Solutions for Human Biology 9th Edition by Johnson

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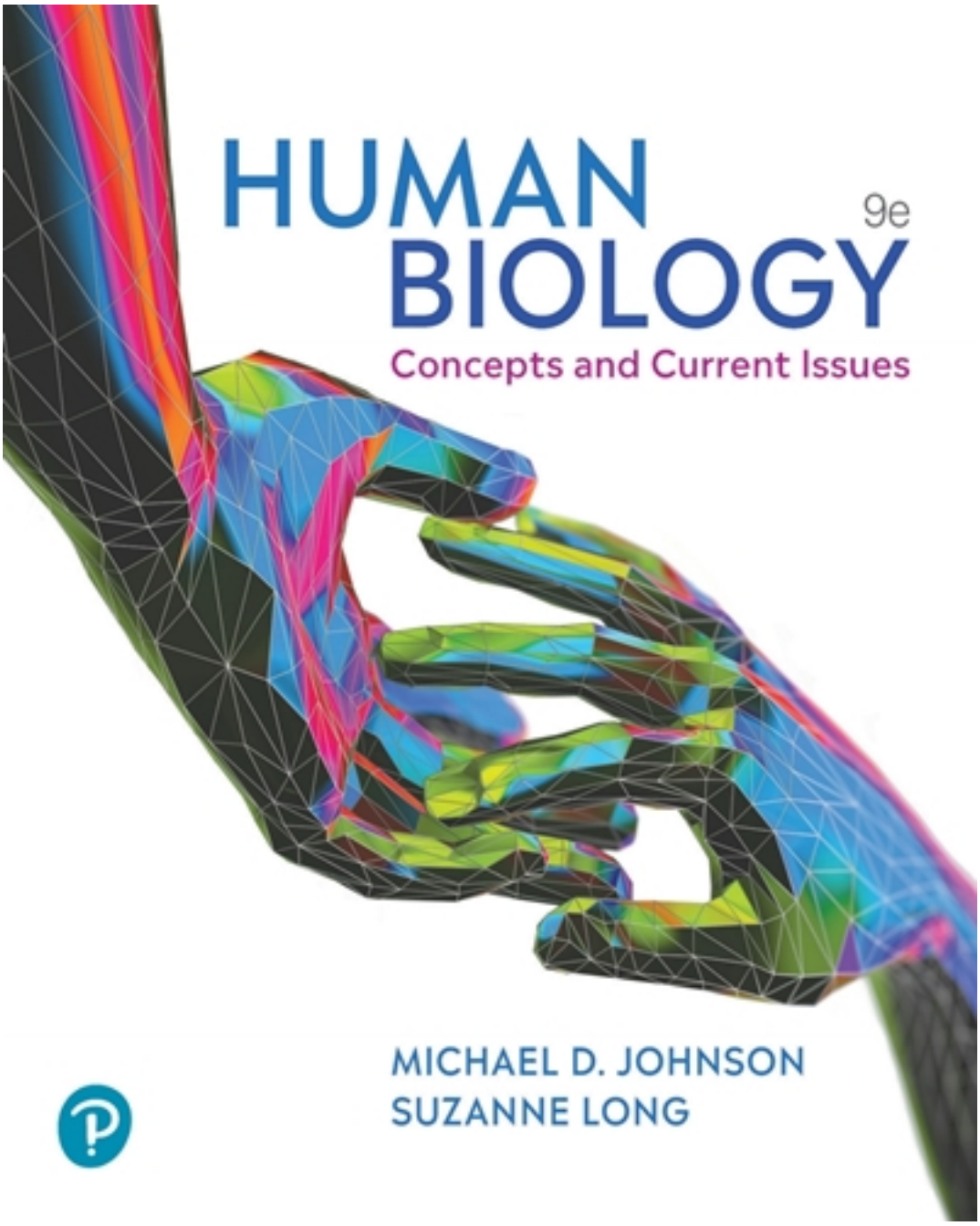

Solutions

CHAPTER 2

The Chemistry of Living Things

Objectives

After studying this chapter, students will be able to

- Define matter and describe the composition of its smallest, identifiable functional unit.
- List the three types of chemical bonds and discuss their relative importance in molecules.
- List five properties of water that are essential to living organisms.
- Explain how acidity and alkalinity are measured by the pH scale.
- Identify and discuss the element that is the common building block for all organic molecules.
- Explain the role of carbohydrates in energy production and structural support for living organisms.

Suggested Lecture Outline

2.1 All matter consists of elements

A. Atoms: smallest functional unit of an element
B. Isotopes: same element, different number of neutrons
C. Free radicals: unpaired electrons

2.2 Atoms combine to form molecules

A. Energy as fuel: life's activities
B. Chemical bonds: link atoms to form molecules
C. Living organisms contain only certain elements

2.3 Life depends on water

A. Water is the biological solvent
B. Water is a liquid at body temperature
C. Water helps regulate body temperature
D. Water participates in chemical reactions

2.4 The importance of hydrogen ions

A. Acids donate hydrogen ions, whereas bases accept them
B. The pH scale expresses the hydrogen-ion concentration
C. Buffers: minimize pH change

2.5 The organic molecules of living organisms

A. Carbon is the common building block of organic molecules
B. Macromolecules are synthesized and broken down within cell

2.6 Carbohydrates: used for energy and structural support

A. Monosaccharides are simple sugars
B. Oligosaccharides: more than one monosaccharide linked together
C. Polysaccharides: store energy

2.7 Lipids: insoluble in water

A. Triglycerides are energy-storage molecules
B. Phospholipids are the primary component of cell membranes
C. Steroids are composed of four ring structures such as cholesterol

2.8 Proteins: complex structures constructed of amino acids

A. Protein function depends on structure
B. Enzymes facilitate chemical reactions

2.9 Nucleic acids: store genetic information

A. DNA (deoxyribonucleic acid): contains the instructions for producing RNA
B. RNA (ribonucleic acid): contains the instructions for producing proteins

2.10 ATP: carries energy

A. ATP (adenosine triphosphate) is used for energy transport
B. Energy is stored in chemical bonds between phosphate groups

Additional Sections

A. Current Issue: Water Crisis in Flint, Michigan
B. Science Consumer: What Are Those Chemicals in My Food?

Lecture Hints

- Relate the need to eat with the necessity of energy to make or break covalent bonds.
- Elicit from the class what parts of this material they may have been exposed to in high school.
- Use the following analogy to teach the difficult concept of the "random" movement of electrons: describe what it's like to follow a young child (age 2–4) down a supermarket aisle as he darts back and forth and takes up much more room than his little body would seemingly justify. This is how a very small electron takes up so much space and, consequently, makes the appropriate size of each element as all the electrons zoom around.
- Are humans worth more or less than last year? Several publications list the annual worth of a human organism according to the worth of the elements in people. Apply this to the students; list different individual weights and what their elements are worth. Be sensitive about the students selected.
- Hydrogen bonds are extremely important in water. They help form a matrix that must include anything dissolved into it. If the amount of material in a container exceeds the water's ability to bind and support all of it, some precipitates out of solution, like too much sugar in a cup of coffee. The vibrations of the bonds move things through the solution and absorb energy put into the solution, assisting in functioning as a heat sink.

- Use the definitions of acids and bases with which you are most comfortable.
- Describe the pH scale as similar to a capital V. A pH of 7, or neutral, is at the point: the numbers that denote stronger acids and bases rise along the arms of the V.
- Emphasize the very narrow range within which human buffer systems maintain the body's pH.
- Describe the buffers found in the blood that maintain the human body's pH.
- To explain the structural uses of carbon, use a split-rail fence to illustrate the "straight" line arrangement; it is more accurate than a truly straight line, and helps explain the angles present in a carbon-based compound.
- Emphasize that the word *sugar* does not just mean table sugar.
- Explain that when a protein is made, the transition from primary to tertiary is continuous, not fragmented, as the use of separate terms might imply. This is analogous to cooking a single strand of spaghetti: first the strand is straight, then a bit bent, and then folded into a more-or-less ball-shape. Give examples of proteins such as insulin, keratin, collagen, and hemoglobin.

Media Guide

Listed next are the portions of the Instructor Resources on Mastering Biology and Interactive Physiology for Human Biology that are relevant to this chapter.

Instructor Resources on Mastering Biology

- Human Biology Animations: Atoms, Ions, and Bonding; Water and Chemistry; Monomers and Polymers; Lipid Structure and Function; Protein Structure; Nucleic Acids
- All images and tables (labeled and unlabeled in .jpeg and PowerPoint formats)
- PowerPoint presentations
- Learning Catalytics Questions

Interactive Physiology for Human Biology

- Fluids and Electrolytes/Introduction to Body Fluids

Class Demonstrations and Student Activities

- Explore the MasteringBiology website.
- See the fluid balance topic on the Interactive Physiology for Human Biology.
- Discuss with the class about the water crisis in Flint Michigan, health consequences of lead toxicity and possibilities of water contamination elsewhere.
- Present three-dimensional illustrations of atoms and electron orbitals.
- Have the class figure out, on an atomic level, why a cubic inch of aluminum weighs so much less than a cubic inch of iron.
- Ask a local radiologist to visit the class to explain medical uses of isotopes.
- Test the pH of common solutions, such as saliva and tap water by using pH paper.

- Have students collect the nutritional panels from the processed food they eat. Construct spreadsheets illustrating the relative amounts of nutrients. Describe how these contribute to the body's biochemistry, or not. Which nutrients are burned for energy first?
- Which nutrients can be more easily converted to storage fats?

Suggestions for Possible Assignments

Any of the following questions or topics can be used as a starting point for a discussion, abstract, paper, debate topic, or poster session:

- Assign the exercises and questions in Chapter 2 of *Human Biology: Concepts and Current Issues*, 9th edition, as homework.
- What is the importance of unpaired electrons in chemical bonding?
- Explain why some isotopes are considered safe, while others are not. Cite examples of each category.
- Why are covalent bonds so much stronger than ionic or hydrogen bonds?
- If hydrogen bonds are weak, how are they useful to a cell?
- What are the roles of hydrogen bonds in water?
- Explain how free radicals might contribute to the development of cancer. How can the effects of free radicals be lessened?
- What is the role of diffusion in normal cell functions? Is this important? Why?
- Why is carbon so important to the chemical structure of human macromolecules? Can there be non-carbon-based life forms? How would they structure molecules?
- What are the common uses and sources of the monosaccharides, disaccharides, and polysaccharides?
- If lipids are relatively insoluble in water, how does the human body work with and transport these compounds?
- Illustrate the transformation of a protein through its various structural forms.
- What happens if an enzyme is not working? What if it is working just a little?
- Why is an enzyme not affected by the chemical reaction related to it?
- How would you prove that DNA is the storage molecule for genetic information? Why not proteins?
- What is the grammar of the genetic code?

Case in Point

I'll Take a Bag of Labs on Chips

Space-age laboratory testing is coming closer to reality with the development of a technology called Lab on a Chip. These "chips" can be made out of silicon, glass, or certain plastics and measure a few millimeters to a few square centimeters. They test fluid volumes that are extremely small, some less than a pico liter. The current terminology used for these minilabs is *Micro Total Analysis System* or µTAS. The chips contain capillary channels, mixers, valves, pumps, and devices for monitoring chemical reactions of a variety of types. These portable laboratories have the advantage of using extremely small volumes, providing fast

turnaround times for testing, and a compactness that rivals medical laboratories seen on a science fiction show.

Applications for this testing include real-time polymerase chain reaction (PCR) testing to detect bacterial growth in time to initiate treatment when traditional methods would not. They can be used in the field to detect biological or chemical weapons. They could bring a level of testing sophistication to physician's offices that has not been possible. Patients could be screened for cancer markers and specific cancer cells while they wait in the office. Genetic testing could be done to determine whether a person carries a defective gene, or if an unborn child has inherited a particular gene from one or both of his or her parents.

Questions

1. In what other ways could this technology be used?
2. Which ethical questions might the use of this technology raise?

Investigate

Yetisen, A. K. et al. Entrepreneurship, *Lab Chip*, 2015.

Bahadır E. B. and M. K. Sezgintürk. Applications of Commercial Biosensors in Clinical, Food, Environmental, and Biothreat/Biowarfare Analyses. *Analytical Biochemistry*, 2015.

Answers to Case in Point

1. As mentioned, these chips could bring a new level of sophistication and certainty to testing in a variety of locations. Microbial infections that take days or weeks to identify could be diagnosed in minutes to hours in the office, at the bedside, or in the home. Specific treatments could begin much earlier than currently possible. People seeking genetic counseling could have a suspected gene identified or ruled out at the time of counseling, not weeks later.
2. Among important questions are who will have access to information generated by this testing? If the sample volume is very small, possibly just exhaled air, will testing be done without the consent of the person being tested? Both of these ethical questions have been raised in the past when other new technologies were first applied. Such questions are still relevant and need to be discussed. Will employers, insurance companies, or credit companies use these data? If so, will people be denied jobs, insurance coverage, or a higher credit rating? Will people even know the basis of the decisions made about them?

Answers to Concept Review and Apply What You Know

Answers to Concept Review and Apply What You Know questions can be found in the Instructor's Resource area of MasteringBiology.

Answers to Test Yourself

Answers to Test Yourself questions can be found in the back of the student textbook.

Example of Classroom Application

Using the postings for *Screening Newborns for Genetic Disorders* have the class investigate other apps that are available online that claim to monitor aspects of health. How do these compare to more traditional methods? Are they effective?

Additional Resources

Books

- Bettelheim, F. A., et al. *Introduction to General, Organic and Biochemistry*, Hybrid, Cengage Learning, 2015.
- Brown, T. *Biochemistry*, Scion Publishing Ltd., 2015.
- Castanho, *M. A. R. B.* and A. T. da Poian. *Integrative Human Biochemistry*, Springer New York, 2015.
- Eljamil, A. S. *Lipid Biochemistry: For Medical Sciences*, iUniverse, Incorporated, 2015.
- Granger, S. *Handbook of Cell Biology: Volume II*, ML Books, 2015.
- Halliburton, W. D. *The Essentials of Chemical Physiology for the Use of Students—Scholar's Choice Edition*, Scholar's Choice, 2015.
- House, J. E. and K. A. House. *Descriptive Inorganic Chemistry*, Elsevier Science, 2015.
- Kumar, D. *Biomedical Applications of Natural Proteins: An Emerging Era in Biomedical Sciences*, Springer India, 2015.
- Lodish, H., et al. *Molecular Cell Biology*, Freeman, W. H. & Company, 2016.
- Smith, M. B. *Organic Chemistry: An Acid-Base Approach*, 2nd ed. Taylor & Francis, 2015.
- Stone O. *Chemical Biology: An Overview on Chemistry and Biology of the Biomolecules*, ML Books International, 2015.
- Vallero, D. *Environmental Biotechnology: A Biosystems Approach*, Elsevier Science, 2015.

Websites

Find the URLs and links to these websites on the MasteringBiology website.

Chemistry of Living Things

This website explores and discusses the chemistry involved in all living organisms.

Web Chemistry Resources

This website contains complete lists of chemistry resources available through the Web for both research and educational applications.

Journal of Biological Chemistry

Journal of the professional society dedicated to the research and educational issues affecting biological chemistry.

Links for Chemists: Virtual Library Chemistry Section

This website contains a virtual library of experiments, research, and educational illustrations.

Chemistry

This website contains a variety of resources such as articles, homework help, demonstrations, news, periodic tables, educational resources, suppliers, and annotated links.