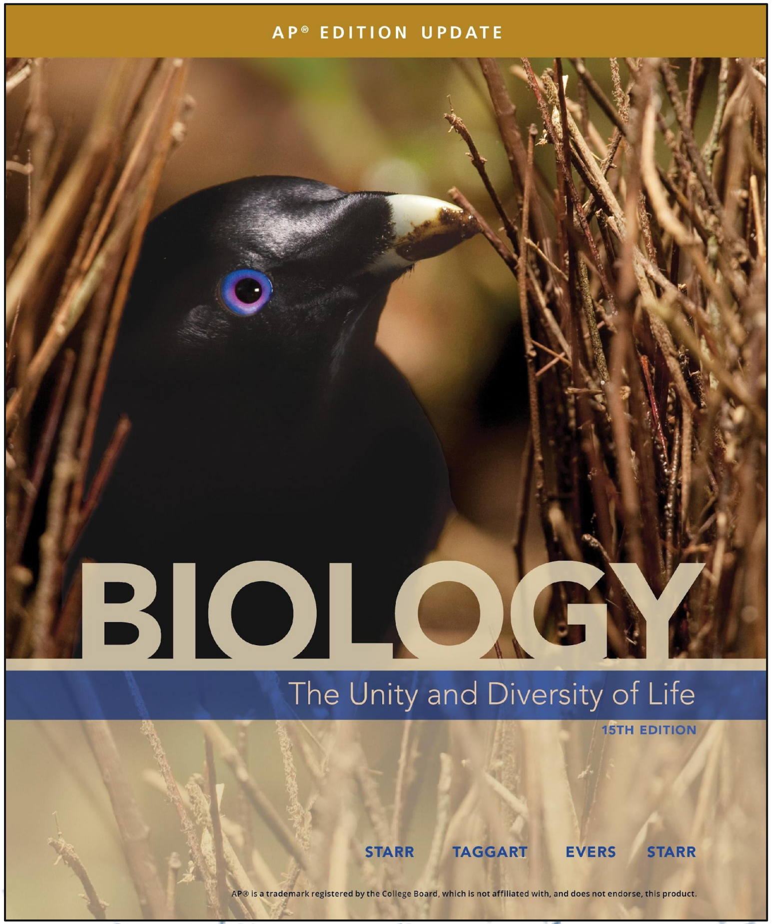
AP Biology



AP® EDITION UPDATE

BIOLOGY

The Unity and Diversity of Life

15TH EDITION

STARR TAGGART EVERS STARR

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Brand New Update!

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AP® Biology Course Updates

Key Framework Changes	Current edition updates
• There are now 8 course units, and the sequence that content should be taught has been re-ordered • Some content has been removed from the course, primarily Body Systems • New science practices have been made explicit • The test has reduced the number of MC questions to 60 (from 69) • The test has reduced the number of FRQ's to 6 (from 8)	The Starr program has new downloadable resources available from the Instructor Companion Site including: • Updated correlation • Updated AP® Teacher's Resource Guide with new correlation • Updated Fast Track to a 5 with new correlation, updated front matter, and question correlation • Student book file update includes front matter pages, and chapter AP® Question correlation • Updated MindTap including new AP chapter questions and Fast Track to a 5 questions

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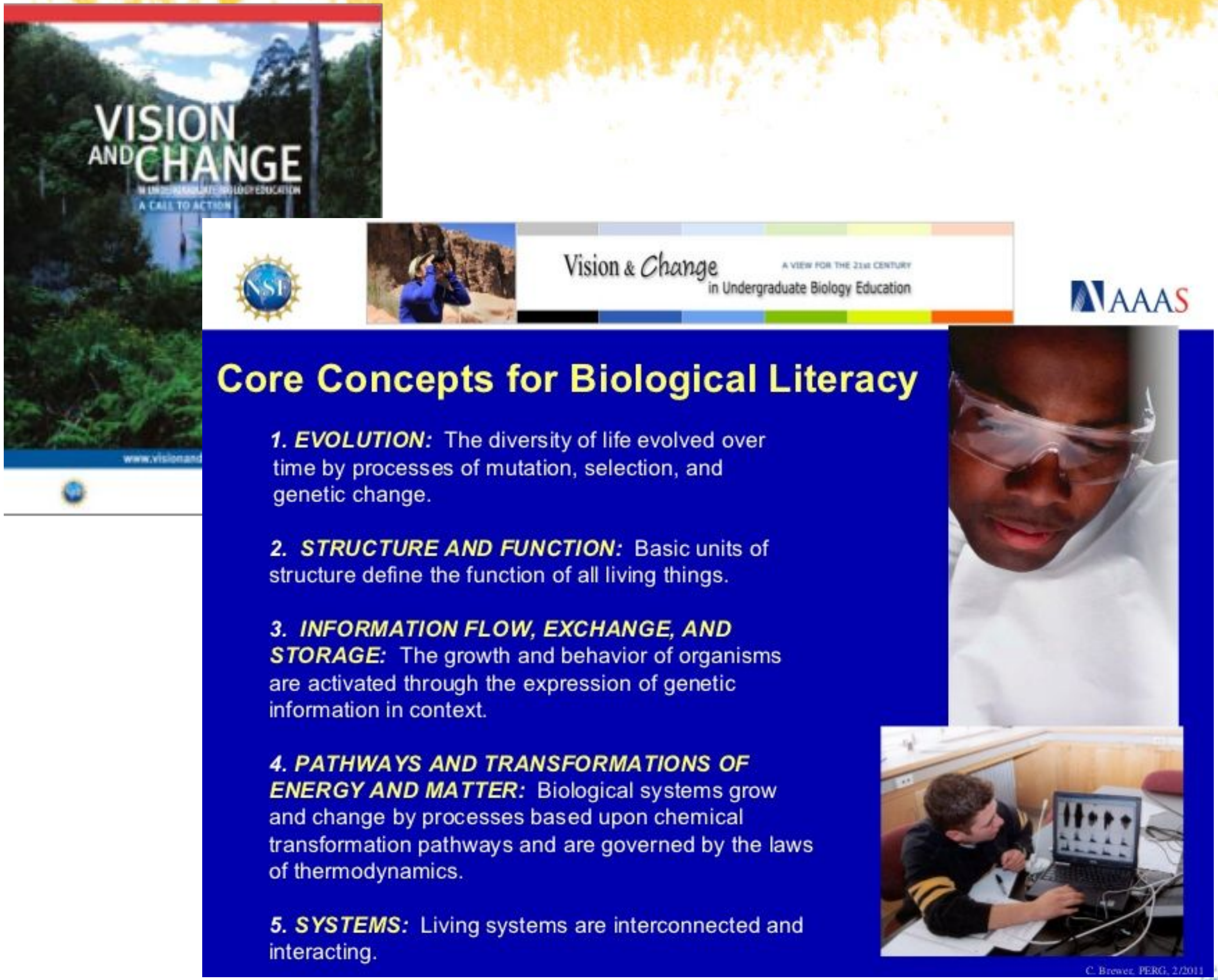
Designed with Core Concepts in Mind



Core Concepts for Biological Literacy

1. ***EVOLUTION:*** The diversity of life evolved over time by processes of mutation, selection, and genetic change.

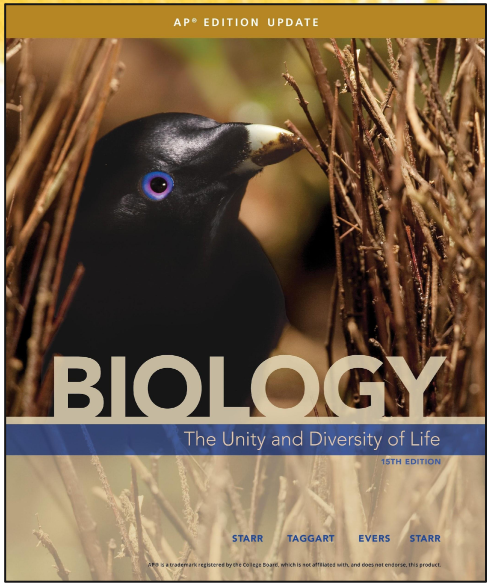
2. ***STRUCTURE AND FUNCTION:*** Basic units of structure define the function of all living things.

3. ***INFORMATION FLOW, EXCHANGE, AND STORAGE:*** The growth and behavior of organisms are activated through the expression of genetic information in context.

4. ***PATHWAYS AND TRANSFORMATIONS OF ENERGY AND MATTER:*** Biological systems grow and change by processes based upon chemical transformation pathways and are governed by the laws of thermodynamics.

5. ***SYSTEMS:*** Living systems are interconnected and interacting.

C. Brewer, PERG, 2/2011



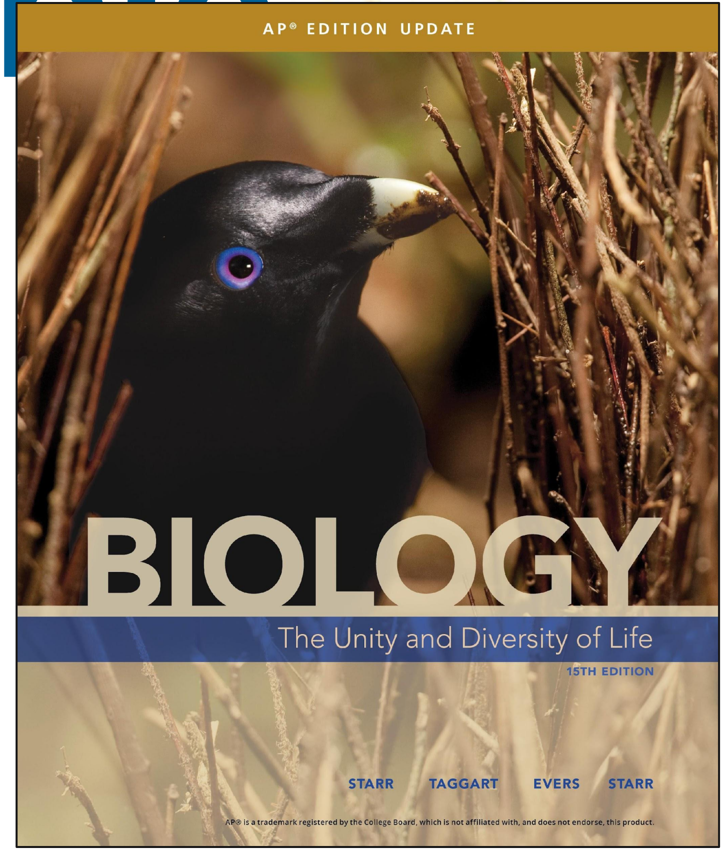
Components Available

Student:

- Student Edition + MindTap w/eBook
- FastTrack to a 5 Test Prep Workbook
- Lab Manual

Teacher:

- MindTap + Instructor Companion Site
- AP Teacher's Resource Guide
- AP Lab Manual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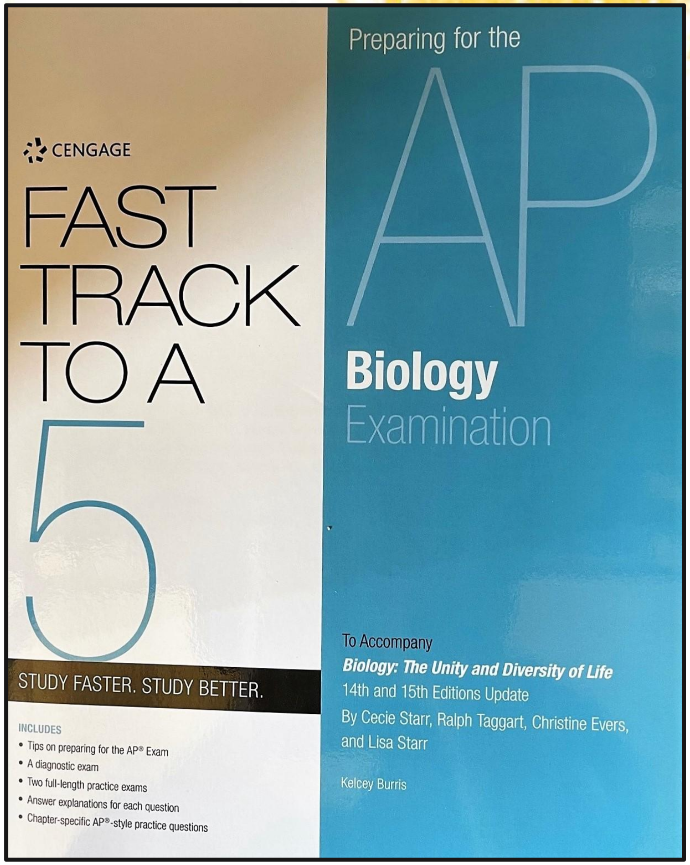
Fast Track to a 5



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Preparing for the AP

Biology Examination

To Accompany

Biology: The Unity and Diversity of Life

14th and 15th Editions Update

By Cecie Starr, Ralph Taggart, Christine Evers, and Lisa Starr

Kelcey Burris

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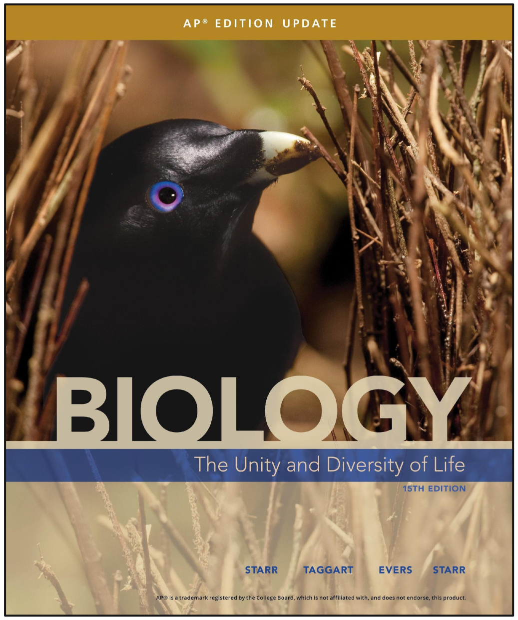

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The Unity and Diversity of Life

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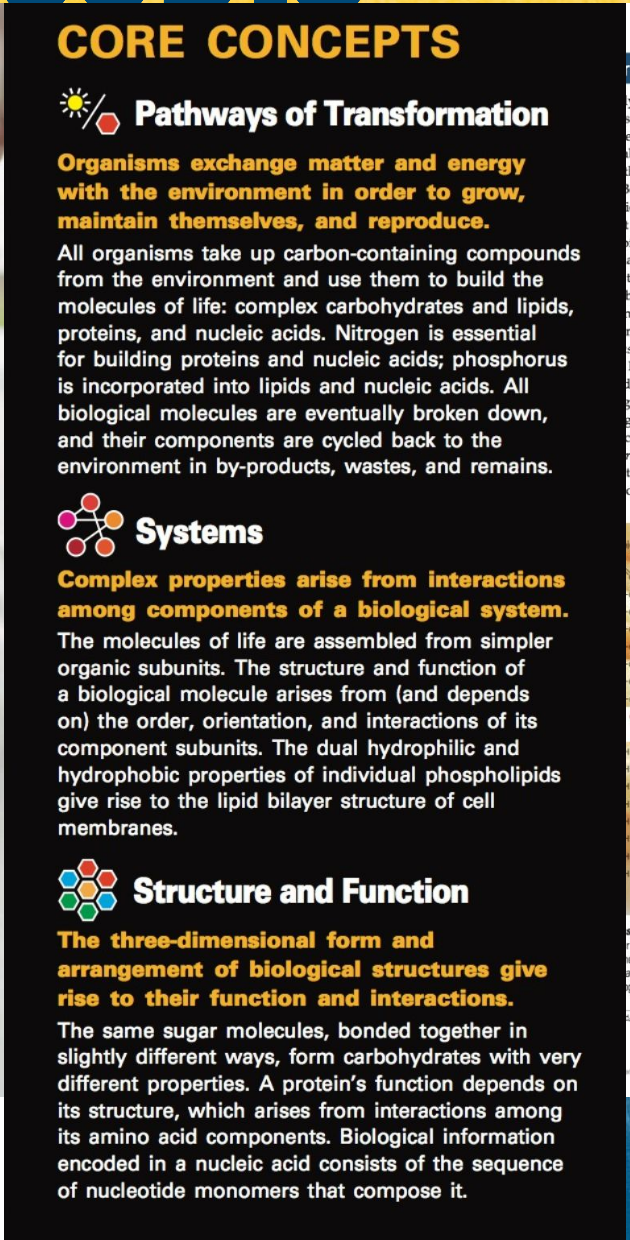
Designed by Core Concepts

3 MOLECULES OF LIFE



CORE CONCEPTS

Pathways of Transformation

Organisms exchange matter and energy with the environment in order to grow, maintain themselves, and reproduce.

All organisms take up carbon-containing compounds from the environment and use them to build the molecules of life: complex carbohydrates and lipids, proteins, and nucleic acids. Nitrogen is essential for building proteins and nucleic acids; phosphorus is incorporated into lipids and nucleic acids. All biological molecules are eventually broken down, and their components are cycled back to the environment in by-products, wastes, and remains.

Systems

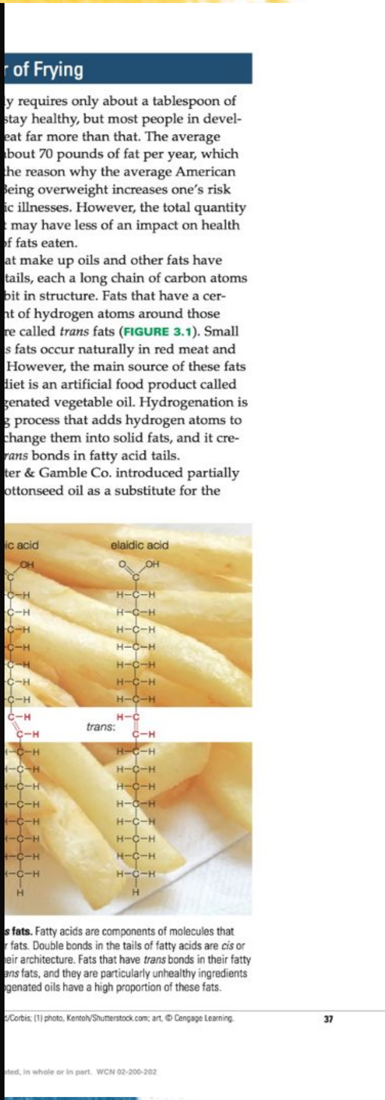
Complex properties arise from interactions among components of a biological system.

The molecules of life are assembled from simpler organic subunits. The structure and function of a biological molecule arises from (and depends on) the order, orientation, and interactions of its component subunits. The dual hydrophilic and hydrophobic properties of individual phospholipids give rise to the lipid bilayer structure of cell membranes.

Structure and Function

The three-dimensional form and arrangement of biological structures give rise to their function and interactions.

The same sugar molecules, bonded together in slightly different ways, form carbohydrates with very different properties. A protein's function depends on its structure, which arises from interactions among its amino acid components. Biological information encoded in a nucleic acid consists of the sequence of nucleotide monomers that compose it.



r of Frying

y requires only about a tablespoon of
stay healthy, but most people in devel-
eat far more than that. The average
bout 70 pounds of fat per year, which
he reason why the average American
Being overweight increases one's risk
ic illnesses. However, the total quantity
t may have less of an impact on health
of fats eaten.
at make up oils and other fats have
tails, each a long chain of carbon atoms
bit in structure. Fats that have a cer-
nt of hydrogen atoms around those
re called *trans* fats (**FIGURE 3.1**). Small
s fats occur naturally in red meat and
However, the main source of these fats
diet is an artificial food product called
genated vegetable oil. Hydrogenation is
g process that adds hydrogen atoms to
change them into solid fats, and it cre-
rans bonds in fatty acid tails.
ter & Gamble Co. introduced partially
ottonseed oil as a substitute for the

s fats. Fatty acids are components of molecules that
r fats. Double bonds in the tails of fatty acids are *cis* or
eir architecture. Fats that have *trans* bonds in their fatty
ans fats, and they are particularly unhealthy ingredients
genated oils have a high proportion of these fats.

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Issue-Based Essay

3.1 Fear of Frying

The human body requires only about a tablespoon of fat each day to stay healthy, but most people in developed countries eat far more than that. The average American eats about 70 pounds of fat per year, which may be part of the reason why the average American is overweight. Being overweight increases one's risk for many chronic illnesses. However, the total quantity of fat in the diet may have less impact on health than the types of fats. Fats are more than inert molecules that accumulate in strategic areas of our bodies. They are the main constituents of cell membranes, and as such they have powerful effects on cell function.

The typical fat molecule has three fatty acid tails, each a long chain of carbon atoms that can vary a bit in structure. Fats with a certain arrangement of hydrogen atoms around those carbon chains are called *trans* fats (**FIGURE 3.1**). Small amounts of *trans* fats occur naturally in red meat and dairy products. However, the main source of these fats in the American diet is an artificial food product called partially hydrogenated vegetable oil.

Hydrogenation is a manufacturing process that adds hydrogen atoms to oils in order to change them into solid fats. In 1908, Procter & Gamble Co. developed partially hydrogenated soybean oil as a substitute for the more expensive solid animal fats they had been using to make candles. However, the demand for candles began to wane as more households in the United States became wired for electricity, and P & G began to look for another way to sell its proprietary fat. Partially hydrogenated vegetable oil looks a lot like lard, so in 1911 the company began aggressively marketing it as a revolutionary new food: a solid cooking fat with a long shelf life, mild flavor, and lower cost than lard or butter.

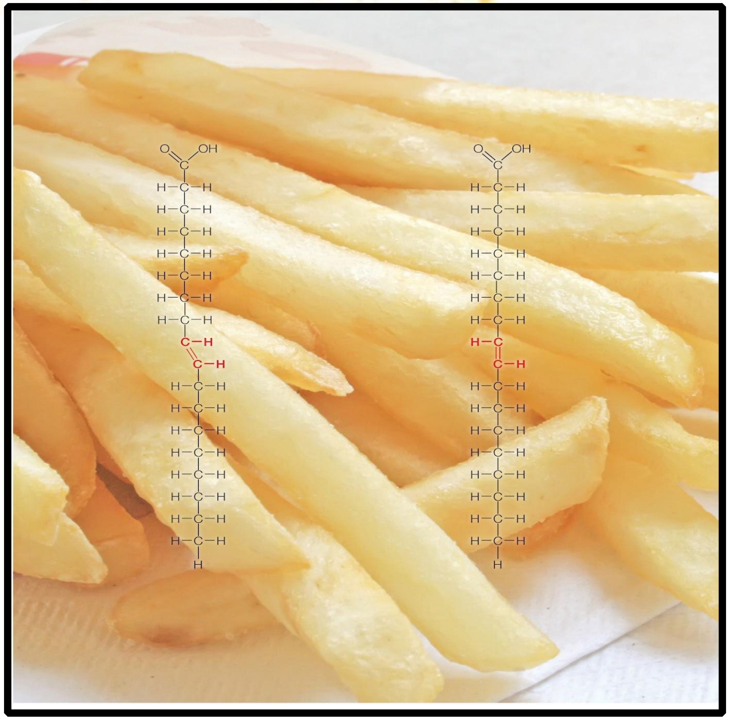
By the mid-1950s, hydrogenated vegetable oil had become a major part of the American diet. At this writing, it can still be found in many manufactured and fast foods: stick margarines, ready-to-use frostings, french fries, cookies, crackers, cakes and pancakes, peanut butter, pies, doughnuts, muffins, chips, granola bars, breakfast bars, chocolate, microwave popcorn, pizzas, burritos, chicken nuggets, fish sticks, and so on.

For decades, hydrogenated vegetable oil was considered more healthy than animal fats because it was made from plants, but we now know otherwise. The *trans* fats in hydrogenated vegetable oils raise the level of cholesterol in our blood more than any other fat, and they directly alter the function of our arteries and veins. The effects of such changes are quite serious. Eating as little as 2 grams per day (about 0.4 teaspoon) of hydrogenated vegetable oil measurably increases one's risk of atherosclerosis (hardening of the arteries), heart attack, and diabetes. A small serving of french fries made with hydrogenated vegetable oil contains about 5 grams of *trans* fat.

All organisms consist of the same kinds of molecules, but small differences in the way those molecules are put together can have big effects. With this concept, we introduce you to the chemistry of life. This is your chemistry. It makes you far more than the sum of your body's molecules.

FIGURE 3.1 Trans fats, an unhealthy food. Double bonds in the tail of most naturally occurring fatty acids are cis, which means that the two hydrogen atoms flanking the bond are on the same side of the carbon backbone. Hydrogenation creates abundant *trans* bonds, with hydrogen atoms on opposite sides of the tail.

37



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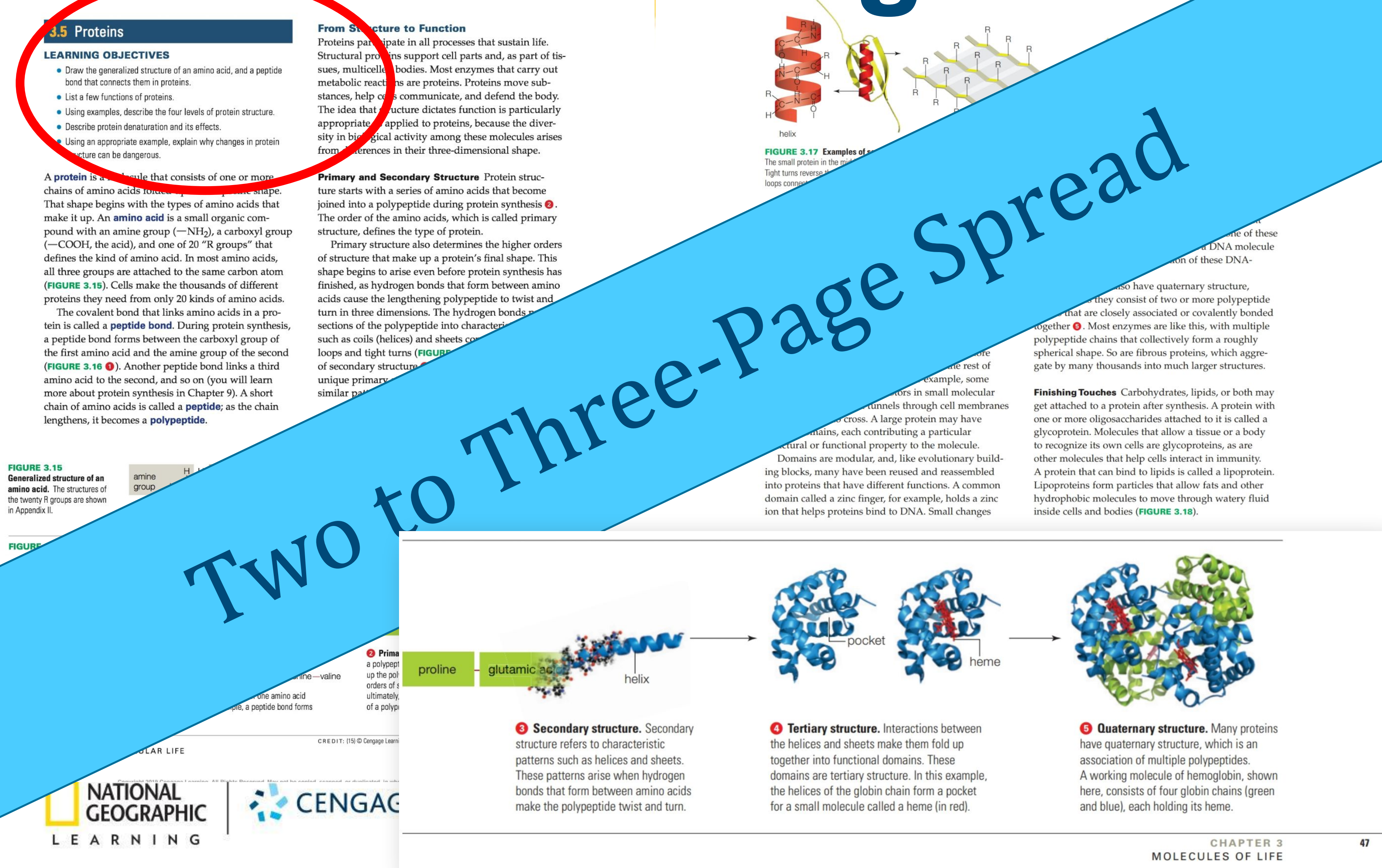
Images Support Learning

Two to Three-Page Spread



3.5 Proteins

LEARNING OBJECTIVES

- Draw the generalized structure of an amino acid, and a peptide bond that connects them in proteins.
- List a few functions of proteins.
- Using examples, describe the four levels of protein structure.
- Describe protein denaturation and its effects.
- Using an appropriate example, explain why changes in protein structure can be dangerous.

A **protein** is a ule that consists of one or more chains of amino acids folde shape. That shape begins with the types of amino acids that make it up. An **amino acid** is a small organic compound with an amine group (—NH_2), a carboxyl group (—COOH, the acid), and one of 20 "R groups" that defines the kind of amino acid. In most amino acids, all three groups are attached to the same carbon atom (**FIGURE 3.15**). Cells make the thousands of different proteins they need from only 20 kinds of amino acids.

The covalent bond that links amino acids in a protein is called a **peptide bond**. During protein synthesis, a peptide bond forms between the carboxyl group of the first amino acid and the amine group of the second (**FIGURE 3.16** ❶). Another peptide bond links a third amino acid to the second, and so on (you will learn more about protein synthesis in Chapter 9). A short chain of amino acids is called a **peptide**; as the chain lengthens, it becomes a **polypeptide**.

FIGURE 3.15 **Generalized structure of an amino acid.** The structures of the twenty R groups are shown in Appendix II.

FIGURE

ine—valine

one amino acid

ple, a peptide bond forms

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of a polyp

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ULAR LIFE

From Structure to Function

Proteins participate in all processes that sustain life. Structural proteins support cell parts and, as part of tissues, multicellular bodies. Most enzymes that carry out metabolic reactions are proteins. Proteins move substances, help cells communicate, and defend the body. The idea that structure dictates function is particularly appropriate applied to proteins, because the diversity in biological activity among these molecules arises from differences in their three-dimensional shape.

Primary and Secondary Structure Protein structure starts with a series of amino acids that become joined into a polypeptide during protein synthesis ❷. The order of the amino acids, which is called primary structure, defines the type of protein.

Primary structure also determines the higher orders of structure that make up a protein's final shape. This shape begins to arise even before protein synthesis has finished, as hydrogen bonds that form between amino acids cause the lengthening polypeptide to twist and turn in three dimensions. The hydrogen bonds r sections of the polypeptide into characteri such as coils (helices) and sheets co loops and tight turns (FIGUR of secondary structure unique primary similar pa

FIGURE 3.17 **Examples of s**
The small protein in the mid
Tight turns reverse
loops conne

ore
e rest of
example, some
tors in small molecular
tunnels through cell membranes
cross. A large protein may have
mains, each contributing a particular
ctural or functional property to the molecule.

Domains are modular, and, like evolutionary building blocks, many have been reused and reassembled into proteins that have different functions. A common domain called a zinc finger, for example, holds a zinc ion that helps proteins bind to DNA. Small changes

ne of these
DNA molecule
on of these DNA-

so have quaternary structure,
they consist of two or more polypeptide
that are closely associated or covalently bonded together ❺. Most enzymes are like this, with multiple polypeptide chains that collectively form a roughly spherical shape. So are fibrous proteins, which aggregate by many thousands into much larger structures.

Finishing Touches Carbohydrates, lipids, or both may get attached to a protein after synthesis. A protein with one or more oligosaccharides attached to it is called a glycoprotein. Molecules that allow a tissue or a body to recognize its own cells are glycoproteins, as are other molecules that help cells interact in immunity. A protein that can bind to lipids is called a lipoprotein. Lipoproteins form particles that allow fats and other hydrophobic molecules to move through watery fluid inside cells and bodies (**FIGURE 3.18**).

❸ **Secondary structure.** Secondary structure refers to characteristic patterns such as helices and sheets. These patterns arise when hydrogen bonds that form between amino acids make the polypeptide twist and turn.

❹ **Tertiary structure.** Interactions between the helices and sheets make them fold up together into functional domains. These domains are tertiary structure. In this example, the helices of the globin chain form a pocket for a small molecule called a heme (in red).

❺ **Quaternary structure.** Many proteins have quaternary structure, which is an association of multiple polypeptides. A working molecule of hemoglobin, shown here, consists of four globin chains (green and blue), each holding its heme.

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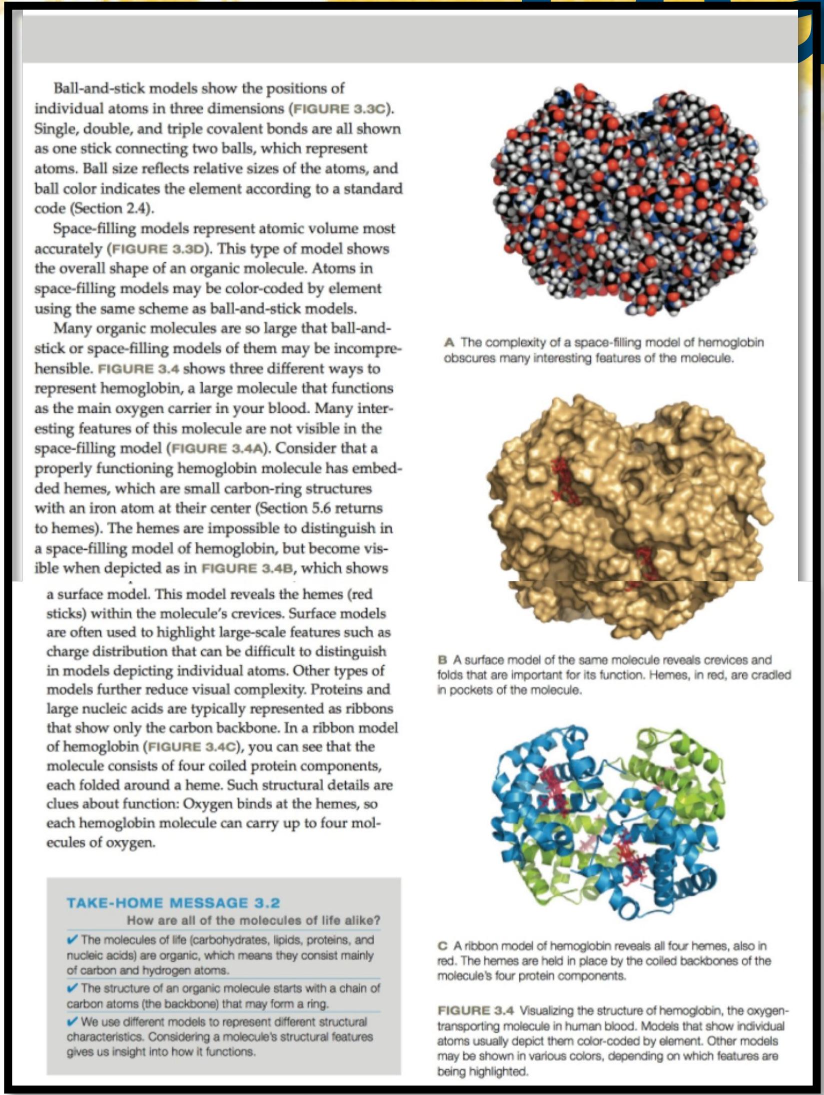


Ball-and-stick models show the positions of individual atoms in three dimensions (FIGURE 3.3C). Single, double, and triple covalent bonds are all shown as one stick connecting two balls, which represent atoms. Ball size reflects relative sizes of the atoms, and ball color indicates the element according to a standard code (Section 2.4).

Space-filling models represent atomic volume most accurately (FIGURE 3.3D). This type of model shows the overall shape of an organic molecule. Atoms in space-filling models may be color-coded by element using the same scheme as ball-and-stick models.

Many organic molecules are so large that ball-and-stick or space-filling models of them may be incomprehensible. FIGURE 3.4 shows three different ways to represent hemoglobin, a large molecule that functions as the main oxygen carrier in your blood. Many interesting features of this molecule are not visible in the space-filling model (FIGURE 3.4A). Consider that a properly functioning hemoglobin molecule has embedded hemes, which are small carbon-ring structures with an iron atom at their center (Section 5.6 returns to hemes). The hemes are impossible to distinguish in a space-filling model of hemoglobin, but become visible when depicted as in FIGURE 3.4B, which shows a surface model. This model reveals the hemes (red sticks) within the molecule's crevices. Surface models are often used to highlight large-scale features such as charge distribution that can be difficult to distinguish in models depicting individual atoms. Other types of models further reduce visual complexity. Proteins and large nucleic acids are typically represented as ribbons that show only the carbon backbone. In a ribbon model of hemoglobin (FIGURE 3.4C), you can see that the molecule consists of four coiled protein components, each folded around a heme. Such structural details are clues about function: Oxygen binds at the hemes, so each hemoglobin molecule can carry up to four molecules of oxygen.

TAKE-HOME MESSAGE 3.2

How are all of the molecules of life alike?

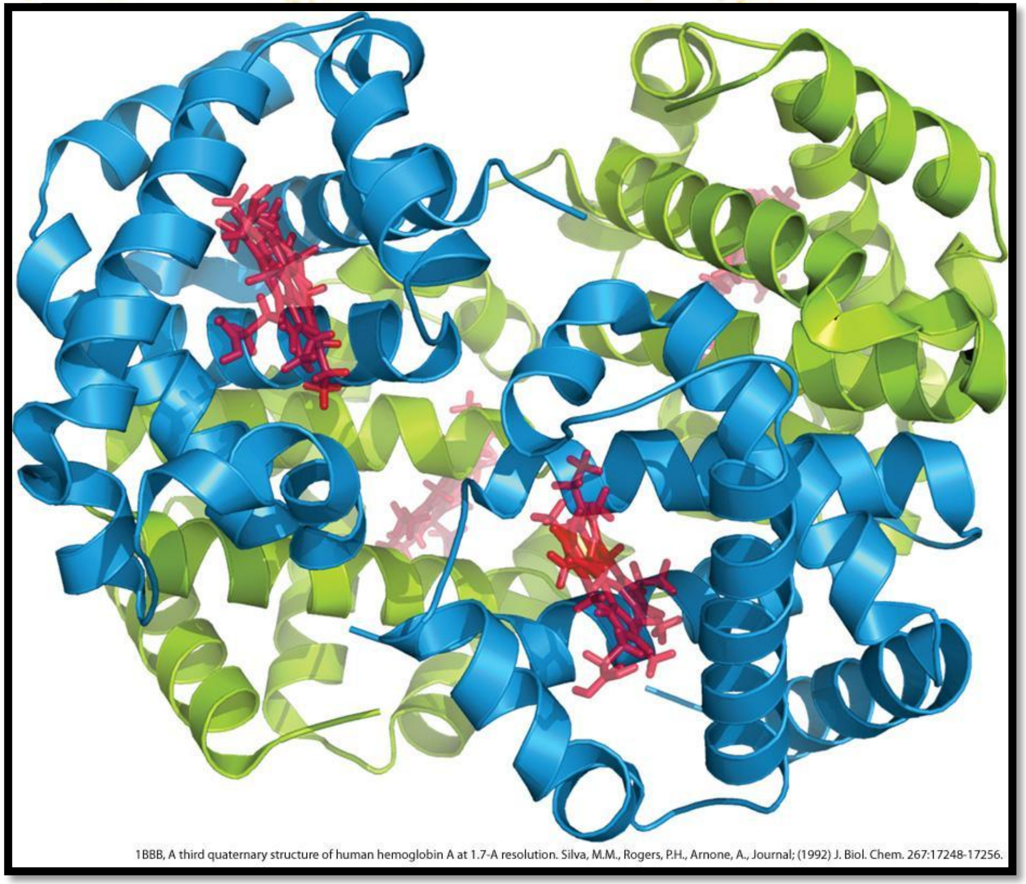
- ✔ The molecules of life (carbohydrates, lipids, proteins, and nucleic acids) are organic, which means they consist mainly of carbon and hydrogen atoms.
- ✔ The structure of an organic molecule starts with a chain of carbon atoms (the backbone) that may form a ring.
- ✔ We use different models to represent different structural characteristics. Considering a molecule's structural features gives us insight into how it functions.

A The complexity of a space-filling model of hemoglobin obscures many interesting features of the molecule.

B A surface model of the same molecule reveals crevices and folds that are important for its function. Hemes, in red, are cradled in pockets of the molecule.

C A ribbon model of hemoglobin reveals all four hemes, also in red. The hemes are held in place by the coiled backbones of the molecule's four protein components.

FIGURE 3.4 Visualizing the structure of hemoglobin, the oxygen-transporting molecule in human blood. Models that show individual atoms usually depict them color-coded by element. Other models may be shown in various colors, depending on which features are being highlighted.



1BBB, A third quaternary structure of human hemoglobin A at 1.7-A resolution. Silva, M.M., Rogers, P.H., Arnone, A., Journal; (1992) J. Biol. Chem. 267:17248-17256.

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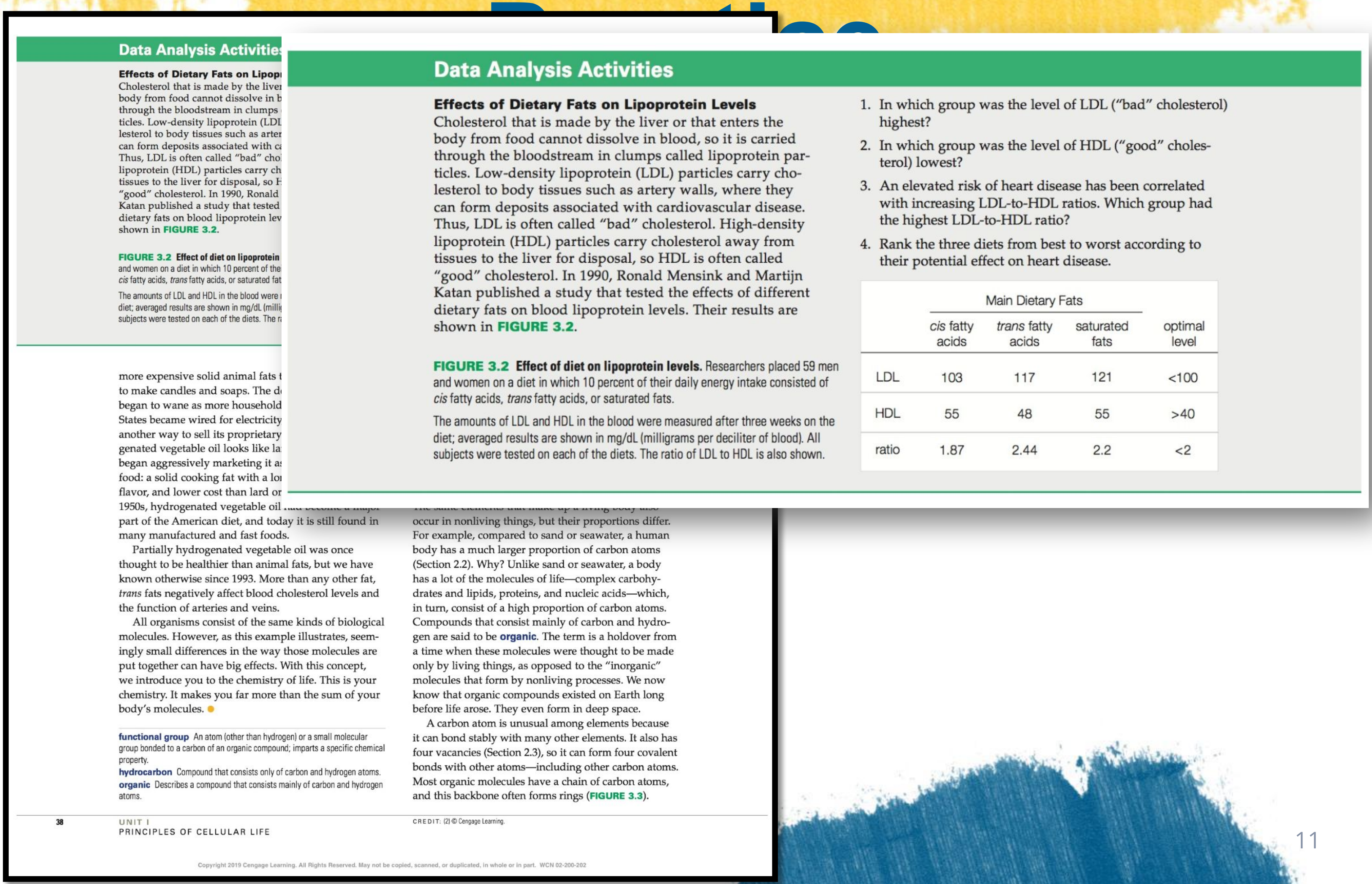
Embedded Analytical



Data Analysis Activities

Effects of Dietary Fats on Lipoprotein Levels
Cholesterol that is made by the liver or that enters the body from food cannot dissolve in blood, so it is carried through the bloodstream in clumps called lipoprotein particles. Low-density lipoprotein (LDL) particles carry cholesterol to body tissues such as artery walls, where they can form deposits associated with cardiovascular disease. Thus, LDL is often called "bad" cholesterol. High-density lipoprotein (HDL) particles carry cholesterol away from tissues to the liver for disposal, so HDL is often called "good" cholesterol. In 1990, Ronald Mensink and Martijn Katan published a study that tested the effects of different dietary fats on blood lipoprotein levels. Their results are shown in **FIGURE 3.2**.

FIGURE 3.2 Effect of diet on lipoprotein levels. Researchers placed 59 men and women on a diet in which 10 percent of their daily energy intake consisted of *cis* fatty acids, *trans* fatty acids, or saturated fats.

The amounts of LDL and HDL in the blood were measured after three weeks on the diet; averaged results are shown in mg/dL (milligrams per deciliter of blood). All subjects were tested on each of the diets. The ratio of LDL to HDL is also shown.

1. In which group was the level of LDL ("bad" cholesterol) highest?
2. In which group was the level of HDL ("good" cholesterol) lowest?
3. An elevated risk of heart disease has been correlated with increasing LDL-to-HDL ratios. Which group had the highest LDL-to-HDL ratio?
4. Rank the three diets from best to worst according to their potential effect on heart disease.

	Main Dietary Fats			
	cis fatty acids	*trans* fatty acids	saturated fats	optimal level
LDL	103	117	121	<100
HDL	55	48	55	>40
ratio	1.87	2.44	2.2	<2

Data Analysis Activitie
Effects of Dietary Fats on Lipopr
Cholesterol that is made by the liver
FIGURE 3.2 Effect of diet on lipoprotein

more expensive solid animal fats t
to make candles and soaps. The d
began to wane as more household
States became wired for electricity
another way to sell its proprietary
genated vegetable oil looks like la
began aggressively marketing it a
food: a solid cooking fat with a lo
flavor, and lower cost than lard o
1950s, hydrogenated vegetable oil
part of the American diet, and today it is still found in many manufactured and fast foods.

Partially hydrogenated vegetable oil was once thought to be healthier than animal fats, but we have known otherwise since 1993. More than any other fat, *trans* fats negatively affect blood cholesterol levels and the function of arteries and veins.

All organisms consist of the same kinds of biological molecules. However, as this example illustrates, seemingly small differences in the way those molecules are put together can have big effects. With this concept, we introduce you to the chemistry of life. This is your chemistry. It makes you far more than the sum of your body's molecules. ●

functional group An atom (other than hydrogen) or a small molecular group bonded to a carbon of an organic compound; imparts a specific chemical property.
hydrocarbon Compound that consists only of carbon and hydrogen atoms.
organic Describes a compound that consists mainly of carbon and hydrogen atoms.

occur in nonliving things, but their proportions differ. For example, compared to sand or seawater, a human body has a much larger proportion of carbon atoms (Section 2.2). Why? Unlike sand or seawater, a body has a lot of the molecules of life—complex carbohydrates and lipids, proteins, and nucleic acids—which, in turn, consist of a high proportion of carbon atoms. Compounds that consist mainly of carbon and hydrogen are said to be **organic**. The term is a holdover from a time when these molecules were thought to be made only by living things, as opposed to the "inorganic" molecules that form by nonliving processes. We now know that organic compounds existed on Earth long before life arose. They even form in deep space.

A carbon atom is unusual among elements because it can bond stably with many other elements. It also has four vacancies (Section 2.3), so it can form four covalent bonds with other atoms—including other carbon atoms. Most organic molecules have a chain of carbon atoms, and this backbone often forms rings (**FIGURE 3.3**).

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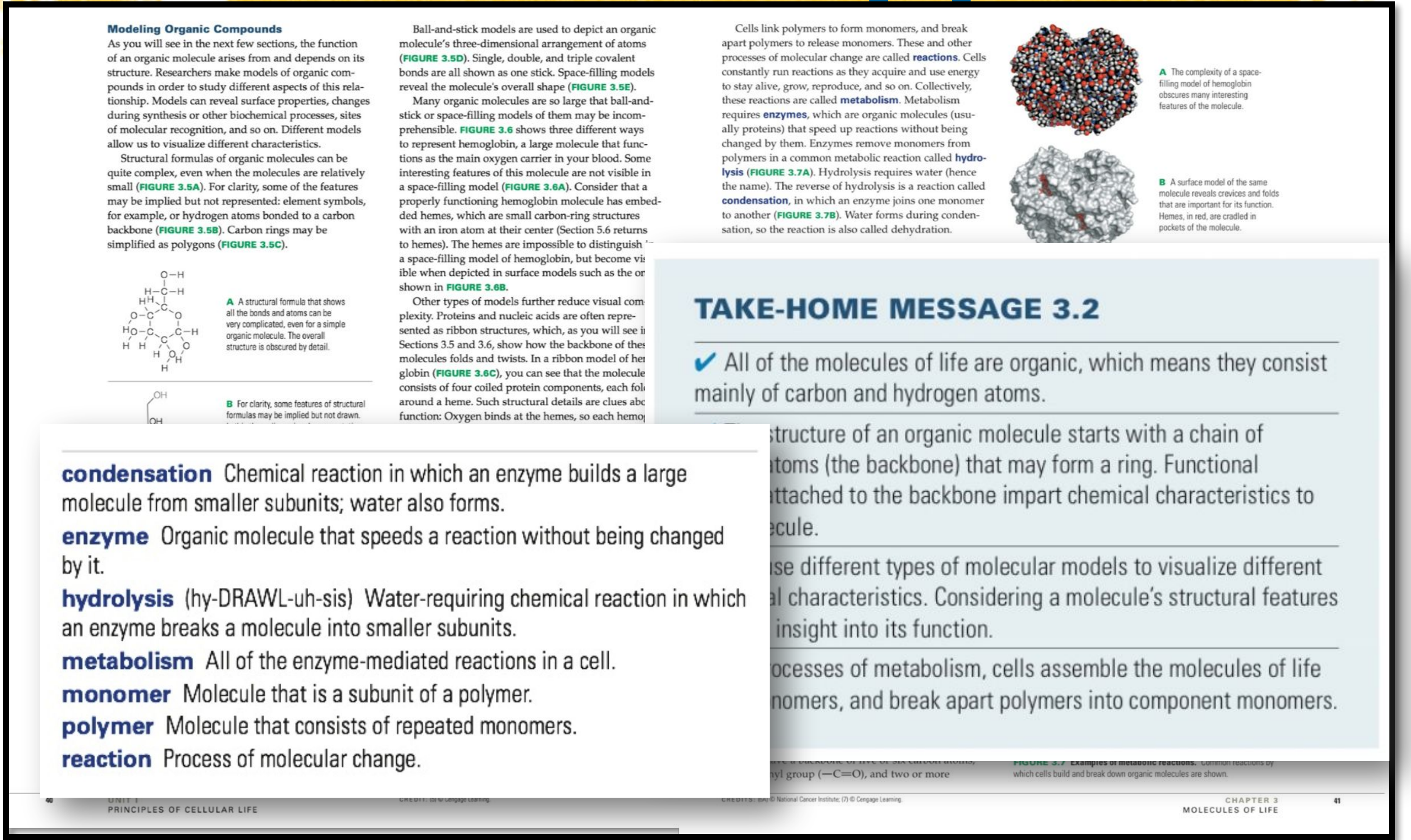
Built In Support



Modeling Organic Compounds

As you will see in the next few sections, the function of an organic molecule arises from and depends on its structure. Researchers make models of organic compounds in order to study different aspects of this relationship. Models can reveal surface properties, changes during synthesis or other biochemical processes, sites of molecular recognition, and so on. Different models allow us to visualize different characteristics.

Structural formulas of organic molecules can be quite complex, even when the molecules are relatively small (**FIGURE 3.5A**). For clarity, some of the features may be implied but not represented: element symbols, for example, or hydrogen atoms bonded to a carbon backbone (**FIGURE 3.5B**). Carbon rings may be simplified as polygons (**FIGURE 3.5C**).

A A structural formula that shows all the bonds and atoms can be very complicated, even for a simple organic molecule. The overall structure is obscured by detail.

B For clarity, some features of structural formulas may be implied but not drawn.

Ball-and-stick models are used to depict an organic molecule's three-dimensional arrangement of atoms (**FIGURE 3.5D**). Single, double, and triple covalent bonds are all shown as one stick. Space-filling models reveal the molecule's overall shape (**FIGURE 3.5E**).

Many organic molecules are so large that ball-and-stick or space-filling models of them may be incomprehensible. **FIGURE 3.6** shows three different ways to represent hemoglobin, a large molecule that functions as the main oxygen carrier in your blood. Some interesting features of this molecule are not visible in a space-filling model (**FIGURE 3.6A**). Consider that a properly functioning hemoglobin molecule has embedded hemes, which are small carbon-ring structures with an iron atom at their center (Section 5.6 returns to hemes). The hemes are impossible to distinguish
a space-filling model of hemoglobin, but become vis
ible when depicted in surface models such as the on
shown in **FIGURE 3.6B**.

Other types of models further reduce visual com
plexity. Proteins and nucleic acids are often repre-
sented as ribbon structures, which, as you will see i
Sections 3.5 and 3.6, show how the backbone of thes
molecules folds and twists. In a ribbon model of her
globin (**FIGURE 3.6C**), you can see that the molecule
consists of four coiled protein components, each fol
around a heme. Such structural details are clues abo
function: Oxygen binds at the hemes, so each hemo

Cells link polymers to form monomers, and break apart polymers to release monomers. These and other processes of molecular change are called **reactions**. Cells constantly run reactions as they acquire and use energy to stay alive, grow, reproduce, and so on. Collectively, these reactions are called **metabolism**. Metabolism requires **enzymes**, which are organic molecules (usually proteins) that speed up reactions without being changed by them. Enzymes remove monomers from polymers in a common metabolic reaction called **hydrolysis** (**FIGURE 3.7A**). Hydrolysis requires water (hence the name). The reverse of hydrolysis is a reaction called **condensation**, in which an enzyme joins one monomer to another (**FIGURE 3.7B**). Water forms during condensation, so the reaction is also called dehydration.

A The complexity of a space-filling model of hemoglobin obscures many interesting features of the molecule.

B A surface model of the same molecule reveals crevices and folds that are important for its function. Hemes, in red, are cradled in pockets of the molecule.

TAKE-HOME MESSAGE 3.2

✔ All of the molecules of life are organic, which means they consist mainly of carbon and hydrogen atoms.

structure of an organic molecule starts with a chain of
atoms (the backbone) that may form a ring. Functional
ttached to the backbone impart chemical characteristics to
ecule.

se different types of molecular models to visualize different
l characteristics. Considering a molecule's structural features
insight into its function.

ocesses of metabolism, cells assemble the molecules of life
nomers, and break apart polymers into component monomers.

condensation Chemical reaction in which an enzyme builds a large molecule from smaller subunits; water also forms.

enzyme Organic molecule that speeds a reaction without being changed by it.

hydrolysis (hy-DRAWL-uh-sis) Water-requiring chemical reaction in which an enzyme breaks a molecule into smaller subunits.

metabolism All of the enzyme-mediated reactions in a cell.

monomer Molecule that is a subunit of a polymer.

polymer Molecule that consists of repeated monomers.

reaction Process of molecular change.

nyl group (—C=O), and two or more

FIGURE 3.7 Examples of metabolic reactions. Common reactions by which cells build and break down organic molecules are shown.

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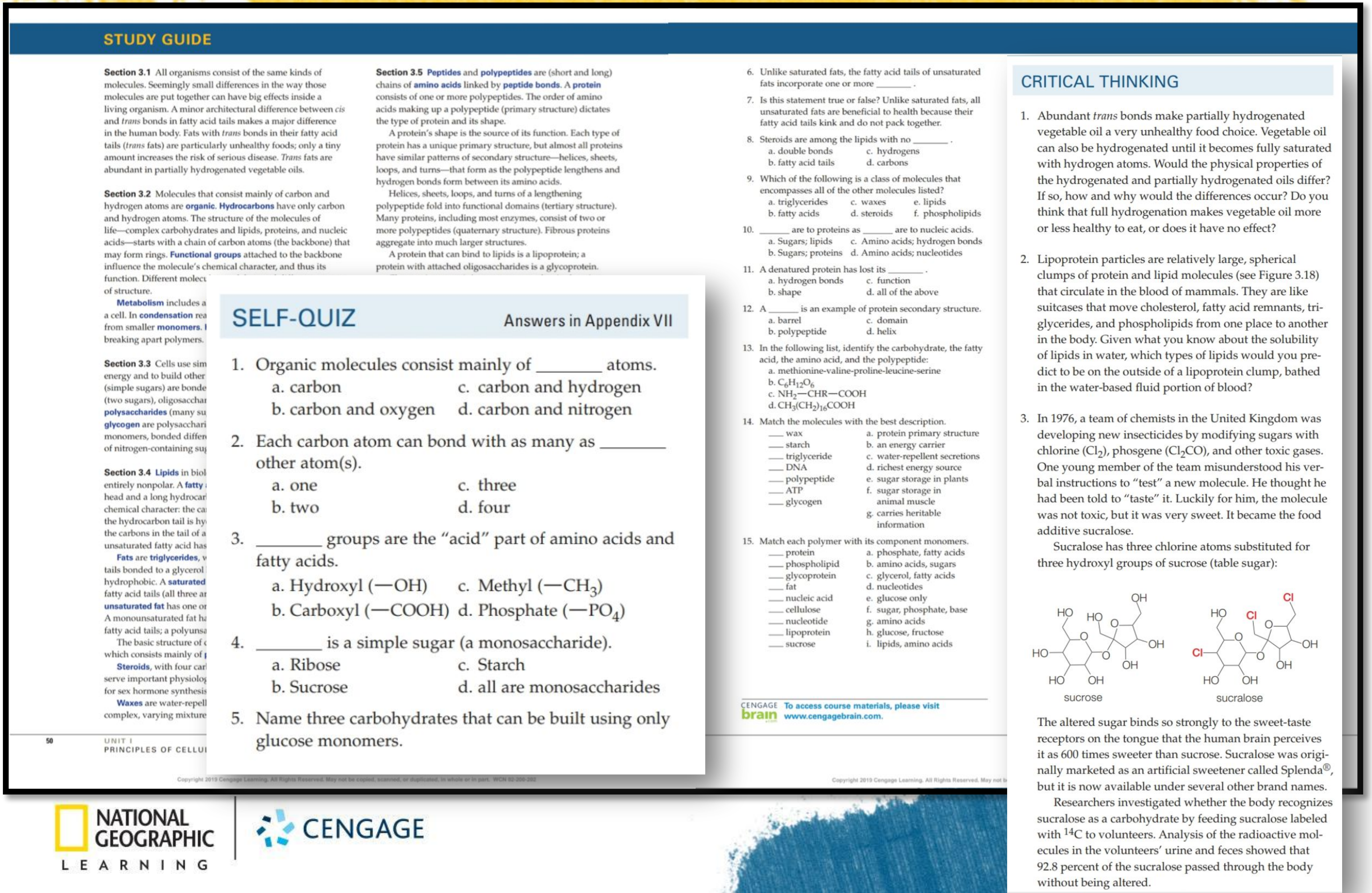
Chapter Review



STUDY GUIDE

Section 3.1 All organisms consist of the same kinds of molecules. Seemingly small differences in the way those molecules are put together can have big effects inside a living organism. A minor architectural difference between *cis* and *trans* bonds in fatty acid tails makes a major difference in the human body. Fats with *trans* bonds in their fatty acid tails (*trans* fats) are particularly unhealthy foods; only a tiny amount increases the risk of serious disease. *Trans* fats are abundant in partially hydrogenated vegetable oils.

Section 3.2 Molecules that consist mainly of carbon and hydrogen atoms are **organic**. **Hydrocarbons** have only carbon and hydrogen atoms. The structure of the molecules of life—complex carbohydrates and lipids, proteins, and nucleic acids—starts with a chain of carbon atoms (the backbone) that may form rings. **Functional groups** attached to the backbone influence the molecule's chemical character, and thus its function. Different molec
of structure.

Metabolism includes a
a cell. In **condensation** rea
from smaller **monomers.**
breaking apart polymers.

Section 3.3 Cells use sim
energy and to build other
(simple sugars) are bonde
(two sugars), oligosacchar
polysaccharides (many su
glycogen are polysacchari
monomers, bonded differ
of nitrogen-containing su

Section 3.4 **Lipids** in biol
entirely nonpolar. A **fatty**
head and a long hydrocar
chemical character: the ca
the hydrocarbon tail is hy
the carbons in the tail of a
unsaturated fatty acid has
Fats are **triglycerides,** v
tails bonded to a glycerol
hydrophobic. A **saturated**
fatty acid tails (all three ar
unsaturated fat has one or
A monounsaturated fat ha
fatty acid tails; a polyunsa
The basic structure of
which consists mainly of
Steroids, with four car
serve important physiolo
for sex hormone synthesis
Waxes are water-repell
complex, varying mixture

Section 3.5 **Peptides** and **polypeptides** are (short and long) chains of **amino acids** linked by **peptide bonds**. A **protein** consists of one or more polypeptides. The order of amino acids making up a polypeptide (primary structure) dictates the type of protein and its shape.

A protein's shape is the source of its function. Each type of protein has a unique primary structure, but almost all proteins have similar patterns of secondary structure—helices, sheets, loops, and turns—that form as the polypeptide lengthens and hydrogen bonds form between its amino acids.

Helices, sheets, loops, and turns of a lengthening polypeptide fold into functional domains (tertiary structure). Many proteins, including most enzymes, consist of two or more polypeptides (quaternary structure). Fibrous proteins aggregate into much larger structures.

A protein that can bind to lipids is a lipoprotein; a protein with attached oligosaccharides is a glycoprotein.

SELF-QUIZ

Answers in Appendix VII

1. Organic molecules consist mainly of _______ atoms.
   a. carbon
   b. carbon and oxygen
   c. carbon and hydrogen
   d. carbon and nitrogen
2. Each carbon atom can bond with as many as _______ other atom(s).
   a. one
   b. two
   c. three
   d. four
3. _______ groups are the "acid" part of amino acids and fatty acids.
   a. Hydroxyl (—OH)
   b. Carboxyl (—COOH)
   c. Methyl ($—CH_3$)
   d. Phosphate ($—PO_4$)
4. _______ is a simple sugar (a monosaccharide).
   a. Ribose
   b. Sucrose
   c. Starch
   d. all are monosaccharides
5. Name three carbohydrates that can be built using only glucose monomers.
6. Unlike saturated fats, the fatty acid tails of unsaturated fats incorporate one or more _______ .
7. Is this statement true or false? Unlike saturated fats, all unsaturated fats are beneficial to health because their fatty acid tails kink and do not pack together.
8. Steroids are among the lipids with no _______ .
   a. double bonds
   b. fatty acid tails
   c. hydrogens
   d. carbons
9. Which of the following is a class of molecules that encompasses all of the other molecules listed?
   a. triglycerides
   b. fatty acids
   c. waxes
   d. steroids
   e. lipids
   f. phospholipids
10. _______ are to proteins as _______ are to nucleic acids.
    a. Sugars; lipids
    b. Sugars; proteins
    c. Amino acids; hydrogen bonds
    d. Amino acids; nucleotides
11. A denatured protein has lost its _______ .
    a. hydrogen bonds
    b. shape
    c. function
    d. all of the above
12. A _______ is an example of protein secondary structure.
    a. barrel
    b. polypeptide
    c. domain
    d. helix
13. In the following list, identify the carbohydrate, the fatty acid, the amino acid, and the polypeptide:
    a. methionine-valine-proline-leucine-serine
    b. $C_6H_{12}O_6$
    c. $NH_2—CHR—COOH$
    d. $CH_3(CH_2)_{16}COOH$
14. Match the molecules with the best description.
    ___ wax
    ___ starch
    ___ triglyceride
    ___ DNA
    ___ polypeptide
    ___ ATP
    ___ glycogen
    a. protein primary structure
    b. an energy carrier
    c. water-repellent secretions
    d. richest energy source
    e. sugar storage in plants
    f. sugar storage in animal muscle
    g. carries heritable information
15. Match each polymer with its component monomers.
    ___ protein
    ___ phospholipid
    ___ glycoprotein
    ___ fat
    ___ nucleic acid
    ___ cellulose
    ___ nucleotide
    ___ lipoprotein
    ___ sucrose
    a. phosphate, fatty acids
    b. amino acids, sugars
    c. glycerol, fatty acids
    d. nucleotides
    e. glucose only
    f. sugar, phosphate, base
    g. amino acids
    h. glucose, fructose
    i. lipids, amino acids

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CRITICAL THINKING

1. Abundant *trans* bonds make partially hydrogenated vegetable oil a very unhealthy food choice. Vegetable oil can also be hydrogenated until it becomes fully saturated with hydrogen atoms. Would the physical properties of the hydrogenated and partially hydrogenated oils differ? If so, how and why would the differences occur? Do you think that full hydrogenation makes vegetable oil more or less healthy to eat, or does it have no effect?

2. Lipoprotein particles are relatively large, spherical clumps of protein and lipid molecules (see Figure 3.18) that circulate in the blood of mammals. They are like suitcases that move cholesterol, fatty acid remnants, triglycerides, and phospholipids from one place to another in the body. Given what you know about the solubility of lipids in water, which types of lipids would you predict to be on the outside of a lipoprotein clump, bathed in the water-based fluid portion of blood?

3. In 1976, a team of chemists in the United Kingdom was developing new insecticides by modifying sugars with chlorine (Cl_2), phosgene (Cl_2CO), and other toxic gases. One young member of the team misunderstood his verbal instructions to "test" a new molecule. He thought he had been told to "taste" it. Luckily for him, the molecule was not toxic, but it was very sweet. It became the food additive sucralose.

   Sucralose has three chlorine atoms substituted for three hydroxyl groups of sucrose (table sugar):

   The altered sugar binds so strongly to the sweet-taste receptors on the tongue that the human brain perceives it as 600 times sweeter than sucrose. Sucralose was originally marketed as an artificial sweetener called Splenda®, but it is now available under several other brand names.

   Researchers investigated whether the body recognizes sucralose as a carbohydrate by feeding sucralose labeled with ^{14}C to volunteers. Analysis of the radioactive molecules in the volunteers' urine and feces showed that 92.8 percent of the sucralose passed through the body without being altered.

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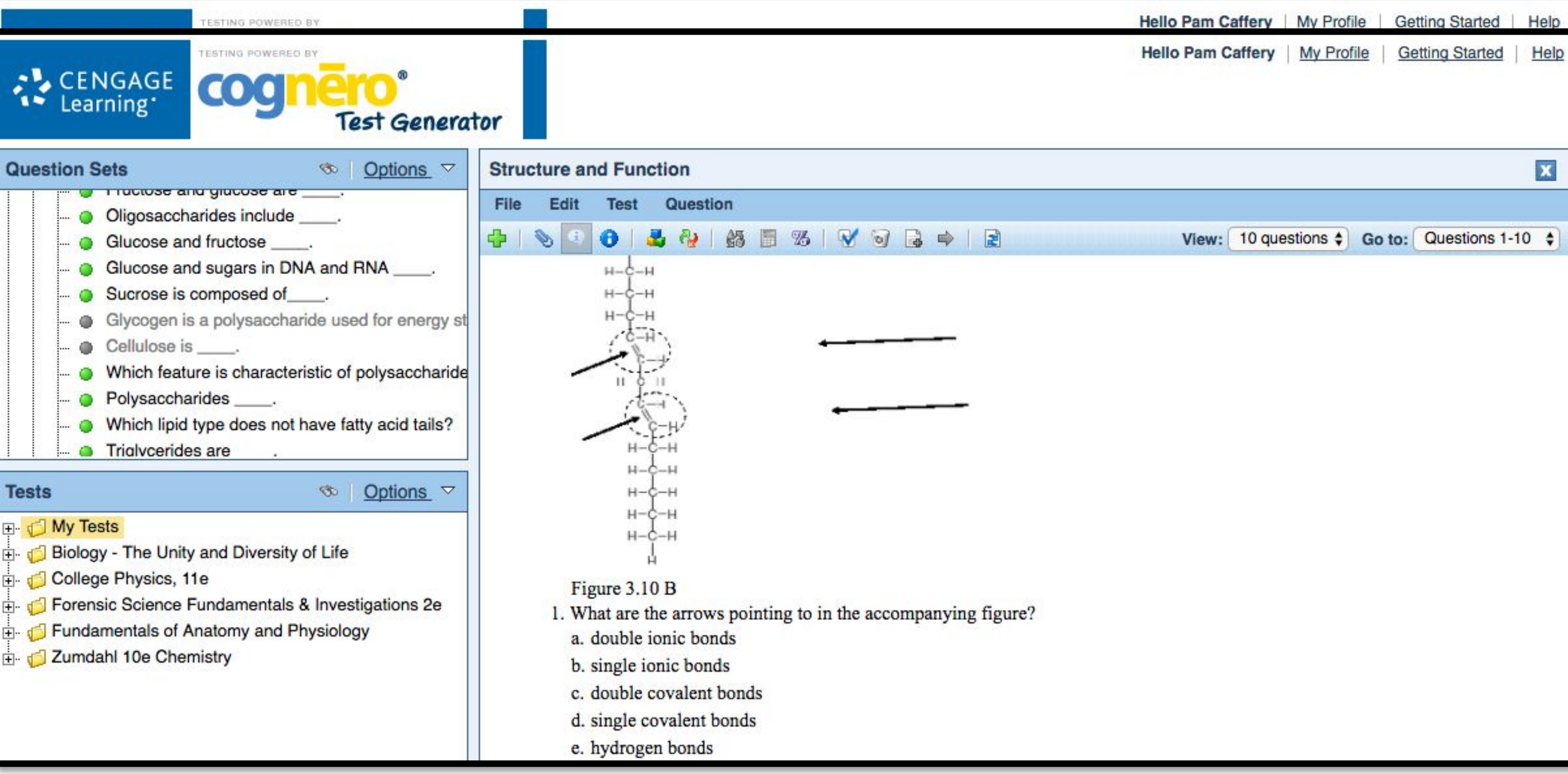

- Fructose and glucose are ____.
- Oligosaccharides include ____.
- Glucose and fructose ____.
- Glucose and sugars in DNA and RNA ____.
- Sucrose is composed of____.
- Glycogen is a polysaccharide used for energy st
- Cellulose is ____.
- Which feature is characteristic of polysaccharide
- Polysaccharides ____.
- Which lipid type does not have fatty acid tails?
- Triglycerides are ____.

- My Tests
- Biology - The Unity and Diversity of Life
- College Physics, 11e
- Forensic Science Fundamentals & Investigations 2e
- Fundamentals of Anatomy and Physiology
- Zumdahl 10e Chemistry

Figure 3.10 B

1. What are the arrows pointing to in the accompanying figure?
   a. double ionic bonds
   b. single ionic bonds
   c. double covalent bonds
   d. single covalent bonds
   e. hydrogen bonds

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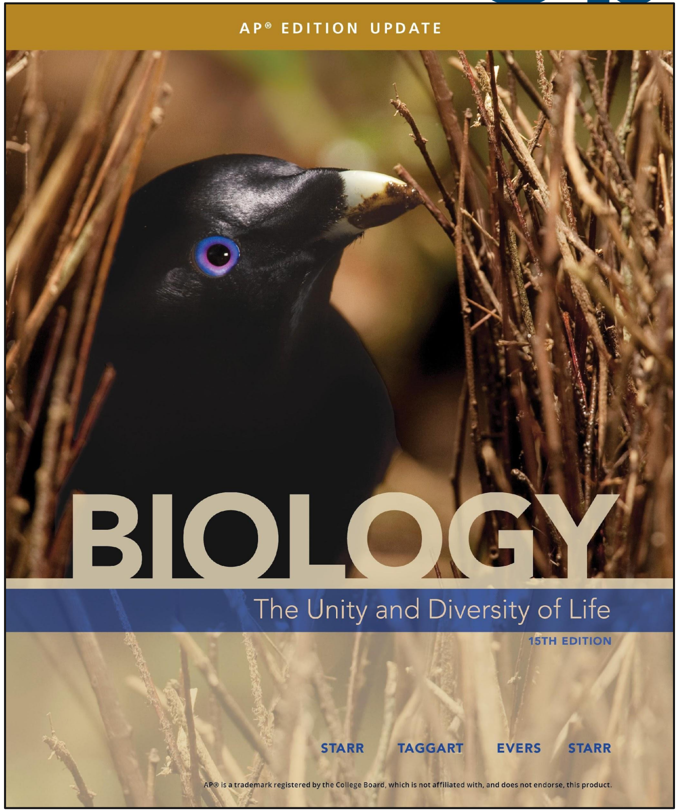
Biology: The Unity and Diversity of Life, Updated



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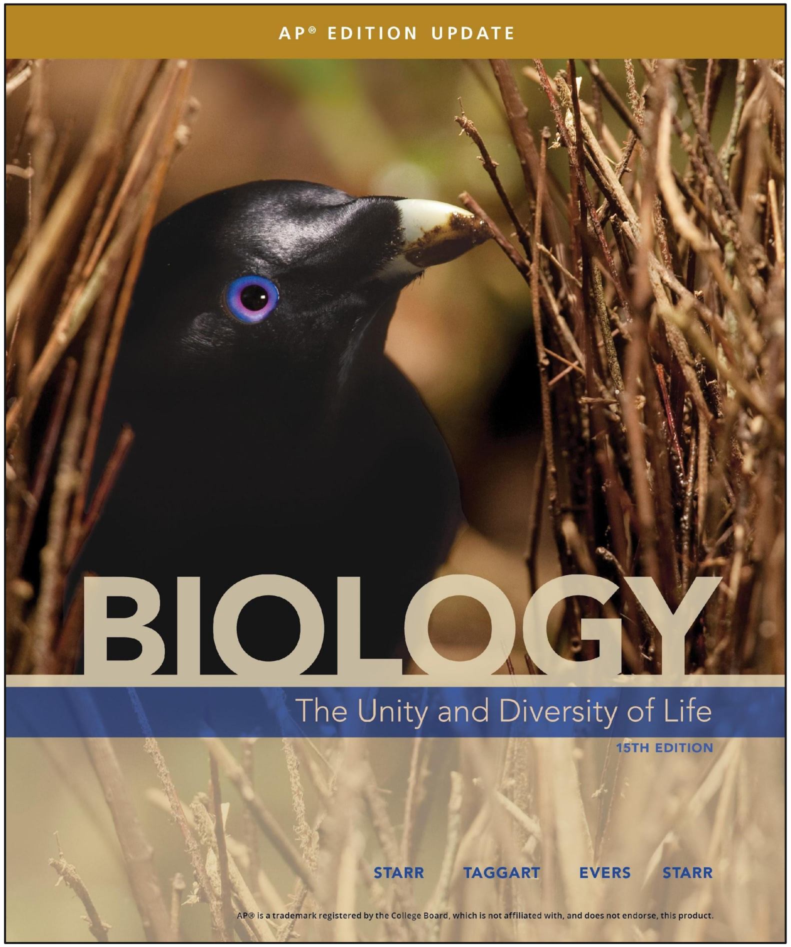

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Thank You!

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