Name _____ Class _____ Date _____

CHAPTER 1 Introduction to Science

SECTION 2

The Way Science Works

KEY IDEAS

As you read this section, keep these questions in mind:

- How can you use critical thinking to solve problems?
- What are scientific methods?
- What is the SI system of units?

What Skills Are Important in Science?

When you think about science skills, you might think of mixing chemicals or pouring liquid into a test tube. These skills may be useful in a lab, but other skills are more important in science. Important science skills include identifying problems, planning experiments, recording observations, and correctly reporting data. The most important science skill, though, is learning to think creatively and critically.

READING TOOLBOX

Summarize After you read this section, create a Spider Map for scientific methods. Label the center "Scientific methods," and create a branch for each step.

SOLVING PROBLEMS WITH CRITICAL THINKING

Imagine that you and a friend want to buy some popcorn at a movie. You are trying to decide whether to share one large container or buy two small containers. The pictures below show the size and price of each container.

Logical decision-making is important in scientific processes and in everyday life.

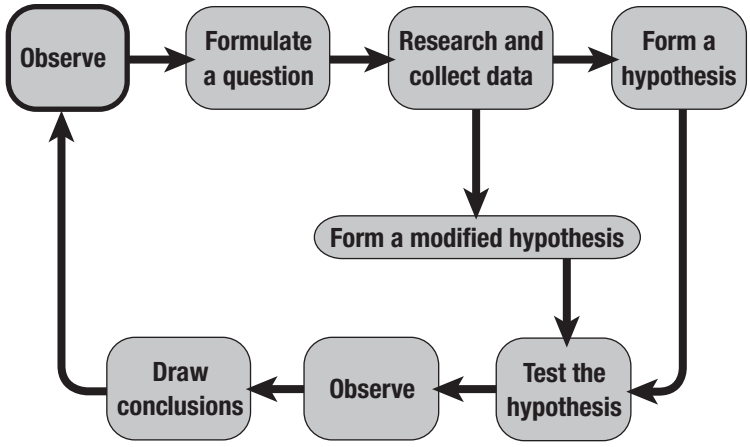
Math Skills

1. Calculate How much money would you save by buying four small containers instead of two large containers? Show your work.

Which size popcorn should you buy in order to get the most popcorn for your money? If you try to solve the problem by asking more questions, making observations, and using logic, you are using **critical thinking**. For example, notice that two small containers cost less than one large container. However, two small containers hold the same amount of popcorn as one large container. Therefore, it is a better deal to buy two small containers.

What Are Scientific Methods?

Recall that science is a process used to answer questions about the natural world. **Scientific methods** are general processes that scientists use to help organize their thinking about the questions they want to answer. The flow chart below shows some of the steps that make up scientific methods. Note that the exact steps can vary.



LOOKING CLOSER

2. Identify When may a scientist change a hypothesis?

_____

_____

_____

Many scientific investigations begin with observations. For example, you may notice that when you open a door, you hear a squeak. You may ask the question, "Why does this door squeak?" Then, you may form a *hypothesis*, or a possible answer that you can test. For example, you may think that the doorknob is causing the squeak.

Every investigation has factors, or **variables**, that can affect the outcome. For example, variables that could make the door squeak include the doorknob and how fast you open the door. ☑

READING CHECK

3. Define What is a variable?

_____

_____

_____

In many cases, scientists test hypotheses by doing controlled experiments. In a *controlled experiment*, only one variable changes at a time. The other variables are kept constant. In this way, scientists can determine how each variable affects the result of the experiment. If many variables changed at a time, it would be hard to determine the effects of only one of them.

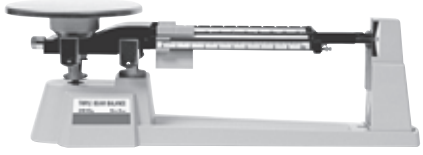
Some scientists test hypotheses without doing experiments. Instead, they collect data by measuring and observing the natural world. Then, they use the data to test their hypotheses.

SHOWING THAT A HYPOTHESIS IS FALSE

If you removed the doorknob and the door still squeaked, your experiment would not be a failure. Experiments that show a hypothesis is false may be just as helpful as experiments that support a hypothesis. Either way, the outcome of the experiment can lead to new hypotheses. For example, you might hypothesize that oiling the hinges would stop the squeak.

Why Do Scientists Use Tools?

Scientists have developed tools to make observations that they cannot make with only their senses. Modern science depends upon the use of tools to make exact measurements. Scientists must know how to use these tools, what the limits of the tools are, and how to interpret data from them. Some common tools are shown in the chart below.

Tool	Measurement
Stopwatch 	time
Meter Stick 	length
Triple-Beam Balance 	mass
Graduated Cylinder 	volume

Critical Thinking

4. Apply Concepts A scientist carries out an experiment. The results do not support the scientist's hypothesis. How can thinking critically be helpful to the scientist?

Talk About It

Discuss In a small group, talk about different tools that you use every day. How does each tool help you in your life?

LOOKING CLOSER

5. Identify A student needs to measure the volume of a liquid. What tool could the student use?

What Units of Measurement Do Scientists Use?

Scientists from all around the world work together and share data. However, different units of measurement are commonly used in different countries. For example, people in the United States measure car trips in miles. However, people in most other countries use kilometers. To avoid confusion, scientists use standard units of measurement. These standard units together form the *International System of Units*, or *SI*. ☑

READING CHECK

6. Explain Why do scientists use SI units?

_____

_____

SI is based on the metric system. Common SI base units are listed in the table below. The base units can be combined to describe area, volume, pressure, weight, force, speed, and other familiar quantities.

Common SI Base Units		
Quantity	**Unit**	**Abbreviation**
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K

In your science class, you will probably measure time, length, volume, and mass. **Length** is the distance between two points, measured in a straight line. **Volume** is a measure of the size of an object or fluid in three-dimensional space. **Mass** is a measure of the amount of matter in an object.

You may hear people say they are "weighing" objects with a balance, but weight is not the same as mass. Mass is the amount of matter in an object. **Weight** is the force with which Earth's gravity pulls on that amount of matter.

Critical Thinking

7. Infer A student uses a triple-beam balance to measure an object. What SI base unit could the student use to describe the measurement?

_____

USING PREFIXES IN SI

Scientists must have a way to measure objects at very different scales. For example, a biologist may want to measure the length of a bird's egg. An Earth scientist may want to measure the length of a river. The egg may be 5/100 m, or 0.05 m, long. The river may be 800,000 m long. The SI system uses prefixes so scientists do not have to write a lot of decimal places and zeros. The table at the top of the next page gives some common SI prefixes.

SI Prefixes			
Prefix	**Symbol**	**Meaning**	**Multiple of Base Unit**
giga-	G	billion	1,000,000,000
mega-	M	million	1,000,000
kilo-	k	thousand	1,000
centi-	c	hundredth	0.01
milli-	m	thousandth	0.001
micro-	μ	millionth	0.000001
nano-	n	billionth	0.000000001

Using SI prefixes, the length of the bird's egg is 5 cm (1 *centi*meter equals 0.01 m). The length of the river is 800 km (1 *kilo*meter equals 1,000 m).

It is easy to *convert*, or change, SI units to smaller or larger units. To convert a large unit to a small unit, multiply by the ratio of the small unit to the large unit. For example, if a person's height is 1.85 m, he is 185 cm tall.

$$1.85 \text{ m} \times \frac{100 \text{ cm}}{1 \text{ m}} = 185 \text{ cm}$$

To convert a small unit to a large unit, multiply by the ratio of the large unit to the small unit. For example, if a book has a mass of 1,500 g, its mass is 1.5 kg.

$$1{,}500 \text{ g} \times \frac{1 \text{ kg}}{1{,}000 \text{ g}} = 1.5 \text{ kg}$$

How Do Scientists Draw Conclusions?

After scientists collect data, they use the data to draw conclusions about the hypothesis they were testing. To keep from making false conclusions, they must carefully search for bias. *Bias* causes people to make judgments that may not be based on evidence. Scientists must also guard against *conflict of interest*. This can occur when groups that pay for experiments want to see specific conclusions.

Scientists who work together may have similar biases. Therefore, it is important for scientists to share their work with scientists they do not work with. The other scientists may be better able to identify biases or errors. ☑

LOOKING CLOSER

8. Identify How many meters are in one gigameter?

_____

Math Skills

9. Calculate The height of a building is 31.0 m. How tall is the building in kilometers? Show your work.

READING CHECK

10. Explain What is one reason that scientists should share their work?

_____

_____

Name _____ Class _____ Date _____

Section 2 Review

SECTION VOCABULARY

critical thinking the ability and willingness to assess claims critically and to make judgments on the basis of objective and supported reasons

length a measure of the straight-line distance between two points

mass a measure of the amount of matter in an object; a fundamental property of an object that is not affected by the forces that act on the object, such as the gravitational force

scientific methods a series of steps followed to solve problems, including collecting data, formulating a hypothesis, testing the hypothesis, and stating conclusions

variable a factor that changes in an experiment in order to test a hypothesis

volume a measure of the size of a body or region in three-dimensional space

weight a measure of the gravitational force exerted on an object; its value can change with the location of the object in the universe

1. **Compare** How is mass different from weight?

_____

_____

_____

2. **Apply Concepts** A student plans an experiment to find out if house plants will grow faster when they are watered more. Describe two variables that the student should keep constant.

_____

_____

3. **Calculate** The width of a soccer goal is 7 m. How wide is the goal in centimeters? Show your work.

4. **Calculate** The mass of an object is 100 mg. What is the object's mass in kg? Show your work.

5. **Infer** A student needs to calculate the density of some liquid. The student knows that density is equal to mass divided by volume. Name two tools the student could use to measure the liquid in order to calculate its density. Explain what the student should measure with each tool.

_____

_____