Solution Manual for Environmental Science 14th Edition by Miller Spoolman ISBN 9781111988937

Full link download

Test Bank:

https://testbankpack.com/p/test-bank-for-environmental-science-14th-edition-by-miller-spoolman-isbn-9781111988937/

Solution Manual: https://testbankpack.com/p/solution-manual-for-environmental-science-14th-edition-by-miller-spoolman-isbn-9781111988937/

CHAPTER 2
SCIENCE, MATTER, AND ENERGY

Outline

2-1 What do scientists do?

A. Science is a search for order in nature.
   1. Science is an attempt to discover how nature works.
   2. Scientists use this knowledge to make predictions about future events in nature..

B. Scientists use observations, experiments, and models to answer questions about how nature works.
   1. The scientific process uses these steps:
      a. Identify a problem.
      b. Find out what is known about the problem.
      c. Ask a question to investigate.
      d. Perform an experiment and collect and analyze data to answer the question.
      e. Propose an hypothesis to explain the .
      f. Use the thesis to make testable predictions.
      g. Test the predictions.
      h. Accept or revise hypothesis.
      i. Develop a scientific theory, if scientific hypothesis is well-tested and widely accepted.
      j. Scientists are curious and skeptical, and demand lots of evidence.
   2. Important features of the scientific process are skepticism, reproducibility, and peer review.

C. Critical thinking and creativity are important in science
   1. Critical thinking involves four important steps.
      a. Be skeptical about everything you read or hear.
      b. Look at the evidence and evaluate it and any related information.
      c. Be open to many viewpoints and evaluate each one before coming to a conclusion.
      d. Identify and evaluate your personal assumptions, biases, and beliefs.
   2. Imagination, creativity and intuition are also important tools in science.

D. Scientific theories and laws are the most important and certain results of science.
   1. The goal of scientists is to develop theories and laws based on facts and data that explain how the physical world works.
   2. A scientific theory has been tested widely, is supported by extensive evidence, and is accepted as being a useful explanation of some phenomenon by most scientists in a particular field or related fields of study.
   3. A scientific law is a well-tested and widely accepted description of events or actions of nature that we find happening repeatedly in the same way.
   4. Scientific laws cannot be broken except by discovering new data that lead to changes in the law.

E. The results of science can be tentative, reliable, or unreliable.

1. Results that have not been widely tested or are not widely accepted can be called tentative or frontier science. At this stage, disagreement among scientists is common and leads to advancement.

2. Reliable science consists of data, hypotheses, models, theories, and laws that are widely accepted by all or most of the scientists who are considered experts in the field under study.
3. Unreliable science includes results that have not been rigorously peer reviewed or that have been discarded as a result of peer review.
4. Questions to ask to determine if scientific findings are reliable or unreliable include:
    a. Was the experiment well designed? Did it involve a control group
    b. Have other scientists reproduced the results?
    c. Does the proposed hypothesis explain the data? Have scientists made and verified projections based on the hypothesis?
    d. Are there no other, more reasonable explanations of the data?

   e. Are the investigators unbiased in their interpretations of the results? Were all the investigators' funding sources unbiased?
   f. Have the data and conclusions been subjected to peer review?
   g. Are the conclusions of the research widely accepted by other experts in this field?
   h. If "yes" is the answer to each of these questions, then the results can be called reliable science. Otherwise, the results may represent tentative science that needs further testing and evaluation, or you can classify them as unreliable science.

F. Science has some limitations.
  1. Scientists cannot prove or disprove anything absolutely because of inherent uncertainty in measurements, observations, and models.
     a. Scientists attempt to establish high probability or certainty of being useful for understanding some aspect of nature.
  2. Being human, scientists are not free of bias.
     a. The peer review process helps to reduce personal bias.
  3. Because the natural world is so complex, there are many variables that cannot be tested one at a time in controlled experiments.
     a. Scientists use mathematical models that can take into account the interaction of many variables.

2-2 What is matter and what happens when it undergoes change?

A. Matter consists of elements and compounds.
  1. Matter is anything that has mass and takes up space, living or not.
  2. Matter exists in three physical states: solid, liquid, gas.
  3. Matter exists in two chemical forms, elements and compounds.
  4. An element is a fundamental substance that has a unique set of properties and cannot be broken down into simpler substances by chemical means.
  5. Elements are represented by a one- or two-letter symbol.
  6. Compounds are combinations of two or more different elements bound in fixed proportions.

B. Atoms, ions, and molecules are the building blocks of matter.
  1. An atom is the smallest unit of matter that exhibits the characteristics of an element.
     a. Each atom consists of subatomic particles: positively charged protons, uncharged neutrons, and negatively charged electrons.
     b. Each atom contains a small center called the nucleus that contains protons and neutrons.
     c. Each element has a unique atomic number that is equal to the number of protons in the nucleus of its atom.
     d. The mass number of an atom is the total number of neutrons and protons in its nucleus.
     e. Isotopes are forms of an element that have the same atomic number, but different mass numbers.
  2. A molecule is a combination of two or more atoms of the same or different elements held together by chemical bonds
  3. An ion is an atom or group of atoms with one or more net positive or negative charges.
  4. pH is a measure of acidity based on the amount of hydrogen ions (H^+) and hydroxide ions (OH^-) in a solution.
     a. A neutral solution has a pH of 7. A pH below 7 is an acidic solution, or acid. A pH above 7 is a basic solution, or base.
  5. Chemical formulas are a type of shorthand to show the type and number of atoms/ions in a compound or molecule.
     a. Each element in the compound is represented by a symbol (e.g., H = hydrogen, O = oxygen).
     b. Subscripts show the number of atoms/ions in the compound (e.g. H_2O, or water, has two hydrogen atom and one oxygen atom). No subscript is used if there if only one atom of an element.

C. Organic compounds are the chemicals of life.
  1. Organic compounds contain at least two carbon atoms combined with various other atoms. Methane (CH_4) is an exception; it is considered an organic compound although it has only one carbon atom.

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

2. All other compounds are called inorganic compounds.
3. Types of organic compounds include:

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

a. Hydrocarbons: compounds of carbon and hydrogen atoms.
b. Chlorinated hydrocarbons: compounds of carbon, hydrogen, and chlorine atoms.
c. Simple carbohydrates: specific types of compounds of carbon, hydrogen, and oxygen atoms.
4. Macromolecules are large organic molecules. Many are polymers, large molecules made of smaller subunits called monomers joined together.
5. The major types of organic molecules are:
a. Complex carbohydrates: two or more monomers of simple sugars such as glucose
b. Proteins: formed by monomers called amino acids
c. Nucleic acids: (DNA and RNA) formed by monomers called nucleotides
d. Lipids, which include fats and waxes, and are not always made of monomers.

D. Matter comes to life through genes, chromosomes, and cells.
1. All living organisms are made of cells.
2. Cells are the smallest and most fundamental structural and functional units of life.
3. DNA contains sequences of nucleotides that form genes that code for traits.
4. Thousands of genes make up chromosomes, which are composed of DNA and proteins.

E. Some forms of matter are more useful than others.
1. High-quality matter is highly concentrated, is typically found near the earth's surface, and has great potential for use as a resource.
2. Low-quality matter is not highly concentrated, is often located deep underground or dispersed in the ocean or atmosphere, and usually has little potential for use as a resource.

F. Matter undergoes physical, chemical, and nuclear changes.
1. Physical change is not chemical composition change but a change in states, such as ice melting or water freezing.
2. Chemical change or chemical reaction is a change in the chemical composition.

G. We cannot create or destroy atoms: the Law of Conservation of Matter.
1. Whenever matter undergoes a physical or chemical change, no atoms are created or destroyed.

2-3 What is energy and how do physical and chemical changes affect it?

A. Energy comes in many forms.
1. Energy is the capacity to do work or transfer heat.
2. Kinetic energy is energy associated with motion.
a. Wind and flowing water are examples of kinetic energy.
b. Heat is a form of kinetic energy. When two objects at different temperatures contact one another heat flows from the warmer to the cooler object.
c. Electromagnetic radiation is a form of kinetic energy and occurs when energy travels as waves as a result of changes in electrical and magnetic fields.
3. Potential energy is stored energy.
a. Examples include water stored behind a dam and the chemical bonds in gasoline.
4. Potential energy can be changed to kinetic energy.
a. Examples include releasing water from behind a dam and burning gasoline in a car
5. Solar energy is major source of renewable energy.
a. It provides about 99% of the energy that heats the earth and provides us with food (through photosynthesis by plants).
b. Indirect forms of renewable solar energy include wind, hydropower and biomass.
6. Non-renewable fossil fuels provide the other 1% of the energy we use.

B. Some types of energy are more useful than others.
1. High-quality energy is concentrated and has a high capacity to do useful work.
2. Low-quality energy is dispersed and has little capacity to do useful work.

C. Energy changes are governed by two scientific laws.
1. The first law of thermodynamics, or the law of conservation of energy, states that when energy is converted from one form to another in a physical or chemical change, no energy is created or destroyed.

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

2. The second law of thermodynamics states that when energy is changed from one form to another, energy quality is depleted.

D. Three scientific laws govern what we can and cannot do with matter and energy

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

a. There is no "away."
b. You cannot get something for nothing.
c. You cannot break even.

Objectives

2-1 What do scientists do?

CONCEPT 2-1 Scientists collect data and develop theories, models, and laws about how nature works.

1. Briefly describe how science works. State the questions that science tries to answer. Summarize scientific methods.
2. State the importance of curiosity, skepticism, peer review, critical thinking and creativity in the scientific process.
3. Define scientific hypothesis, theory and scientific law or law of nature.
4. Describe the differences among frontier science, reliable science and unreliable science.

2-2 What is matter and what happens when it undergoes change?

CONCEPT 2-2A Matter consists of elements and compounds, which in turn are made up of atoms, ions, or molecules.

CONCEPT 2-2B Whenever matter undergoes a physical or chemical change, no atoms are created or destroyed (the law of conservation of matter).

1. Define *matter*. Distinguish between high- and low- quality of matter.
2. Define matter, elements, compounds and molecules. Describe the atomic theory and the sub-atomic particles and structure of an atom.
3. Describe pH and its importance.
4. Distinguish between organic and inorganic compounds.
5. Describe cells, genes and chromosomes.
6. Distinguish among physical, chemical, and nuclear changes.
7. State the law of conservation of matter.

2-3 What is energy and what happens when it undergoes change?

CONCEPT 2-3A Whenever energy is converted from one form to another in a physical or chemical change, no energy is created or destroyed (first law of thermodynamics).

CONCEPT 2-3B Whenever energy is converted from one form to another in a physical or chemical change, we end up with lower quality or less usable energy than we started with (second law of thermodynamics).

1. Define *energy*. Distinguish among forms of energy and between high- and low-quality energy.
2. State the first and second laws of energy and give an example of each.
3. Describe the implications of the laws of matter and energy for a long-term sustainable-Earth society.
4. Describe the chapter's *three big ideas*.

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

Key Terms

acidity (p. 31)
atom (p. 30)
atomic number (p. 30)
atomic theory (p. 30)
cells (p. 32)
chemical change (p. 33)
chemical formula (p. 32)
chemical reaction (p. 33)
chromosomes (p. 32)
compounds (p. 30)
data (p. 27)
electromagnetic radiation (p. 35)
electrons (p. 30)
elements (p. 30)
energy (p. 35)
energy quality (p. 36)
first law of thermodynamics (p. 36)
fossil fuels (p. 36)
frontier science (p. 29)
genes (p. 32)
heat (p. 35)
high-quality energy (p. 36)
high-quality matter (p. 33)
inorganic compounds (p. 32)
ion (p. 31)
isotopes (p. 31)
kinetic energy (p. 35)
law of conservation of energy (p. 36)
law of conservation of matter (p. 34)
low-quality energy (p. 36)
low-quality matter (p. 33)
mass number (p. 31)
matter (p. 30)
matter quality (p. 33)
model (p. 27)
molecule (p. 31)
neutrons (p. 30)
nuclear change (p. 34)
nucleus (p. 30)
organic compounds (p. 32)
peer review (p. 28)
pH (p. 31)
physical change (p. 33)
potential energy (p. 35)
protons (p. 30)
radioactive decay (p. 34)
reliable science (p. 29)
science (p. 26)
scientific hypothesis (p. 27)
scientific law (p. 28)
scientific theory (p. 27)
second law of thermodynamics (p. 36)
tentative science (p. 29)
trait (p. 32)
unreliable science (p. 29)

Teaching Tips

Ask the students to describe what scientists "do," or how scientists expand our knowledge base. Lead the discussion to controlled experiments, namely how scientists develop experiments and test hypotheses. Use the discussion of controlled experiments to introduce the core case study, Hubbard Brook.

Use the core study to solidify the students' understanding of control group, experimental group, and baseline data. Here, Borman and Likens perform the daunting task of conducting a controlled experiment in the field. Therefore, laboratory and field experiments can be compared.

Many students have little notion of how science is "done." Considerable time should be spent discussing what science is, including the scientific method, its uses, and limitations.

As the underpinning of all topics discussed in the course/book, the topics of matter, energy, and energy use should be emphasized.

Ask the students to select a scientist (you can have index cards with scientists (name, dates, location, scientific achievements) or they can research the scientist on their own. Ask the students to pretend they are that scientist, and have the class try to guess who each student represents.

Bring in products made of materials found on the periodic table (jewelry works well). Food or plants work well for organic (carbon-containing) examples, while sea salt works well for inorganic examples.

In clear glasses, place sugar in cold water and hot water (heat energy) to show different rates of dissolving, then stir (mechanical energy).

Show examples of potential versus kinetic energy. Dropping something is a simple example. If building codes allow, lighting a peanut or walnut on fire is more exciting.

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

Discussion Topics

1. How does the total amount of matter and energy in the universe relate to the Big Bang Theory of the origin of the universe and the role of entropy in the destiny of the universe?

2. Can we get something for nothing? Explore the attempts of advertising to convince the public that we can indeed get something for nothing. Explore attempts to create perpetual motion machines. Explore the history of the *free lunch* concept.

3. How much are you willing to pay in the short term to receive long-term economic and environmental benefits? Explore costs and payback times of energy-efficient appliances, energy-saving light bulbs, and weather stripping.

4. What actions can you take to improve your home's energy efficiency and reduce consumption of materials? Do you believe these reductions will increase or decrease your quality of life?

5. What is our national energy policy? How has it changed over the past 20 years? Is our current policy supported by the science in this chapter regarding the laws of energy? What are the short- and long-term economic, environmental, and national-security implications?

6. What would it be like to lead a low-energy lifestyle? Are people already successfully using less energy while maintaining a high quality of life? What are some of the challenges in convincing more people to embrace a low-energy lifestyle?

Activities and Projects

1. A human body at rest yields heat at about the same rate as a 100-watt incandescent light bulb. As a class exercise, calculate the heat production of the student body of your school, the U.S. population, and the global population. Where does the heat come from? Where does it go?

2. As a class exercise, conduct a survey of the students at your school to determine their degree of awareness and understanding of the three basic laws of matter and energy. Discuss the results in the context of the need for low-entropy lifestyles and sustainable-Earth societies.

3. Ask a physics or chemistry instructor to visit your class and, by using simple experiments, demonstrate the matter and energy laws.

4. As a class exercise, make an inventory the types of appliances that are used to maintain a classroom environment—the lighting; space heating and cooling; electricity for projectors; and other facilities, equipment, and services. List the matter from which they are made and their approximate mass and energy consumption, if applicable.

5. Invite a medical technician to speak to your class on the beneficial uses of ionizing radiation. Discuss the controls that are employed to limit the risks associated with the use of radioisotopes for diagnostic and treatment procedures?

Attitudes and Values Assessment

1. Where do you fit into the flow of energy from the sun?

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

2. Do you feel you play a role in nature's cycles of matter and energy?

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

3. What is your body temperature? How does your body stay at that temperature even in the cold weather? How do you feel when you are in air-conditioned or heated rooms?

4. Do you use a lot of energy (e.g., lights, television, CD player, car, or heated water)? Where does the energy come from? What could cause you to increase or decrease your usage?

5. How do you feel on a sunny day? A cloudy day? What is the wind doing with the atmospheric energy on those days?

6. What right do you have to use Earth's material resources? Are there any limits to your rights? What are they?

7. What rights do you have to Earth's energy resources? Are there any limits to your rights? What are they?

8. Do you believe that cycles of matter and energy flowing from the sun have anything to do with your lifestyle? With your country's economic or energy policies?

Laboratory Skills

Wells, Edward. *Lab Manual for Environmental Science.* 2009. Lab #1: Introduction to Experimental Design.

News Videos

Finding alternatives to oil, The Brooks/Cole Environmental Science Video Library 2009, ©2011, DVD ISBN-13: 978-0-538-73355-7

Additional Videos

Acid Rain The Invisible Threat Hands-on lab activities plus video.
http://www.kelvin.com/Merchant2/merchant.mv?Screen=PROD&Store_Code=K&Product_Code=360042

The Scientific Method Song
A musical explanation of the scientific method
http://www.youtube.com/watch?v=jPaGOHwv7mQ

The Scientific Method
An explanation of the history behind the method
http://www.livevideo.com/media/playvideo_fs.aspx?fs=1&cid=41A6FC752EF3407EA2CE5DE6883B882 3

Web Resources

The Particle Adventure
An exploration of the fundamentals of matter from the Lawrence Berkeley Lab.
http://www.particleadventure.org/

Digital Integration

Correlation to Global Environment Watch

Acid Rain	Green Chemistry
Energy Efficiency	

Correlation to Explore More

Ecology	Environmental Science
Energy	Nature of Science
Environmental History	Science

Suggested Answers to End of Chapter Questions

Answers will vary but these represent phrases from this chapter. The following are examples of the material that should be contained in possible student answers to the end of chapter questions. They represent only a summary overview and serve to highlight the core concepts that are addressed in the text. It should be anticipated that the students will provide more in-depth and detailed responses to the questions depending on an individual instructor's stated expectations.

Review

Core Case Study

1. Describe the *controlled scientific experiment* carried out in the Hubbard Brook Experimental

Forest. See page 25.

Section 2-1

2. What is the key concept for this section? What is science? Describe the steps involved in a scientific process. What is data? What is a model? Distinguish among a scientific hypothesis, a scientific theory, and a scientific law (law of nature). What is peer review and why is it important? Explain why scientific theories are not to be taken lightly and why people often use the term theory incorrectly.

The key concept for this section is that scientists collect data and develop theories, models, and laws about how nature works.

Science is an attempt to discover how nature works and to use that knowledge to make predictions about what is likely to happen in nature.

Data is the information needed to answer scientific questions usually obtained by making observations and measurements.

Model is an approximate representation or simulation of a system being studied.

Scientific hypothesis is a possible and testable explanation of what is observed in nature or in the results of experiments.

A well-tested and widely accepted scientific hypothesis or a group of related hypotheses is called a scientific theory.

A scientific law, or law of nature is a well-tested and widely accepted description of what we find happening in nature.

An important part of the scientific process is peer review, in which scientists openly publish details of the methods and models they used, the results of their experiments, and the reasoning

behind their hypotheses for other scientists working in the same field (their peers) to evaluate. Any evidence gathered to verify a hypothesis must be reproducible. That is, scientists should repeat and analyze the work to see if the data can be reproduced and whether the proposed hypothesis is reasonable and useful.
A scientific theory should be taken very seriously. It has been tested widely, supported by extensive evidence, and accepted by most scientists in a particular field or related fields of study. Nonscientists often use the word theory incorrectly when they actually mean scientific hypothesis, a tentative explanation that needs further evaluation. The statement, "Oh, that's just a theory," often made in everyday conversation, implies that the theory was stated without proper investigation and careful testing—the opposite of the scientific meaning of the word.

3. Explain why scientific theories and laws are the most important results of science and most certain results of science.

   Since the goal of science is to come up with theories and laws based on facts to explain how the world works, these theories and laws are the culmination of the scientific process, especially since a scientific law cannot be broken as long as the data used to formulate it is accurate.

4. Distinguish among tentative science (frontier science), reliable science, and unreliable science. What are three limitations of science and environmental science?

   Tentative science or frontier science is the preliminary results that capture news headlines and may be controversial because they have not been widely tested and accepted by peer review yet.
   Reliable science consists of data, hypotheses, theories, and laws that are widely accepted by all or most of the scientists who are considered experts in the field under study, in what is referred to as a scientific consensus. The results of reliable science are based on the self-correcting process of testing, peer review, reproducibility, and debate. New evidence and better hypotheses may discredit or alter accepted views.
   Scientific hypotheses and results that are presented as reliable without having undergone the rigors of peer review, or that have been discarded as a result of peer review, are considered to be unreliable science.

   Environmental science and science in general have three important limitations:
   - Scientists cannot prove or disprove anything absolutely, because there is always some degree of uncertainty in scientific measurements, observations, and models.
   - A limitation of science is that scientists are human and thus are not totally free of bias about their own results and hypotheses.
   - A limitation—especially important to environmental science—is that many environmental phenomena involve a huge number of interacting variables and complex interactions.

Section 2-2

5. What are the two key concepts for this section? What is matter? Distinguish between an element and a compound and give an example of each. Distinguish among atoms, molecules, and ions and give an example of each. What is the atomic theory? Distinguish among protons, neutrons, and electrons. What is the nucleus of an atom? Distinguish between the atomic number and the mass number of an element. What is an isotope? What is acidity? What is pH?

   The key concepts for this section are:
   - Matter consists of elements and compounds, which in turn are made up of atoms, ions, or molecules.
   - Whenever matter undergoes a physical or chemical change, no atoms are created or destroyed (the law of conservation of matter).

   Matter is anything that has mass and takes up space. It can exist in three physical states—solid, liquid, and gas, and two chemical forms—elements and compounds.

A chemical element is a fundamental substance that has a unique set of properties and cannot be broken down into simpler substances by chemical means. Compounds are a combinations of two or more different elements held together in fixed proportions.

The most basic building block of matter is an atom—the smallest unit of matter into which an element can be divided and still have its characteristic chemical properties, such as a single hydrogen atom. A second building block of some types of matter is an ion—an atom or group of atoms with one or more net positive (+) or negative (–) electrical charges, such as H^+. A molecule is a combination of two or more atoms of the same elements held together by forces called chemical bonds, such as O_2, oxygen.

The atomic theory is the idea that all elements are made up of atoms.

Three different types of subatomic particles: positively charged protons (p), neutrons (n) with no electrical charge, and negatively charged electrons (e).

Each atom consists of an extremely small and dense center called its nucleus—which contains one or more protons and, in most cases, one or more neutrons— and one or more electrons moving rapidly somewhere around the nucleus.

Each atom has equal numbers of positively charged protons and negatively charged electrons. Because these electrical charges cancel one another, atoms as a whole have no net electrical charge. Each element has a unique atomic number, equal to the number of protons in the nucleus of its atom. The mass of an atom is described by its mass number: the total number of neutrons and protons in its nucleus.

Forms of an element having the same atomic number but different mass numbers are called isotopes of that element.

Ions are also important for measuring a substance's acidity in a water solution, a chemical characteristic that helps determine how a substance dissolved in water will interact with and affect its environment.

Scientists use pH as a measure of acidity, based on the amount of hydrogen ions (H+) and hydroxide ions (OH–) contained in a particular volume of a solution.

6. What is a chemical formula? Distinguish between organic compounds and inorganic compounds and give an example of each. Distinguish among complex carbohydrates, proteins, nucleic acids, and lipids. What is a cell? Distinguish among a gene, a trait, and a chromosome. What is matter quality? Distinguish between high-quality matter and low-quality matter and give an example of each.

See pages 32–33. Student answers will vary slightly.

Chemists use a chemical formula to show the number of each type of atom or ion in a compound. Organic compounds contain at least two carbon atoms combined with atoms of one or more other element, such as table sugar and methane. All other compounds, except methane (CH_4), are called inorganic compounds, such water.

Complex carbohydrates, such as cellulose and starch, consist of two or more monomers of simple sugars, such as glucose.

Proteins are formed by monomers called amino acids.

Nucleic acids (DNA and RNA) are formed by monomers called nucleotides.

Lipids, which include fats and waxes, are not all made of monomers, but are a fourth type of macromolecule essential for life.

Cells are the smallest and most fundamental structural and functional units of life.

Within some DNA molecules are certain sequences of nucleotides called genes. Each of these distinct pieces of DNA contains instructions, called genetic information, for making specific proteins. Each of these coded units of genetic information concerns a specific trait, or characteristic, passed on from parents to offspring during reproduction. Thousands of genes, in turn, make up a single chromosome, a DNA molecule combined with proteins.

Matter is anything that has mass and takes up space. It can exist in three physical states: solid, liquid, and gas and two chemical forms: elements and compounds.

High-quality matter is highly concentrated, is typically found near the earth's surface, and has great potential for use as a resource, coal for example. Low-quality matter is not highly concentrated, is often located deep underground or dispersed in the ocean or atmosphere, and usually has little potential for use as a resource, a salt solution for example.

7. Distinguish between a physical change and a chemical change (chemical reaction) and give an example of each. What is a nuclear change? Explain the differences among radioactive decay, nuclear fission, and nuclear fusion. What is the law of conservation of matter and why is it important?

See pages 33–34. Student answers will vary slightly.

When a sample of matter undergoes a physical change, there is no change in its chemical composition. A piece of aluminum foil cut into small pieces is still aluminum foil.

When a chemical change, or chemical reaction, takes place there is a change in chemical composition of the substances involved. Chemists use a chemical equation to show what happens in a chemical reaction. For example, when coal burns completely, the solid carbon (C) in the coal combines with oxygen gas (O_2) from the atmosphere to form the gaseous compound carbon dioxide (CO_2).

Nuclear change is a change in the nucleus of an atom.

Radioactive decay occurs when nuclei of unstable isotopes spontaneously emit fast-moving chunks of matter (alpha particles or beta particles), high-energy radiation (gamma rays), or both at a fixed rate.

Nuclear fission occurs when the nuclei of certain isotopes with large mass numbers (such as uranium-235) are split apart into lighter nuclei when struck by a neutron and release energy plus two or three more neutrons.

Nuclear fusion occurs when two isotopes of light elements, such as hydrogen, are forced together at extremely high temperatures until they fuse to form a heavier nucleus and release a tremendous amount of energy.

The law of conservation of matter states whenever matter undergoes a physical or chemical change, no atoms are created or destroyed. This law helps us understand that we need to let our waste cycle back to its original nutrients/products in order for our resources to be sustainable.

Section 2-3

8. What are the two key concepts for this section? What is energy? Distinguish between kinetic energy and potential energy and give an example of each. What is heat? Define and give two examples of electromagnetic radiation. What are fossil fuels and what three fossil fuels do we use to provide most of the energy that we use to supplement energy from the sun? What is energy quality? Distinguish between high-quality energy and low-quality energy and give an example of each.

See pages 35–36. Student answers will vary slightly.

The key concepts for this section are:

- Whenever energy is converted from one form to another in a physical or chemical change, no energy is created or destroyed (first law of thermodynamics).
- Whenever energy is converted from one form to another in a physical or chemical change, we end up with lower quality or less usable energy than we started with (second law of thermodynamics).

Energy is the capacity to do work or transfer heat.

There are two major types of energy: moving energy (called kinetic energy) and stored energy (called potential energy). Examples of kinetic energy include wind (a moving mass of air), flowing water, and electricity (flowing electrons). An example of potential energy is gasoline.

Heat is a form of kinetic energy, the total kinetic energy of all moving atoms, ions, or molecules within a given substance. When two objects at different temperatures contact one another, heat flows from the warmer object to the cooler object.

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

- Electromagnetic radiation is energy that travels in the form of a wave as a result of changes in electrical and magnetic fields. Forms of electromagnetic radiation are short wavelengths such as gamma rays and X rays.
- Fossil fuels were formed over millions of years as layers of the decaying remains of ancient plants and animals were exposed to intense heat and pressure within the earth's crust.
- Oil, coal, and natural gas supply most of the commercial energy that we use to supplement energy from the sun.

Energy quality is a measure of an energy source's capacity to do useful work.

- High-quality energy is concentrated and has a high capacity to do useful work. Examples are very high-temperature heat, nuclear fission, concentrated sunlight, high-velocity wind, and energy released by burning natural gas, gasoline, or coal.
- Low-quality energy is dispersed and has little capacity to do useful work. An example is heat dispersed in the moving molecules of a large amount of matter (such as the atmosphere or an ocean) so that its temperature is low.

9. What is the first law of thermodynamics (law of conservation of energy) and why is it important? What is the second law of thermodynamics and why is it important? Explain why the second law means that we can never recycle or reuse high-quality energy.

See page 36. Student answers will vary slightly.

- The first law of thermodynamics, also known as the law of conservation of energy, states that whenever energy is converted from one form to another in a physical or chemical change, no energy is created or destroyed. This scientific law tells us that no matter how hard we try or how clever we are, we cannot get more energy out of a physical or chemical change than we put in because energy input always equals energy output.
- The second law of thermodynamics states that when energy is changed from one form to another, it always goes from a more useful to a less useful form.
- We can never recycle or reuse high-quality energy because whenever energy is converted from one form to another, we always end up with a lower quality or less "usable" energy than we started with.

10. What are this chapter's three big ideas? Relate the three principles of sustainability to the Hubbard Brook Experimental Forest controlled experiment.

See page 37 and the Hubbard Brook Experiment. Student answers should slightly vary.

The three big ideas of this chapter:

- There is no away. According to the law of conservation of matter, no atoms are created or destroyed whenever matter undergoes a physical or chemical change. Thus, we cannot do away with chemicals; we can only change them from one physical state or chemical form to another.
- You cannot get something for nothing. According to the first law of thermodynamics, or law of conservation of energy, no energy is created or destroyed whenever energy undergoes a physical or chemical change. This means that in such changes we cannot get more energy out than we put in.
- You cannot break even. According to the second law of thermodynamics, whenever energy is converted from one form to another in a physical or chemical change, we always end up with lower quality or less usable energy than we started with.

Critical Thinking

1. What ecological lesson can we learn from the controlled experiment on the clearing of forests described in the Core Case Study that opened this chapter?

   Vegetation controls water and nutrient loss from ecosystems. Loss of vegetation diminishes the systems' ability to retain nutrients and water.

2. You observe that all of the fish in a pond have disappeared. Describe how you might use the scientific process described in the Core Case Study and Figure 2-2 on p. 27 to determine the cause of this fish kill.

   Answers will vary but the steps in Figure 2.2 for the scientific process should be followed. Observation: the fish kill; Question: What caused the fish to die? Hypothesis: Maybe the dissolved oxygen was too low; Test the hypothesis with an experiment: Measure the dissolved oxygen level; Result: Dissolved oxygen level is too low; Conclusion: Hypothesis is verified.

3. Respond to the following statements:
   a. Scientists have not absolutely proven that anyone has ever died from smoking cigarettes.
   b. The natural greenhouse theory—that certain gases such as water vapor and carbon dioxide warm the lower atmosphere—is not a reliable idea because it is just a scientific theory.

   (a) The medical and scientific evidence that links smoking to premature death caused by a number of pathological conditions is overwhelming. As we are exposed to many chemical hazards in our environment it is often difficult to specifically link the cause and effect. The chances of an individual dying from smoking one cigarette is statistically negligible and highly unlikely, but many years of heavy smoking has a much higher probability that a disease leading to death could result.

   (b) Sometimes people with a limited knowledge of the scientific method often confuse a theory with a hypothesis. A theory has been widely tested and is endorsed by a wide group of scientists working in that particular field of study. Many scientists concur with the scientific evidence, obtained through conducting controlled experiments, that water and carbon dioxide are greenhouse gases.

4. A tree grows and increases its mass. Explain why this phenomenon is not a violation of the law of conservation of matter.

   The growth of a tree is an example of a chemical change or chemical reaction. Small inorganic elements and compounds are combined to form more complex molecules that make up the material found in the tree. The components that were present in the soil and air have been rearranged to form other types of chemical components. The amount of material that was present before this rearrangement or chemical change took place is the same as the amount afterwards. A student may discuss photosynthesis to support and explain their answer.

5. If there is no "away" where organisms can get rid of their wastes because of the law of conservation of matter, why is the world not filled with waste matter?

   Just like when small molecules are combined to form larger compounds, as in the case of the growth of a tree, when larger compounds are broken down they release smaller molecules back into the environment. An example is that of a rotting log. A tree limb may break off and fall to the forest floor. Over a period of time it is decomposed by a variety of organisms and the materials contained in the log return once again into the environment. In this way nature recycles all matter that exists in the environment. The student may discuss cell respiration to support or explain their answer.

6. Someone wants you to invest money in an automobile engine, claiming that it will produce more energy than the energy in the fuel used to run it. What is your response? Explain.

   That is not a good investment! The first law of thermodynamics states that energy can be changed from one form to another (such as chemical energy into mechanical energy), but energy cannot be created or destroyed. An engine that produces more energy than it consumes is simply not a feasible scientifically sound prospect.

7. Use the second law of thermodynamics to explain why we can use oil only once as a fuel, or in other words, why we cannot recycle its high-quality energy.

   The second law of thermodynamics states that when energy changes from one form to another, some of the useful energy is always degraded to lower-quality, more dispersed, less useful energy. When a barrel of oil that contains high-quality chemical energy is used as a fuel in order to do useful work, it is transformed or changed into low-quality energy such as heat, which has little ability to do useful work. Therefore the barrel of oil can only be used once as a fuel.

8. a. Imagine you have the power to revoke the law of conservation of matter for one day. What are three things you would do with this power? Explain your choices.
   b. Imagine you have the power to violate the first law of thermodynamics for one day. What three things would you do with this power? Explain your choices.

   (a) Student answers will vary but could include: make more oil to offset the world shortage; produce more water to supply areas that desperately need it; transform all chemical pollutants into useful materials that are not harmful.

   (b) Student answers will vary but could include: grow more crops to provide food; produce electricity that can be stored in batteries for later use; physically change more of the water in the Arctic Ocean into sea ice to offset the losses that have occurred in the past few decades.

Global Environment Watch Exercise

Search for "climate change" and use this portal to research the controversy. Evaluate an argument on each side of this issue and the credentials of the individuals presenting the information. Then decide whether you think climate change research is an example of reliable or unreliable science and write a short report. Revisit your conclusion after you have studied more on this issue later in your course.

Answers will vary but should include the concept of reliable science, that is, science based on data, hypotheses, models and theories versus unreliable science, which includes results that have not been rigorously peer reviewed or that have been discarded as a result of peer review.

Data Analysis

1. In what year did the calcium loss from the experimental site begin a sharp increase? In what year did it peak? In what year did it again level off?

   The sharp increase began in 1966, peaked in 1967 then began to level off in 1968.

2. In what year were the calcium losses from the two sites closest together? In the span of time between 1963 and 1972, did they ever get that close again?

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning

3. Does this graph support the hypothesis that cutting the trees from a forested area causes the area to lose nutrients more quickly than leaving the trees in place? Explain.

   This graph clearly shows that deforested land loses much higher levels of nutrients than forested land. There is a significant difference in the loss of calcium between the two sites.

© 2013 Brooks/Cole Publishing, a Division of Cengage Learning