The World of Science

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CHAPTER 1 The World of Science

CHAPTER OUTLINE

Have you ever experienced the thrill of an exciting fireworks display like this one? Fireworks were invented about 2000 years ago in China. But it wasn't until much later that people understood the science behind the technology.

Do you know why fireworks explode? Do you know what causes the brilliant bursts of light and the deep rumbling booms? In this FlexBook® digital resource, you'll find out the "hows" and "whys" of many things in the physical world around you—from the chemical reactions that cause fireworks to the waves of energy that travel through space from the sun.

Ghengis Fireworks (*www.ghengisfireworks.com*). *www.flickr.com/photos/ghengisfireworks/9710103655/*. *CC BY* 2.0.

1.1 What Is Science?

Lesson Objectives

- Define science.
- Explain how scientists use induction.
- Distinguish between scientific theories and laws.
- Describe milestones in the history of science.
- Identify contributions of women and minorities to science.

Lesson Vocabulary

- induction
- science
- scientific law
- scientific theory

Introduction

Understanding the "hows" and "whys" of the world is the goal of science. The term science comes from a Latin word that means "having knowledge." But science is as much about adding to knowledge as it is about having knowledge. Science is a way of thinking as well as a set of facts. **Science** can be defined as a way of learning about the natural world that is based on evidence and logic.

Thinking Like a Scientist

Are you like the teen in **Figure** 1.1? Do you ever wonder why things happen? Do you like to find out how things work? If so, then you are already thinking like a scientist. Scientists also wonder how and why things happen. They are curious about the world. To answer their questions, they make many observations. Then they use logic to draw general conclusions.

Induction

Drawing general conclusions from many individual observations is called **induction**. It is a hallmark of scientific thinking. To understand how induction works, think about this simple example. Assume you know nothing about gravity. In fact, pretend you've never even heard of gravity. Perhaps you notice that whenever you let go of an object it falls to the ground. For example, you drop a book, and it crashes to the floor. Your pencil rolls to the edge of the

FIGURE 1.1

Like a scientist, this teen wonders about how and why things happen. What do you wonder about?

desk and down it goes. You throw a ball into the air, and it falls back down. Based on many such observations (**Figure** 1.2), you conclude that all objects fall to the ground.

FIGURE 1.2

From skydivers in the air to kids on a playground slide, whatever goes up always comes back down. Or does it?

Now assume that someone gives you your first-ever helium balloon. You discover that it rises up into the air if you don't hold on to it. Based on this new observation, do you throw out your first idea about falling objects? No; you decide to observe more helium balloons and try to find other objects that fall up instead of down. Eventually, you come to a better understanding based on all your observations. You conclude that objects heavier than air fall to the ground but objects lighter than air do not. Your new conclusion is better because it applies to a wider range of observations. You can learn more about induction, including its limits, by watching the video at this link: http://www.youtube.com/watch?v=E1TpZ_HbK3M (5:39).

MEDIA

Click image to the left for use the URL below.
URL: http://www.ck12.org/flx/render/embeddedobject/5002

How Science Advances

The above example shows how science generally advances. New evidence is usually used to improve earlier ideas rather than entirely replace them. In this way, scientists gradually refine their ideas and increase our understanding of the world. On the other hand, sometimes science advances in big leaps. This has happened when a scientist came up with a completely new way of looking at things. For example, Albert Einstein came up with a new view of gravity. He said it was really just a dent in the fabric of space and time.

Different conclusions can be drawn from the same observations, and it's not possible to tell which one is correct. For example, based on observations of the sun moving across the sky, people in the past couldn't tell whether the sun orbits Earth or Earth orbits the sun. Both models of the solar system are pictured in **Figure** 1.3. It wasn't until strong telescopes were invented that people could make observations that let them choose the correct idea. Not sure which idea is correct? You can learn more by watching the student-created video at this link: http://www.youtube.com/watch?v=JcqdUq16S28 .

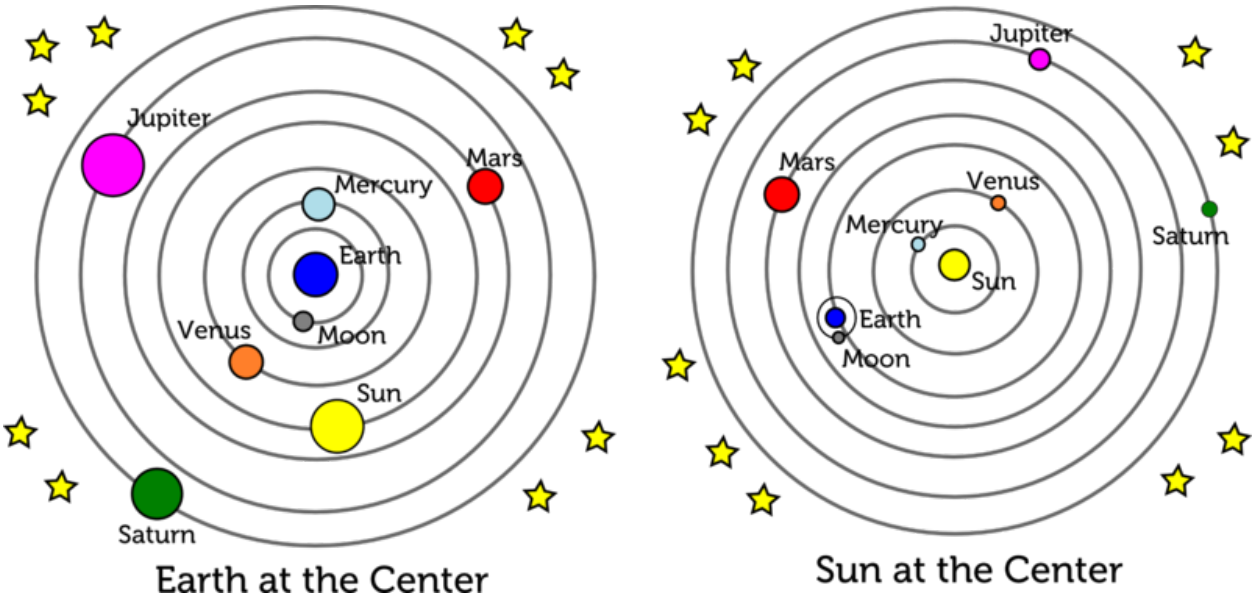


FIGURE 1.3

Both of these models could explain why the sun appears to move across the sky each day. Other observations were needed to decide which model is correct.

Theories and Laws

Some ideas in science gain the status of theories. Scientists use the term "theory" differently than it is used in everyday language. You might say, "I think the dog ate my homework, but it's just a theory." In other words, it's just one of many possible explanations for the missing work. However, in science, a theory is much more than that.

Scientific Theories

A **scientific theory** is a broad explanation that is widely accepted because it is supported by a great deal of evidence. An example is the kinetic theory of matter. According to this theory, all matter consists of tiny particles that are in constant motion. Particles move at different speeds in matter in different states. You can see this in **Figure** 1.4 and at the following URL: http://preparatorychemistry.com/Bishop_KMT_frames.htm . Particles in solids move the least; particles in gases move the most. These differences in particle motion explain why solids, liquids, and gases look and act differently. Think about how ice and water differ, or how water vapor differs from liquid water. The kinetic theory of matter explains the differences. You can learn more about this theory in the chapter *States of Matter*.

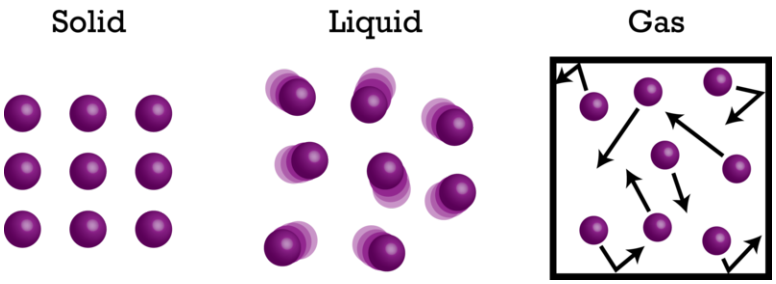


FIGURE 1.4

Why do you think particles move differently in different states of matter? (*Hint*: What causes ice to melt?)

Scientific Laws

Scientific laws are often confused with scientific theories, but they are not the same thing. A **scientific law** is a statement describing what always happens under certain conditions in nature. It answers "how" questions but not "why" questions. An example of a scientific law is Newton's law of gravity. It describes how all objects attract each other. It states that the force of attraction is greater for objects that are closer together or have more mass. However, the law of gravity doesn't explain why objects attract each other in this way. Einstein's theory of general relativity explains why. You can learn more about Newton's law of gravity and Einstein's theory in the chapter *Forces*, and at the following link: http://www.youtube.com/watch?v=O-p8yZYxNGc .

History of Science

People have wondered about the natural world for as long as there have been people. So it's no surprise that modern science has roots that go back thousands of years. The **Table** 1.1 describes just a few milestones in the history of science. A much more detailed timeline is available at the link below. Often, new ideas were not accepted at first because they conflicted with accepted views of the world. A good example is Copernicus' idea that the sun is the center of the solar system. This idea was rejected at first because people firmly believed that Earth was the center of the solar system and the sun moved around it.

http://www.sciencetimeline.net/

TABLE 1.1: Timeline of Scientific Discovery

Date	Scientific Discovery

TABLE 1.1: (continued)

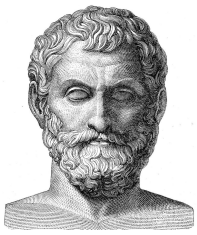
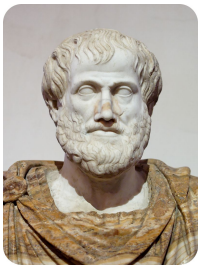
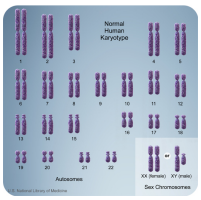
Date	Scientific Discovery
3500 BC  *Mesopotamian calendar*	Several ancient civilizations studied astronomy. They recorded their observations of the movements of stars, the sun, and the moon. We still use the calendar developed by the Mesopotamians about 5500 years ago. It is based on cycles of the moon.
600 BC  *Thales*	The ancient Greek philosopher Thales proposed that natural events, such as lightning and earthquakes, have natural causes. Up until then, people blamed such events on gods or other supernatural causes. Thales has been called the "father of science" for his ideas about the natural world.
350 BC  *Aristotle*	The Greek philosopher Aristotle argued that truth about the natural world can be discovered through observation and induction. This idea is called empiricism. Aristotle's empiricism laid the foundation for the methods of modern science.
400 AD to 1000 AD  *Early Chinese Seismograph*	When Europe went through the Dark Ages, European science withered. However, in other places, science still flourished. For example: • In North Africa, the scientist Alhazen studied light. He used experiments to test competing theories about light. • In China, scientists invented compasses. They also invented seismographs to measure earthquakes. They studied astronomy as well.

TABLE 1.1: (continued)

Date	Scientific Discovery
Mid-1500s to late 1600s  *Galileo*	The Scientific Revolution occurred in Europe. This was the beginning of modern Western science. Many scientific advances were made during this time. • Copernicus proposed that the sun, not Earth, is the center of the solar system. • Galileo improved the telescope and made important discoveries in astronomy. He discovered evidence that supported Copernicus' theory. • Newton proposed the law of gravity.
2001  *Human Chromosomes*	Many scientists around the world worked together to complete the genetic sequence of human chromosomes. This amazing feat will help scientists understand, and perhaps someday cure, genetic diseases.

Women and People of Color in Science

Throughout history, women and people of color have rarely had the same chances as white males for education and careers in science. But they have still made important contributions to science. The **Table** 1.2 gives just a few examples of their contributions to physical science. More contributions are described at these links:

- http://www.inventions.org/culture/science/women/index.html
- http://www1.umn.edu/ships/gender/giese.htm
- https://webfiles.uci.edu/mcbrown/display/faces.html
- http://library.thinkquest.org/20117/

TABLE 1.2: A diversity of people has contributed to physical science.

Contributor	Description
Marie Curie (1867-1934) 	Marie Curie was the first woman to win a Nobel Prize. She won the 1903 Nobel Prize in physics for the discovery of radiation. She won the 1911 Nobel Prize in chemistry for discovering the elements radium and polonium.

TABLE 1.2: (continued)

Contributor	Description
Lise Meitner (1878-1968) 	Lise Meitner was one of the scientists who discovered nuclear fission. This is the process that creates enormous amounts of energy in nuclear power plants.
Irene Joliot-Curie (1897–1956) 	Irene Joliot-Curie, daughter of Marie Curie, won the 1935 Nobel prize in chemistry, along with her husband, for the synthesis of new radioactive elements.
Maria Goeppert-Mayer (1906–1972) 	Maria Goeppert-Mayer was a co-winner of the 1963 Nobel prize in physics for discoveries about the structure of the nucleus of the atom.
Ada E. Yonath (1939–present) 	Ada E. Yonath was a co-winner of the 2009 Nobel prize in chemistry. She made important discoveries about ribosomes, the structures in living cells where proteins are made.

TABLE 1.2: (continued)

Contributor	Description
Shirley Ann Jackson (1946-present) 	Shirley Ann Jackson earned a doctoral degree in physics. She became the chair of the US Nuclear Regulatory Commission.
Ellen Ochoa (1958-present) 	Ellen Ochoa is an inventor, research scientist, and NASA astronaut. She has flown several space missions.

Lesson Summary

- Science is a way of learning about the natural world that is based on evidence and logic. The hallmark of scientific thinking is induction.
- A scientific theory is a broad explanation that is widely accepted because it is supported by a great deal of evidence. A scientific law is a statement describing what always happens under certain conditions in nature.
- Modern science has roots that go back thousands of years. Diverse people from around the world have contributed to the evolution of science.
- Women and minorities have rarely had the same chances in science as white males, but they still have made important contributions.

Lesson Review Questions

Recall

1. Define science.
2. What is induction?
3. State the contributions of Thales and Aristotle to the evolution of science.
4. What was the Scientific Revolution?

Apply Concepts

5. Use induction to draw a logical conclusion based on **Table** 1.3.

TABLE 1.3: Freezing Point of Substances

Substance	Temperature at Freezing (°C)
Pure water (1 cup water)	0
Salt water (1 cup water + 5 grams table salt)	-4
Sugar water (1 cup water + 6 grams sugar)	-5

6. What observation would require you to revise your conclusion in question 5?

Think Critically

7. Compare and contrast scientific theories and scientific laws. Give an example of each.

Points to Consider

Most of the scientists mentioned in this lesson are physical scientists.

- Based on their work, what do you think is the subject matter of physical science?
- What are some questions that physical scientists might investigate?

1.2 The Scope of Physical Science

Lesson Objectives

- Define physical science.
- Explain the relevance of physical science to everyday life.
- Describe examples of careers in physical science.

Lesson Vocabulary

- chemistry
- physical science
- physics

Introduction

Physical science covers a lot of territory. It's easier to describe by what it is not than by what it is. Basically, it's all science that is not life science.

Defining Physical Science

Physical science can be defined as the study of matter and energy. Matter refers to all the "stuff" that exists in the universe. It includes everything you can see and many things that you cannot see, including the air around you. Energy is what gives matter the ability to move and change. Energy can take many forms, such as electricity, heat, and light. Physical science can be divided into chemistry and physics. Chemistry focuses on matter and energy at the scale of atoms and molecules. Physics focuses on matter and energy at all scales, from atoms to outer space.

Chemistry

Chemistry is the study of the structure, properties, and interactions of matter. Important concepts in chemistry include physical changes, such as water freezing, and chemical reactions, such as fireworks exploding. Chemistry concepts can answer all the questions on the left page of the notebook in **Figure** 1.5. Do you know the answers?

Physics

Physics is the study of energy and how it interacts with matter. Important concepts in physics include motion, forces such as magnetism and gravity, and different forms of energy. Physics concepts can answer all the questions on the right page of the notebook in **Figure** 1.5.

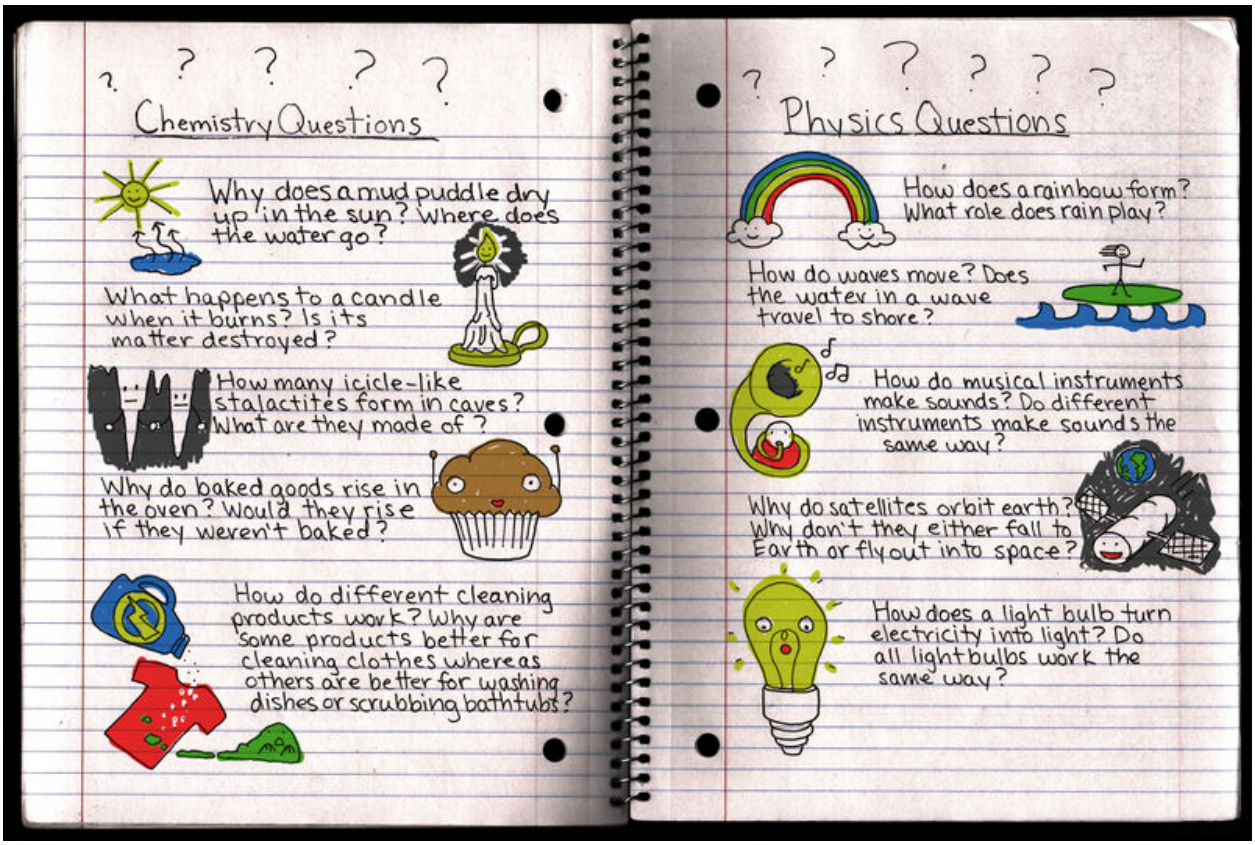


FIGURE 1.5

Using what you already know, try to answer each of these questions. Revisit your answers after you read about the relevant concepts in later chapters.

Physical Science and You

Physical science explains much of what you observe and do in your daily life. In fact, you depend on physical science for almost everything that makes modern life possible. You couldn't drive a car, text message, or send a tweet without decades of advances in chemistry and physics. You wouldn't even be able to turn on a light. **Figure** 1.6 shows some other examples of common activities that depend on advances in physical science. You'll learn the "hows" and "whys" about them as you read the rest of this book.

Careers in Physical Science

People with training in physical science are employed in a variety of places. There are many career options. Just four are described in **Figure** 1.7. Many more are described at the URL below. Do any of these careers interest you?

- http://diplomaguide.com/article_directory/sh/page/Physical%20Science/sh/Job_Titles_and_Careers_List.html .

FIGURE 1.6

All these activities involve matter and energy. Can you explain how or why?

Lesson Summary

- Physical science is the study of matter and energy. It includes chemistry, which focuses on matter, and physics, which focuses on energy.
- Physical science explains everyday observations and actions. Its advances make modern life possible.
- There are many career options in physical science. Examples include pharmacist and surveyor.

Lesson Review Questions

Recall

1. Define physical science.
2. What is the focus of chemistry?
3. Describe an example of a career in physical science.

FIGURE 1.7

How might chemistry or physics be involved in each of these careers?

Apply Concepts

4. What practical question might be answered with physics concepts?

Think Critically

5. Energy is needed to make matter move. Explain how you use energy to ride a bike uphill. What force allows you to coast downhill without peddling?

Points to Consider

Figure 1.7 describes several careers in physical science. Other careers in physical science include research scientist and engineer.

- What do you think research scientists do?
- How do you think the work of engineers differs from that of research scientists?

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1.3 References

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