because \_\_\_\_\_

\_\_\_\_\_

b. Choice \_\_\_\_\_ is less water-soluble because \_\_\_\_\_

\_\_\_\_\_

**Concept 2.3** explains how carbohydrates, or sugar molecules, yield chemical energy when catabolized (taken apart). Many organisms, including plants, catabolize glucose and other sugars to liberate energy for their own use. Plants also synthesize sugars by using solar energy and environmental sources of carbon dioxide and water.

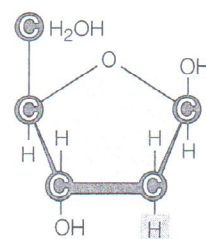
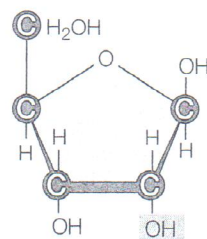
9. Solar energy drives \_\_\_\_\_ in green plants, resulting in the synthesis of \_\_\_\_\_, a monosaccharide. Sucrose is a disaccharide resulting from the formation of a \_\_\_\_\_ linkage between two monosaccharides. The starch molecule, also known as \_\_\_\_\_, is an even larger polymer of the products of these synthetic processes, and the most abundant member of this group on Earth is \_\_\_\_\_.

10. Number the carbons in the figure at the right.  
What are the names of these two monosaccharides?

---



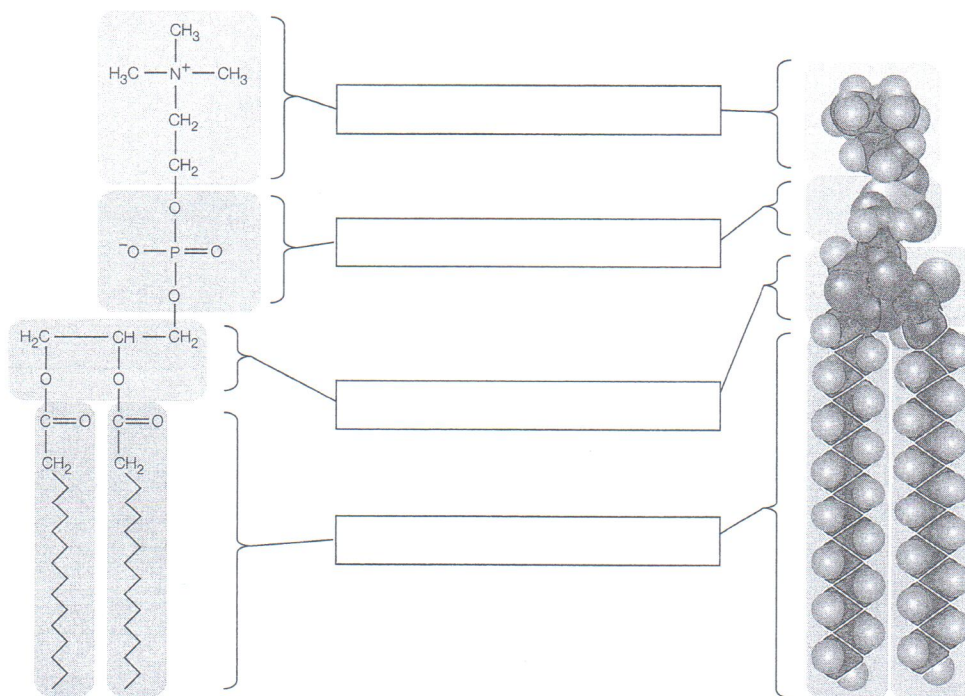
---



**Concept 2.4** explains that lipids (fats) are large storage molecules that do not dissolve readily in water.

11. Refer to the models below.

- a. Provide labels for the four different areas of the molecule, indicated by the four shaded blocks on each representation. (Two models are shown.)



b. The hydrophobic tail includes \_\_\_\_\_

---

c. The hydrophilic head includes \_\_\_\_\_

---

12. Steroids and other fatty substances pass readily through most cellular membranes because

---



---



---



---



**Concept 2.5** explains how energy for life comes from biochemical changes in molecules.

13. Anabolic steroids are drugs that are sometimes misused by people who want to increase their athletic prowess. Describe what is meant by *anabolic* in this term.

## Science Practices & Inquiry

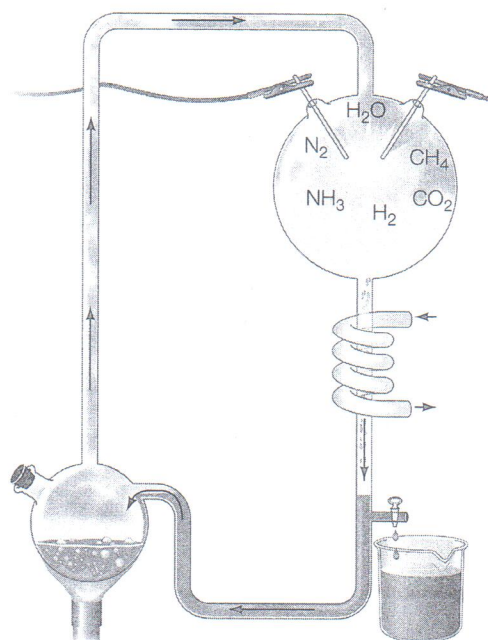
There are seven **Science Practices** in the AP Biology Curriculum Framework. In this chapter, we focus on **Science Practice 6**: The student can work with scientific explanations and theories. More specifically, we look at **Science Practice 6.2**: The student can construct explanations of phenomena based on evidence produced through scientific practices.

Questions 14–17 ask you to construct explanations based on evidence of how variations in molecular units provide cells with a wider range of functions (**Learning Objective 4.22**).

In 1953, Stanley Miller and Harold Urey set up an apparatus, depicted at the right, to simulate Earth's early atmosphere. The gases they added in their original setup were methane ( $\text{CH}_4$ ), ammonia ( $\text{NH}_3$ ), hydrogen ( $\text{H}_2$ ), water ( $\text{H}_2\text{O}$ ), carbon dioxide ( $\text{CO}_2$ ), and nitrogen gas ( $\text{N}_2$ ). Energy was added by passing a spark across two electrodes and by boiling the reactants. After one week of continuous sparking and boiling of this "primordial soup," several amino acids—including aspartic acid, glycine, and alanine—were found in the condensed fluid from the apparatus.

The final lines from the original paper state:

In this apparatus an attempt was made to duplicate a primitive atmosphere of the earth, and not to obtain the optimum conditions for the formation of amino acids. Although in this case the total yield was small for the energy expended, it is possible that, with more efficient apparatus ... this type of process would be a way of commercially producing amino acids. A more complete analysis of the amino acids and other products of the discharge is now being performed and will be reported in detail shortly.



14. Define *abiogenesis*.

15. Define *biogenesis*.

16. Explain whether or not abiogenesis and biogenesis were demonstrated in the Miller–Urey experiment.

---

---

---

17. Discuss this claim: "The Miller–Urey apparatus proves that life originated in a primordial sea."

---

---

---

---

---

---

---

---

---

---

---

---

---

---

---