Solutions for Human Biology 14th Edition by Mader

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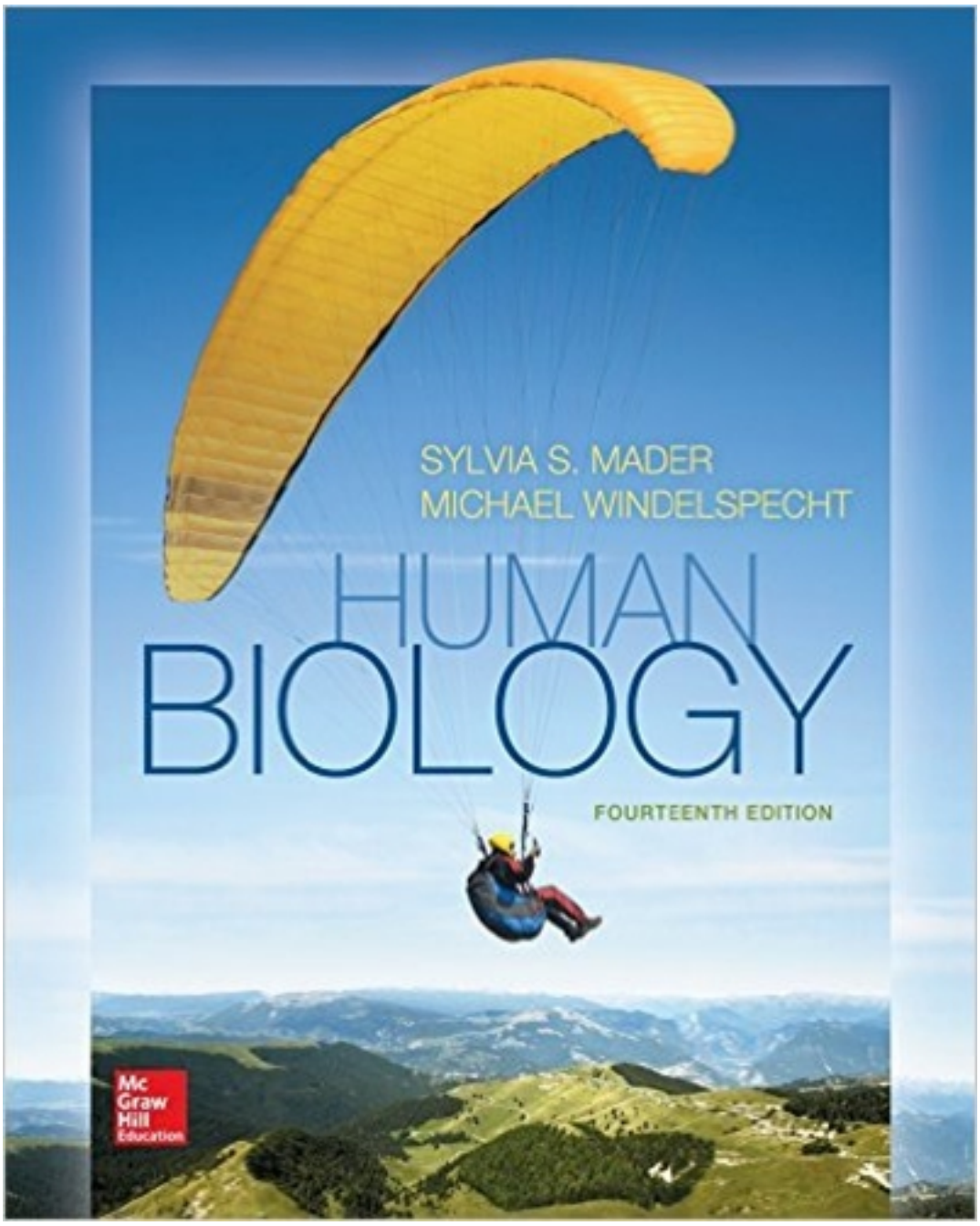

Solutions

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CHAPTER 1
EXPLORING LIFE AND SCIENCE

LEARNING OUTCOMES

1.1 The Characteristics of Life

1. Explain the basic characteristics that are common to all living things.
2. Describe the levels of organization of life.
3. Summarize how the terms *homeostasis*, *metabolism*, *development*, and *adaptation* all relate to living organisms.
4. Explain why the study of evolution is important in understanding life.

1.2 Humans Are Related to Other Animals

1. Summarize the place of humans in the overall classification of living organisms.
2. Describe the relationship between humans and the biosphere, and the role of culture in shaping that relationship.

1.3 Science as a Process

1. Describe the general process of the scientific method.
2. Distinguish between a control group and an experimental group in a scientific test.
3. Recognize the importance of scientific journals in the reporting of scientific information.

1.4 Making Sense of a Scientific Study

1. Explain the difference between anecdotal and testimonial data.
2. Interpret information that is presented in a scientific graph.
3. Recognize the importance of statistical analysis to the study of science.

1.5 Challenges Facing Science

1. Distinguish between science and technology.
2. Summarize some of the major challenges facing science.

EXTENDED LECTURE OUTLINE

1.1 The Characteristics of Life

The science of biology is the study of living organisms and their environments. All living things share certain characteristics of life.

Life is Organized

Atoms join together to form molecules that make up cells. A cell is the smallest structural and functional unit of an organism. In more complex living things, cells join to form tissues, which form organs, which form organ systems, which then form individual organisms. Biological organization extends beyond the individual to populations, communities, ecosystems, and finally the biosphere.

Organisms Acquire Materials and Energy

Human beings require an outside source of materials and energy to carry on life's activities. Humans and other animals get these materials when they eat food. The ultimate source of energy for the majority of life on Earth is the sun.

Organisms Maintain Homeostasis

The ability of a cell or an organism to maintain an internal environment that operates under specific conditions is called homeostasis.

Organisms Respond to Stimuli

Living things respond to external stimuli, often by moving toward or away from a stimulus.

Organsims Reproduce and Grow

When organisms reproduce, they pass on genetic information to the next generation. Following fertilization of the egg by the sperm cell, the zygote that results undergoes growth and development. Growth is an increase in size and number of cells and is a part of development. In humans, development includes all the changes that occur from the time the egg is fertilized until death, as well as repair that takes place following an injury. DNA enables living organisms to pass on hereditary information from parent to child.

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Organisms Have an Evolutionary History

Evolution is the process by which a population changes through time. Evolution explains both the unity and the diversity of life.

1.2 Humans Are Related to Other Animals

Living things are now classified into three domains: Archaea, Bacteria, and Eukarya. Humans are mammals within the vertebrates of the kingdom Animalia within the domain Eukarya.

Humans Have a Cultural Heritage

Culture encompasses human activities and products that are passed on from one generation to the next outside of direct biological inheritance. This includes beliefs, values, and skills.

Humans Are Members of the Biosphere

All living things on Earth are part of the biosphere, a living network that spans the surface of the Earth into the atmosphere and down into the soil and seas.

1.3 Science as a Process

Science is a way of knowing about the natural world.

The Scientific Method Has Steps

The process of science involves the scientific method, which includes observation, hypotheses, controlled experiments, conclusions that either support or reject hypotheses, and reformulation of hypotheses.

Start with an Observation

The scientific method begins with observation. Scientists may expand their understanding beyond observations by taking advantage of the knowledge and experiences of other scientists.

Develop a Hypothesis

After making observations and gathering knowledge about a phenomenon, a scientist uses inductive reasoning. A hypothesis is a supposition that is formulated after making an observation. A hypothesis is based on existing knowledge, so it is much more informed than a mere guess. It can be tested by obtaining more data, often by experimentation.

Make a Prediction and Perform Experiments

An experiment is an artificial situation devised to test a hypothesis. The manner is which a scientist intends to conduct an experiment is called the experimental design. If the hypothesis is well prepared, then the scientist should be able to make a prediction of what the results of the experiment will be. Experiments can take many forms, however in all experimental designs, the researcher attempts to keep all the conditions constant except for the experimental variable. One or more test groups are exposed to the experimental variable, but one other group called the control group, is not. Scientists often use model organisms and model systems to test a hypothesis.

Collect and Analyze the Data

Statistical analysis allows a scientist to detect relationships in the data that may not be obvious on the surface.

Develop a Conclusion

Scientists must analyze the data in order to reach a conclusion about whether a hypothesis is supported or not. In science, many experiments, often involving a considerable number of subjects, are required before a conclusion can be reached.

Scientific Theory

The ultimate goal of science is to understand the natural world in terms of scientific theories such as the cell theory and the theory of evolution. These concepts are based on the conclusion of a large number of observations and experiments. Evolution is the unifying concept of biology because it makes sense of what we know about the nature of life.

An Example of a Controlled Study

Controlled laboratory studies involve two groups of subjects, a control group not given the test medication or treatment, and the test group given the medication or treatment. It is important to reduce the number of possible differences between the two groups.

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The Results

A double-blind study helped researchers determine if medications could relieve stomach ulcers.

Publication of Scientific Studies

The results of scientific studies are published in a scientific journal so that an experiment's design and results can be available to all scientists.

Further Study

The conclusion of one experiment often leads to another experiment.

Scientific Journals Versus Other Sources of Information

The information in many scientific journals is highly regarded by scientists because of the review process. Unfortunately, the studies in scientific journals may be technical and difficult for a layperson to read and understand.

1.4 Making Sense of a Scientific Study

When evaluating scientific information, it is important to consider the type of data given to support it. Anecdotal data and correlations are not considered reliable data.

What to Look For

It is important to read beyond the abstract (synopsis) at the beginning of the study. Always examine the investigators' methodology and results before going to the conclusion. Keep in mind that the conclusion is an interpretation of the data.

Graphs

Data are often depicted in the form of a bar graph or a line graph. A graph shows the relationship between two quantities with the experimental variable plotted along the horizontal or x-axis, and the result plotted along the vertical or y-axis.

Statistical Data

Most authors who publish research articles use statistics to help them evaluate experimental data. In statistics, the standard error tells us how uncertain a particular value is.

Statistical Significance

When scientists conduct an experiment, there is always the possibility that the results are due to chance or some other factor other than the experimental variable. This is taken into account when they calculate the probability value that their results were due to chance alone.

1.5 Challenges Facing Science

Science is a systematic way of acquiring knowledge about the natural world. It can only examine things that can be observed objectively, not supernatural or religious beliefs. Science differs from technology. Technology is the application of scientific knowledge to the interests of humans. Science and technology are not risk free.

Bioethics

Although science has improved our lives, science can produce potentially disastrous technologies. Technology raises difficult ethical issues.

Human Influence on Ecosystems

Human activities tend to modify ecosystems. Unfortunately, these technology-enabled human activities present a major threat to biodiversity. It is estimated that these activities have increased the extinction rate by a factor of 100 to 1000.

Emerging Diseases

New diseases have generated a lot of publicity. These *emerging diseases* may result from human behavior and use of technology.

Climate Change

Climate change is primarily due to an imbalance in the chemical cycling of the element carbon. However, due to human activities, more carbon dioxide is being released into the atmosphere than is being removed. This phenomenon is causing a rise in temperature called global warming.

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STUDENT ACTIVITIES

Is It Alive?

1. Bring to class a collection of living things and inanimate objects. Plastic models of living organisms are particularly useful. Have students gather around the specimens and identify the features that distinguish the living specimens from the inanimate ones. List the distinguishing features on the board or overhead as students suggest them.

Humans Are Related to Other Animals

2. Give students a list of organisms that include members of the four kingdoms within Eukarya (animals, plants, fungi, and protists). Ask them to divide the organisms into the various groups based on what they already know about these organisms. Then ask them to describe the common characteristics of each group.

Exploring the Scientific Method

3. Propose a simple hypothetical experiment in class, such as how salt affects the hatching of brine shrimp. Suggest the use of water, weak salt solution, and strong salt solution as the 3 "habitats." Have students formulate a hypothesis and discuss the steps needed to carry out their plan. Have some brine shrimp, or photographs of brine shrimp, available for observation.

Animals in the Lab

4. Arrange to take your students to a laboratory on campus or at a nearby research facility to tour the animal housing facilities. Have the laboratory technician in charge of the lab explain what methods are used to ensure the animals receive good care and adequate housing. Explain the nature of the research involving animals in the research lab. Allow time for the students to ask questions.

One Application of the Scientific Method

5. Invite a fellow faculty member engaged in research on your campus to tell the class how they use the scientific method to address a specific question. Ask them to include a description of the control group(s) used in their research.

CLASSROOM DISCUSSION TOPICS

1. Viruses are not considered to be living organisms. Have students determine which of the characteristics of life viruses do not possess. Why would another parasitic organism, such as a disease-causing bacteria, be considered a living organism?
2. How does evolution explain both the unity and the diversity of life? Have students discuss what living things have in common and why this suggests a common ancestor. Have students discuss how living things are diverse and how this came about.
3. If humans are members of the biosphere, what gives them the right to modify and/or destroy the habitats of other organisms? Are humans "above" other organisms? Are they in some way "special" or "different"? What responsibilities do humans have to take care of the other organisms of the biosphere?
4. Read BIOLOGY MATTERS-Science "Adapting to Life at High Elevations" on page 6 of the text. Have students answer the following questions: What is the function of hemoglobin? How is the hemoglobin of people who live at high elevations different from the that of people who live at low elevations? How is the gene *EPSA1* and the transcription factor it encodes involved with hemoglobin production? Define the term "adaptation" using the example of Tibetans who reside at high altitudes.
5. Read BIOLOGY MATTERS-Science "Discovering the Cause of Ulcers" on page 13 of the text. Have students explain how Marshall's approach was similar to, and different from, the scientific method.

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CHAPTER 2
CHEMISTRY OF LIFE

LEARNING OUTCOMES

2.1 From Atoms to Molecules

1. Distinguish between atoms and elements.
2. Describe the structure of an atom.
3. Define an isotope and summarize its application in both medicine and biology.
4. Distinguish between ionic and covalent bonds.

2.2 Water and Life

1. Describe the properties of water.
2. Explain the role of hydrogen bonds in the properties of water.
3. Summarize the structure of the pH scale and the importance of buffers to biological systems.

2.3 Molecules of Life

1. List the four classes of organic molecules that are found in cells.
2. Describe the processes by which the organic molecules are assembled and disassembled.

2.4 Carbohydrates

1. Summarize the basic chemical properties of a carbohydrate.
2. State the roles of carbohydrates in human physiology.
3. Compare the structure of simple and complex carbohydrates.
4. Explain the importance of fiber in the diet.

2.5 Lipids

1. Compare the structures of fats, phospholipids, and steroids.
2. State the function of each class of lipids.

2.6 Proteins

1. Describe the structure of an amino acid.
2. Explain how amino acids are combined to form proteins.
3. Summarize the four levels of protein structure.

2.7 Nucleic Acids

1. Explain the difference between RNA and DNA.
2. Summarize the role of ATP in cellular reactions.

EXTENDED LECTURE OUTLINE

2.1 From Atoms to Molecules

Matter refers to anything that takes up space and has mass.

Elements

All matter is composed of elements, 92 of which occur naturally. Every element has a name and symbol.

Atoms

Matter is composed of atoms that contain the subatomic particles. Positively charged protons and neutral neutrons occupy the nucleus of the atom, with negatively charged electrons in orbit about the nucleus. The atomic number is equal to the number of protons and therefore the number of electrons in an electrically neutral atom. The atomic weight equals the number of protons plus the number of neutrons.

The Periodic Table (Figure 2.1 on page 21 of the text)

In the periodic table of elements, the number on the top of each square is the atomic number. The letter symbols represent each element. Below the symbol is the value for atomic mass. A complete periodic table is located in Appendix A.

Isotopes

Isotopes are atoms that have the same atomic number but differ in the number of neutrons. Most isotopes are stable but some emit radiation.

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Low Levels of Radiation

A radioactive isotope behaves the same as do stable isotopes of the same element. Many medical uses of radioactive isotopes that emit low levels of radiation have been found.

High Levels of Radiation

High levels of radiation can harm cells, damage DNA, and cause cancer. Accidents at nuclear power plants can have long-ranging effects.

Molecules and Compounds

Atoms bond with each other to form molecules. If the atoms come from different elements, the molecule is a compound.

Ionic Bonding

During an ionic reaction, certain atoms give up and others receive electrons to achieve a stable outer shell. The resulting oppositely charged ions (charged particles) are attracted to each other, forming an ionic bond.

Covalent Bonding

Following a covalent reaction, atoms share pairs of electrons within a covalent bond in order to achieve a stable outer shell.

Double and Triple Bonds

In addition to single bonds, double and triple bonds are also possible in some molecules.

Structural and Molecular Formulas

Covalent bonds can be represented in a number of ways, including structural and molecular formulas

2.2 Water and Life

Life as we know it would be impossible without water which comprises 60-70% of total body weight. Water molecules are polar; the oxygen end has a slight negative charge and the hydrogen end has a slight positive charge.

Hydrogen Bonds

Hydrogen bonds occur when a covalently bonded, slightly positively charged hydrogen atom is attracted to a negatively charged atom in the vicinity.

Properties of Water

Due to its polarity and/or hydrogen bonding, water is a liquid at room temperature, loses and gains heat slowly, has a high heat of vaporization, is less dense when frozen, fills vessels, and is the universal solvent. These properties are necessary to life.

Water Has a High Heat Capacity

Water holds onto its heat. Its temperature falls and rises more slowly than other liquids.

Water Has a High Heat of Evaporation

Since hydrogen bonds must be broken when water boils, our bodies can release excess body heat in a hot environment.

Water Is a Solvent

Due to its polarity, water facilitates chemical reactions.

Water Molecules Are Cohesive and Adhesive

Cohesion refers to the ability of water molecules to cling to one another and adhesion refers to the ability of water molecules to cling to other polar surfaces These properties are due to hydrogen bonding.

Frozen Water is Less Dense Than Liquid Water

As liquid water cools, the molecules come closer together, below $4^{\circ}C$, hydrogen bonding becomes more open, meaning that water expands and is why ice floats on liquid water.

Acids and Bases

Water dissociates into an equal number of hydrogen and hydroxide ions.

Acidic Solutions (High H^+ Concentrations)

Acids release hydrogen ions. Compared to water, acidic solutions have more hydrogen ions than hydroxide ions.

Basic Solutions (Low H^+ Concentrations)

Bases take up hydrogen ions or release hydroxide ions. Compared to water, basic solutions have more hydroxide ions than hydrogen ions.

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pH Scale

The pH scale is used to indicate the acidity or basicity of a solution. The scale ranges from 0 to 14 with 7 being neutral. Acids have a pH lower than 7 and bases have a pH higher than 7.

Buffers

Buffers are mechanisms that help keep pH within normal limits by taking up excess hydrogen ions or hydroxide ions. Maintaining pH within a narrow range is important to health.

2.3 Molecules of Life

Four categories of organic molecules—carbohydrates, lipids, proteins, and nucleic acids—are unique to cells. Large organic molecules (macromolecules) are polymers which are formed when monomers join together through a dehydration reaction (synthesis). They can be broken down by a hydrolysis reaction (degradation).

2.4 Carbohydrates

Carbohydrates contain the grouping H—C—OH in which the ratio of hydrogen atoms to oxygen is approximately 2:1. Carbohydrates serve as an energy source for cells.

Simple Carbohydrates

Monosaccharides have a low number of carbon atoms; a pentose has five carbon atoms and a hexose has six carbon atoms. Glucose provides a ready source of energy for cells.

Complex Carbohydrates (Polysaccharides)

Carbohydrate macromolecules are called polysaccharides. Polysaccharides such as starch (fewer side branches) and glycogen are polymers of glucose molecules. Cellulose, a polysaccharide found in plant cell walls, is commonly called fiber. The linkages joining glucose units cannot be digested and therefore cellulose adds bulk that passes through our digestive system as fiber.

2.5 Lipids

Lipids are hydrophobic and do not dissolve in water. They function in the storage of energy.

Fats and Oils

Solid fats of animal origin and liquid oils of plant origin are both composed of glycerol bonded to three fatty acids. Fats and oils are a long-term energy source for organisms. Emulsifiers cause fat droplets to disperse in water because a nonpolar end projects into a fat droplet, and a polar end projects outward to interact with water.

Saturated, Unsaturated, and Trans-Fatty Acids

Saturated fatty acids have no double bonds and unsaturated fatty acids do have double bonds between carbon atoms. Saturated fats are associated with cardiovascular disease. Even more harmful than naturally occurring saturated fats are the so-called trans fats, which are in vegetable oils that have been partially hydrogenated to make them semisolid.

Dietary Fat

The diet should contain some fat. The total recommended amount of fat in a 2,000 calorie diet is 65 g.

Phospholipids

Phospholipids, which have a polar phosphate group instead of a third fatty acid, are the primary constituent of the plasma membrane bilayer. The nonpolar tails face one another and the polar ends face the external environment.

Steroids

Steroid molecules have a backbone of four fused carbon rings that differ according to the functional groups attached to the rings. Cholesterol and the sex hormones are steroids.

2.6 Proteins

Proteins are of primary importance in the structure and function of cells. Some of their functions include: support, enzymes, transport, defense, hormones, and motion.

Amino Acids: Subunits of Proteins

An amino acid contains an amine group, an acid group, and an R (remainder) group that distinguishes the twenty different amino acids in cells.

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Peptides

Amino acids are joined by a linkage called a peptide bond. Three or four amino acids linked together are called a polypeptide.

Shape of Proteins

The final shape of a protein is important to its function. When proteins are exposed to extremes in heat and pH, they undergo an irreversible change in shape called denaturation which destroys the proteins' ability to function.

Levels of Protein Organization

The primary structure of a polypeptide is the sequence of amino acids. The secondary structure is an alpha helix or a pleated sheet, The tertiary, globular shape is due to interactions between the R groups. A quaternary structure occurs if there is more than one polypeptide.

2.7 Nucleic Acids

The two types of nucleic acids are DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). Each DNA molecule contains many genes, and genes specify the sequence of the amino acids in proteins. RNA is the intermediary that conveys DNA's instructions regarding the amino acid sequence in a protein.

How the Structure of DNA and RNA Differs

Both DNA and RNA are polymers of nucleotides.

Nucleotide Structure

A nucleotide contains phosphate, a pentose sugar, and a nitrogen-containing base. The bases in DNA are adenine, thymine, cytosine, and guanine. In RNA, uracil replaces thymine.

DNA and RNA Structure DNA is a double helix—if unwound, its structure resembles a stepladder. Phosphate and the pentose sugar make up the sides of the ladder and the hydrogen bonded bases are the rungs. RNA is single-stranded and is complementary to one DNA strand.

ATP: An Energy Carrier

ATP is a nucleotide that has been modified by the addition of three phosphate groups. It functions as an energy carrier in cells.

Structure of ATP Suits Its Function

ATP is a high-energy molecule because the last two phosphate bonds are unstable and easily broken. The energy released by ATP breakdown is used by the cells for various functions.

STUDENT ACTIVITIES

pH Measurements

1. Students should research the topic of acid rain on the Internet before coming to class. They should also collect and bring in water samples from their dorm faucets, drinking fountains, rainwater, snow, or a nearby pond or stream. Have pH paper or a pH meter available in class to determine the pH of these samples. Discuss the known or potential effects of acid rain in your particular geographic location, which might include: effects on forests (including interruption of the symbiotic association between trees and their mycorrhizae), depletion of fisheries in lakes, or deterioration of car finishes and statues.
2. Bring in various types of colas and coffee. Have pH paper or a pH meter available in class to determine the pH of these beverages. How acidic are these? Discuss why you can drink such acidic beverages and not damage your stomach.

What Are You Eating?

3. Ask students to bring in one food label from a processed food they normally consume. Does it have added sugar? Where is sugar in the list of ingredients? Ingredients are listed in order from the most abundant to the least abundant. What other terms (such as corn syrup) could be used on the nutrition label instead of sugar?
4. Ask students to keep a food log of everything they eat for 24 hours. Using a calorie/fat counter or the nutritional label on the food, determine how many grams of fat and how many calories they consumed in one day. Convert the grams of fat into calories by multiplying by nine. What percentage of their total dietary calories was made up of fat? What is the recommended amount?

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Jobs for Chemists

5. Have a chemistry professor, graduate student, technician, or chemist from your town water treatment facility talk to your students about the job opportunities available to those with a background in chemistry.

CLASSROOM DISCUSSION TOPICS

1. Ask someone who is a diabetic to come to class and describe their disease and its management. Discuss the dietary changes that are necessary to control diabetes.
2. Liken the primary structure of a protein to beads on a string. Describe how the primary structure helps determine the secondary structure. Discuss how certain diseases, such as sickle cell anemia or cystic fibrosis, result from a change in the primary sequence of a protein. Why does one amino acid change result in so many symptoms?
3. Of the four organic molecules discussed in this section (carbohydrates, lipids, proteins, and nucleic acids), why are nucleic acids the best suited to store and transmit information? What properties of DNA allow these particular functions?
4. Ask the students to explain the difference between a period and a group using the periodic table (Figure 2.1 on page A1 of the text and Appendix A).

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