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"Extensive knowledge and modern science must be acquired. The educational process we see today is in an ongoing and escalating challenge which requires hard work.
We succeeded in entering the third millennium, while we are more confident in ourselves."

H.H. Sheikh Khalifa Bin Zayed Al Nahyan
President of the United Arab Emirates



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Technology and Design



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Be a Scientist

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Nature of Science & Technology

CHAPTER 1

Building a Better Scientist



THE BIG IDEA How do scientists perform scientific investigations?

Chapter Preview Have students read the essential questions, look at the vocabulary words and pictures, and predict what the chapter will be about.

Vocabulary

- Have a volunteer read the **vocabulary** words aloud to the class. Ask students to find one or two words in the chapter. Add these words and their definitions to a class Word Wall.
- Encourage students to use the glossary in the student edition's reference section.

Follow the **Instructional Plan** at right after assessing students' prior knowledge of chapter content.

CHAPTER 1

Building a Better Scientist



How do scientists perform scientific investigations?

Answers will vary.

Vocabulary



observation using one or more of your senses to identify or learn about something



hypothesis a prediction or an answer to a question that can be tested



controlled experiment a scientific investigation that involves changing one factor and observing its effects on another factor while keeping all other factors constant



data different types of information that can be collected to answer a scientific question



technology the practical use of science



precision a description of how close repeated measurements are to each other

2
CHAPTER 1

Differentiated Instruction

Instructional Plan

Chapter Concept Scientists use the scientific method and a variety of tools to learn and communicate about the natural world.

EXTRA SUPPORT **Lesson 1** introduces students to the nature of science and what a scientist does.

ON LEVEL **Lesson 2** describes the steps scientists use to conduct investigations and solve problems.

ENRICHMENT **Lesson 3** students learn about the tools scientists use to collect, analyze, and communicate data.

Before reading this chapter, write down what you already know in the first column. In the second column, write down what you want to learn. After you have completed this chapter, write down what you learned in the third column.

Building a Better Scientist		
What We Know	What We Want to Know	What We Learned
Scientists study science.	What is science all about?	
Scientists conduct investigations.	What steps do scientists follow to conduct investigations?	
Scientists look at objects, measure, and weigh them.	What tools do scientists use?	

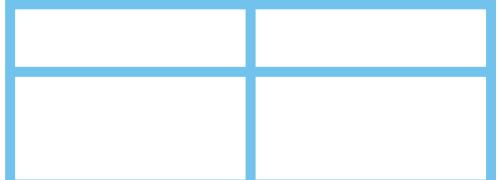
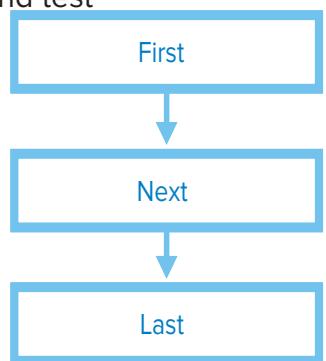
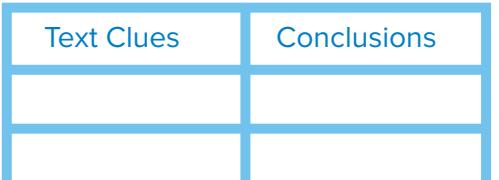
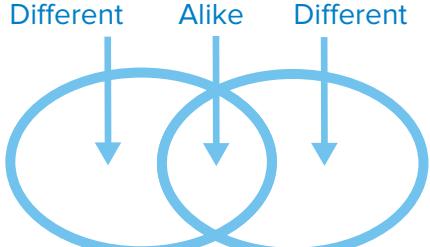
► Assess Prior Knowledge

Before reading the chapter, create a **KWL** chart with students. Read the Big Idea question, and then ask:

- What do scientists do?
- How do scientists find out about things?
- How do scientists collect information?

Answers shown represent sample student responses.

CHAPTER 1 Planner

Lesson	OBJECTIVES AND READING SKILLS	VOCABULARY
1 Becoming a Scientist PERIODS : 3	<ul style="list-style-type: none"> Describe what scientific inferences, observations, experiments, theories, and laws are and how they are used in science. Describe how science and technology are related. <p>Reading Skill Classify</p> 	science observation inference controlled experiment model independent variable dependent variable scientific theory scientific law technology
2 The Scientific Method PERIODS : 3	<ul style="list-style-type: none"> Identify the steps in the scientific method. Learn how scientists formulate and test a hypothesis. <p>Reading Skill Sequence</p> 	scientific method hypothesis data
3 Tools of the Scientist PERIODS : 3	<ul style="list-style-type: none"> Understand how to collect, organize, and communicate data appropriately. Explain how to stay safe when conducting a scientific investigation. <p>Reading Skill Draw Conclusions</p> 	quantitative data qualitative data description explanation precision consistency mean median range
4 Making Measurements PERIODS : 3	<ul style="list-style-type: none"> Describe some properties of matter that can be observed, described, and measured. Measure properties of matter using tools, such as gram spring scales, metric rulers, metric balances, and Celsius thermometers. <p>Reading Skill Compare and Contrast</p> 	observation description measurement metric balance spring scale graduated cylinder

PACING

Assumes a period is a 35- to 45-minute

Activity Planner

EXPLORE Activities

Explore PACING: 30 minutes



Objective Understand that one observation can lead to multiple explanations.

Skills predict, make a model, communicate, infer

Materials cardboard mailing tubes, scissors, rope

 Create the model ahead of time.

Explore PACING: 20 minutes



Objective Understand how a scientist gathers information for an investigation.

Skills observe, predict, interpret data

Materials box with mystery object, classroom objects, balance with set of masses

 Select and place the mystery object ahead of time.

Explore PACING: 30 minutes



Objective Understand scale and scale drawings

Skills measure, use numbers, infer, communicate

Materials 1-cm graph paper, meterstick

 Review how to measure accurately.

Explore PACING: 20 minutes



Objective Classify objects by their measurable properties.

Skills observe, classify, interpret data, infer

Materials various objects, metric ruler, 4 index cards per group, marker

 Locate examples of dichotomous keys to show students, as well as types of items detailed in the Explore activity.

QUICK LAB Activities

Quick Lab PACING: 15 minutes



Objective Complete a simple experiment to demonstrate scientific thinking.

Skills observe, infer

Materials distilled water, vegetable oil, food coloring, test tube, test tube stand, dropper

 Students should wear smocks.

Quick Lab PACING: 15 minutes



Objective Complete a simple experiment to demonstrate how to form and test a hypothesis.

Skills observe, form a hypothesis, interpret data

Materials large pot partially filled with water, 1 can of diet soda, 1 can of regular soda

 Students should wear smocks.

Quick Lab PACING: 30 minutes



Objective Practice precision and consistency in measuring distance and time.

Skills measure, infer

Materials 1 stopwatch and 1 metric ruler or measuring tape per group

 Review how to measure accurately.

Quick Lab PACING: 15 minutes



Objective Understand the difference between mass and weight.

Skills predict, measure

Materials balance with weights, spring scale, textbook, notebook

 Notebook should be spiral bound if using a hanging spring scale.



Academic Language

When learning, students need help in building their understanding of the academic language used in daily instruction and science activities. The following strategies will help to increase students' language proficiency and comprehension of content and instructional words.

Strategies to Reinforce Academic Language

- Use **Context** Academic language should be explained in the context of the task. Use gestures, expressions, and visuals to support meaning.
- Use **Visuals** Use charts, transparencies, and graphic organizers to explain key labels to help students understand classroom language.
- **Model** Use academic language as you demonstrate the task to help students understand instruction.

Academic Language Vocabulary Chart

The following chart shows chapter vocabulary and inquiry skills. **Vocabulary** words help students comprehend the main ideas. **Inquiry Skills** help students develop questions and perform investigations.

Vocabulary	Inquiry Skills
science observation inference controlled experiment model independent variable dependent variable scientific theory scientific law technology scientific method hypothesis data quantitative data qualitative data description explanation precision consistency mean median	range observation description measurement metric balance spring scale graduated cylinder observe predict interpret data make a model communicate infer form a hypothesis measure use numbers classify

Vocabulary Routine

Use the routine below to discuss the meaning of each word on the vocabulary chart. Use gestures and visuals to model all words.

Define An observation is using one or more of your senses to identify or learn about something.

Example You can make an observation about a flower's color.

Ask What observation can you make about the weather today?

Students may respond to questions according to proficiency level with gestures, one-word answers, or phrases.

Vocabulary Activities

Help students to understand how scientists make observations.

BEGINNING List six animals on the board, and supply a visual of each. Assign one animal per small group or student pair. Have the group list observations about that animal. Ask groups to share their observations with the class.

INTERMEDIATE Have student pairs each find two examples of animals in their student books, and ask the pairs to list observations about the animals. Encourage pairs to share their observations with the class. Provide prompts such as the following as needed: My observation about this animal is _____.

ADVANCED Ask students to each name an animal. Make a list on the board. As they name the animal, ask them to describe observations they could make about it. Encourage students to compare and contrast observations of differing animals.

Stop Here to

Plan Your Lesson

Lesson 1 Becoming a Scientist

Essential Question

What do scientists do?

Reading Skill **Classify**



You will need a classify graphic organizer.

- Describe what scientific inferences, observations, experiments, theories, and laws are and how they are used in science.
- Describe how science and technology are related.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Develop Vocabulary

Discuss the Main Idea

3 Close

Think, Talk, and Write

Teacher Notes

Lesson 1 Becoming a Scientist

Objectives

- Describe what scientific inferences, observations, experiments, theories, and laws are and how they are used in science.
- Describe how science and technology are related.

1 Introduce

► Assess Prior Knowledge

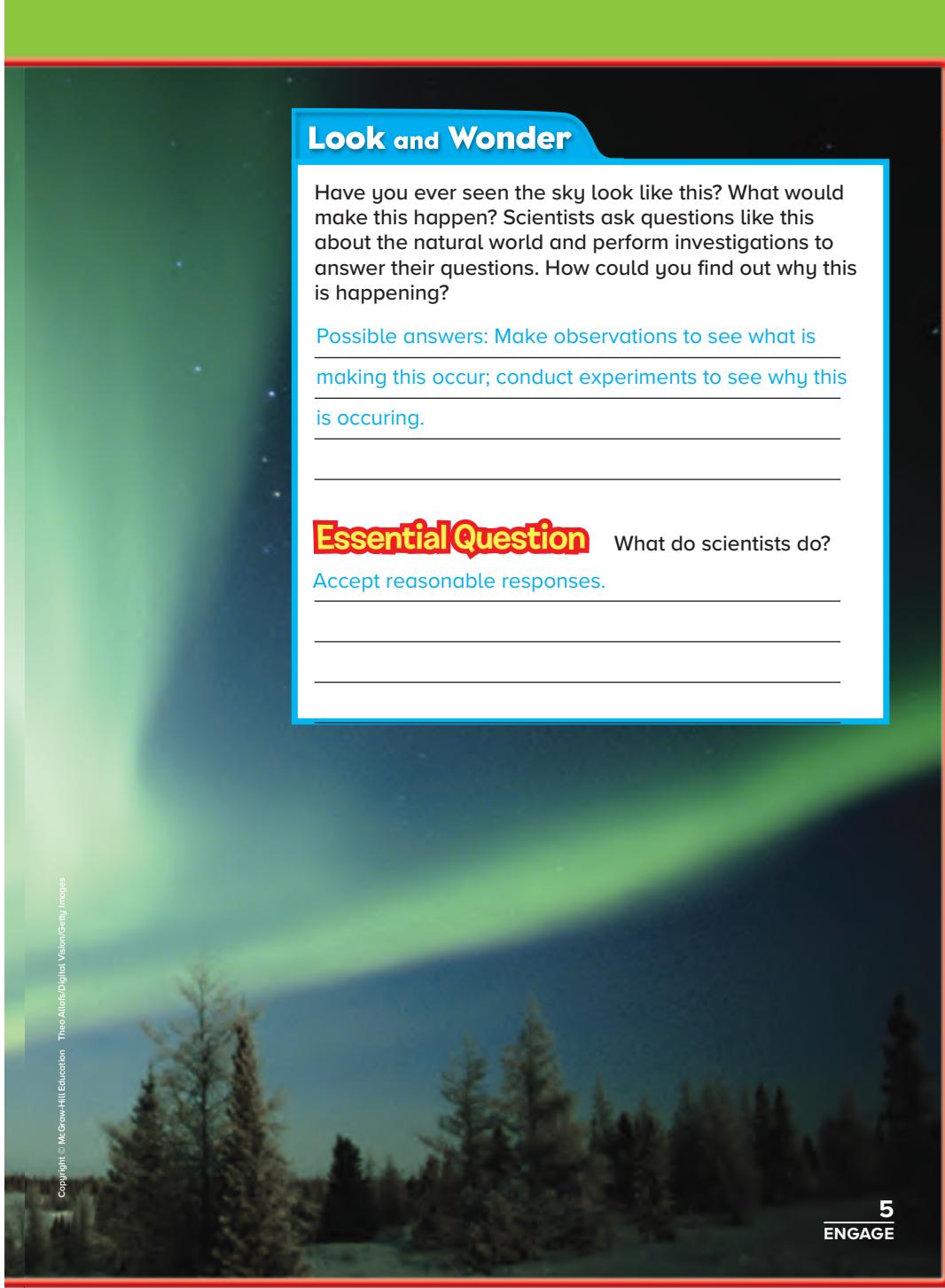
Have students discuss the purpose of science and some of the ways scientists investigate nature. List student responses on the board. Possible answer:

They observe what is happening, conduct experiments, summarize their observations, and test their ideas. Ask:

- Why is science important? Possible answer: It helps us to answer questions about nature and explain natural occurrences.
- What are some ways a scientist works to answer questions about nature? Possible answers: They notice things in nature. They watch for patterns and conduct experiments to see what conditions lead to the event. They summarize their findings.

Lesson 1

Becoming a Scientist



Look and Wonder

Have you ever seen the sky look like this? What would make this happen? Scientists ask questions like this about the natural world and perform investigations to answer their questions. How could you find out why this is happening?

Possible answers: Make observations to see what is making this occur; conduct experiments to see why this is occurring.

Essential Question What do scientists do?
Accept reasonable responses.

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Look and Wonder

Invite students to share their responses to the Look and Wonder statement and questions:

■ **How could you find out why this is happening?**

Write ideas on the board and note any misconceptions that students may have. Address these misconceptions as you teach the lesson.

Essential Question

Have children read the Essential Question. Tell them to think about it as they read through the lesson. Advise children that they will return to this question at the end of the lesson.

Explore



individuals



30 minutes

Plan Ahead Create a model using the cardboard tube and ropes to demonstrate steps 1 and 2. Have enough materials for each student to create their own model.

Purpose This activity helps students understand how one observation can lead to multiple explanations.

Structured Inquiry

Make a Prediction Possible prediction: The 3 shorter ropes are tied to the longer rope. The knot is hidden inside the tube.

- 1 **Have** Have several students take turns pulling on the strings. Have the class describe what they observe.
- 2 **Predict** Ask the class for predictions. Write their responses on the board. Make sure they understand the importance of keeping an open mind from the outset of the activity.
- 3 **Make a Model** Remind students that the two ropes should be cut to different lengths.

Explore

Why do scientists interpret information differently?

Purpose

Scientists use observations that they gather to form explanations. In this activity, you will see if more than one explanation can apply to the same observation.

Materials



- cardboard mailing tube
- scissors
- rope



Step 3

Procedure

- 1 You will be shown a cardboard tube with four ropes coming out of it, one longer than the others. Your teacher will show you that when any of the three short ropes—A, C, or D—are pulled, the longer rope, B, gets shorter. Pulling on rope B returns the other ropes to their original lengths.
- 2 **Predict** Make a prediction as to how your teacher's model works.
Accept all reasonable responses.
- 3 **Make a Model** Sketch a model of the tube with ropes based on your prediction. Using a cardboard tube and two lengths of rope, build a model according to your design.
- 4 Test your model by pulling on each of the ropes. If it does not perform as planned, modify your prediction and model to make it work like your teacher's model.

6
EXPLORE

Draw Conclusions

5 Communicate Is your model the same as your classmates' model? Can more than one model give the same result? Explain.

Answers will vary.

6 Infer Without opening the tubes, can you tell which models are exactly like your teacher's model?

Answers will vary.

Explore More

Make a model of our solar system. Is there more than one way that you could construct your model? How is your model different from real life? What are the strengths and weaknesses of your model?

Possible answers: Answers will vary depending on students' model. Students should conclude that there is more than one way to model the solar system.

Teacher Notes

5 Communicate Have several students present their models to the class.

6 Infer See if the class can identify if the model is the same as the teacher model and explain any differences.

Guided Inquiry

Explore More

There are many different ways in which the solar system model can be constructed. The model would be smaller than actual size. It should be to scale which might be difficult to accurately represent the distance. Strengths of the model include the fact that an accurate model demonstrates the relative position and orbit of the planets. Discuss with the class what a good and accurate model would include. Discuss the size and distance of the planets in the model.

Open Inquiry

Have students determine some observations they might make based on the model of the solar system.

What possible explanations are there for your observations?

2 Teach

Read and Respond

Main Idea Have students look at the pictures and the captions in this lesson and share what they think a scientist is or does.

Vocabulary Have students read aloud the vocabulary terms and note any with which they are not familiar. Ask them to share definitions of these terms.

Reading Skill Classify

Graphic Organizer Have students fill in a Classify graphic organizer as they read through the lesson. They can use the Reading Check questions to identify each classification.

What is science?

► Discuss the Main Idea

Ask students to think about what it means to be a scientist. Ask:

- **Who is a scientist?** A scientist is anyone who is trying to learn about the natural world.
- **What are some things a scientist does?** They make observations that lead to questions about the natural world.
- **What are some observations in your classroom that can lead to scientific inquiry?** Possible answers: Chalk leaves marks on the chalkboard; it feels warmer in the sunlight coming through the window.

► Develop Vocabulary

science *Word Origin* The word science originates from the Latin word *scientia* which means “knowledge.” This knowledge is attained through study and practice; it encompasses truths and laws that are tested by scientific method.

observation *Word Origin* Explain that the word *observation* comes from the Latin word *observationem* which means “a watching over.” So, an observation requires human senses to learn about the natural world.

Read and Respond

What is science?

When you think about a scientist, do you think of a person in a laboratory surrounded by bubbling test tubes? It might surprise you that anyone who tries to learn about the natural world is a scientist. The scientist in the photo below is a biologist who does most of his research under water. **Science** is a way of learning about the natural world. Scientists want to know why, how, or when something occurred. Scientists ask questions about the natural world and try to answer those questions using evidence that they gather. This process is called **scientific inquiry**.

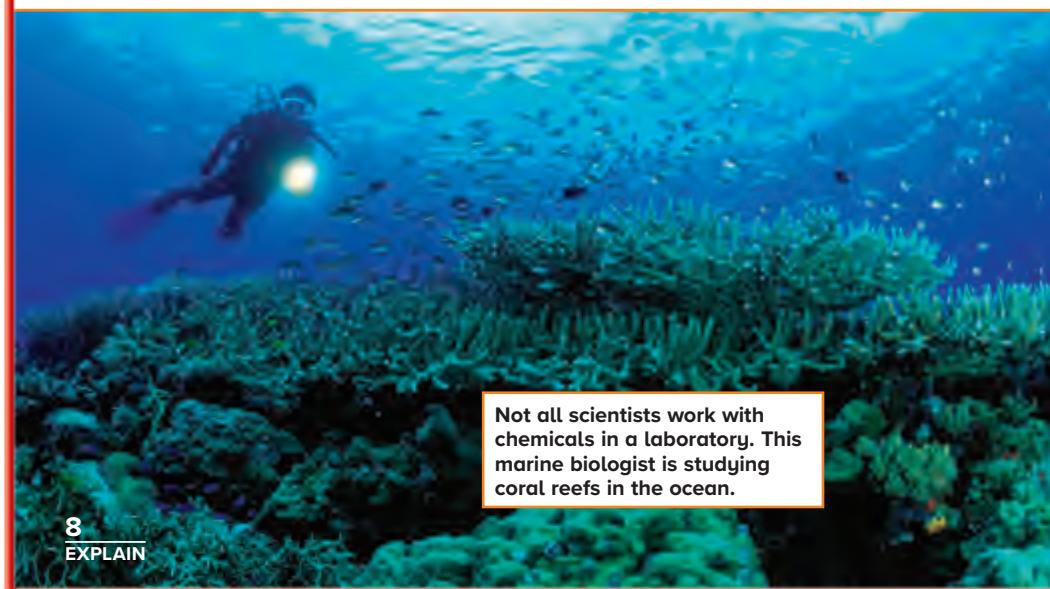
Scientific inquiry often starts with an observation. An **observation** is using one or more of your senses to identify or learn about something. Observations often lead to questions about the natural world. For example, you might observe that the days get shorter in the winter. This would lead you to ask why. You would then do research and collect many different types of



Draw a circle around the term that describes the process scientists use to gather evidence.

Quick Lab

To learn more about the inquiry process, complete the Quick Lab in the activity workbook.



Not all scientists work with chemicals in a laboratory. This marine biologist is studying coral reefs in the ocean.

8 EXPLAIN

Science Background

Scientific Research Scientists usually use the research of others as the building blocks of their own research. They use the work of others and others use their work. It is for this reason that scientists must be very detail-oriented in recording all of their observations and methods. They must look at their research objectively with no predetermined expectation of outcome. Research is reviewed by other scientists to eliminate bias. For science to progress, scientists stand on the work of good scientific research and build on it for others.

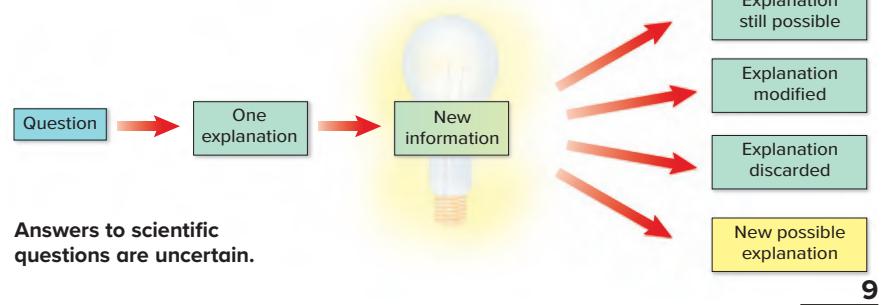
information to help you answer your question.

If learning about your world begins with asking questions and making observations, can science provide answers to these questions? Science can answer a question only with the information available at the time.

Sometimes, the answers to scientific questions are inferred. An **inference** is a conclusion formed from available information or evidence. You might infer, based on the information you gather, that days are shorter in winter because of the tilt of Earth's axis.

Any answer to a scientific question is uncertain because people will never know everything about the world around them. With new knowledge, they might realize that some of the old explanations no longer fit the new information. The figure below shows how scientists modify their explanations as new information becomes available. Some observations might force scientists to think of new explanations. Science can only provide possible explanations.

Modifying Explanations



9
EXPLAIN

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students explain in their own words the difference between an observation and an inference. Ask them to write their explanation in their science learning logs.

ENRICHMENT Take the class outside to the recess area. Have them each observe something in nature. Ask them to write an inference based on their observation in their science learning logs. Return to the classroom and have students share their observations and inferences with the class.

Quick Check

1. Explain the difference between an observation and an inference.

An observation is learning

about something by using your

senses. An inference involves

drawing a conclusion formed from

information.

Read a Diagram

What do scientists do when new information is discovered about an existing explanation?

Clue: Look at the boxes.

They determine whether the existing

explanation is still possible, or it

needs to be modified or discarded, or

there is a new possible explanation.

ENGAGE EXPLORE EXPLAIN EVALUATE EXTEND

Quick Lab

small groups

15 minutes

Thinking Like a Scientist

See the Quick Labs in the Activity Lab Manual.

Objective Complete a simple experiment to demonstrate scientific thinking.

Materials distilled water, vegetable oil, food coloring, test tube, test tube stand, dropper

- 3 Tell students to be patient and watch for changes that occur in the liquids throughout the 5 minutes.
- 4 **Observe** Students should record observations throughout the 5 minutes. The liquids begin to separate with the oil moving to the top of the solution.
- 5 **Infer** Answers will vary. The molecules in the oil and water are unable to combine. The oil is “lighter” and floats to the top of the solution.

► Develop Vocabulary

inference **Word Origin** The word *inference* originated from the word *infer* which comes from the Latin word *inferre* meaning “bring into, cause.” Provide an example by turning off the light, and explaining that an inference would be that the darkness is the absence of light.

What is a scientific investigation?

► Discuss the Main Idea

Discuss different types of investigations used for answering a scientific question. Write the types on the board. Ask students to think of different scientific questions that would require the different types of studies mentioned. Ask:

■ **How does a scientist determine the best type of investigation to use to answer the question?**

Possible answer: A scientist should evaluate the most efficient way to answer the question of the investigation. If it involves seeing the effect of a changed factor on another factor, a controlled experiment is best. If data is needed that cannot be gathered in a laboratory, a field study should be used. For situations that are difficult to understand, a model could be used to try to interpret the data.

■ **Models are also used in professions other than science. How does an architect use models?**

Possible answer: They create scale drawings of buildings as a plan for the construction of the building. A scale drawing is a model.

► Develop Vocabulary

controlled experiment *Word Origin* Explain that the word *experiment* comes from the Latin word *experimentum* which means “a trial, test.” So, a controlled experiment involves a trial where one or more factors are controlled by the scientist who does the investigation.

model *Scientific vs. Common Use* The word *model* often calls to mind fashion models or a smaller version of a car or boat that you assemble as a hobby. However, in science, a model is something that helps us better understand a scientific concept. It can be a scaled object or drawing, a graph, a computer generated figure, or even a math formula.

Scientific Investigations



What is a scientific investigation?

Different types of scientific questions call for different types of investigations. A *scientific investigation* is a way of answering a scientific question.

Questions that ask about the effects of one factor or another are often tested by performing an experiment. A **controlled experiment** is a scientific investigation that involves changing one factor and observing its effects on another factor while keeping all other factors constant.

Sometimes scientists have questions that cannot be answered with a laboratory experiment. Scientists often attempt to answer these types of questions by observing the natural world. A *field study* is an investigation in which scientists make observations and collect information outside of the laboratory.

Sometimes making a model is an effective way to answer a scientific question. A **model** is a representation of an object or an event that is used as a tool for understanding the natural world. Models are often made when the investigation involves elements that are difficult to observe or understand. Models are useful, but they are not exact and often lack detail.

Scientists run experiments, build models, and conduct field studies to gather information to help answer their questions.

10
EXPLAIN

Classroom Equity

Visual Learners Have students work in groups of 2 or 3. Have several samples of models available. These could be pictures, scale drawings, or physical models of objects like a water molecule, our solar system, a road map, a drawing of the water cycle, etc. Give each group a model. Have the groups discuss how the model helps them to understand the concept better. Have one person from each group present their group's model and a summary of their group's discussion to the class.

Controlled Experiment



This student is adding different types of gas to each of the experimental test tubes. He will not add any gas to the control test tube.

Read a Photo

What is the independent variable in this experiment?

Clue: Which factor was changed?

The independent variable is the different types of gases being introduced to the test tubes.

Variables

A controlled experiment allows scientists to determine a cause-and-effect relationship among the factors that are changed in the experiment. These factors are called *variables*. The variable that is changed in a controlled experiment is called the **independent variable**, or manipulated variable. The variable that is being measured is called the **dependent variable**. The dependent variable might change as a result of the change in the independent variable. Scientists try to keep all other variables constant—or unchanged.

A controlled experiment must have two groups—a control group and an experimental group. The independent variable is changed in the experimental group and unchanged in the control group. Both groups include the same factors under the same conditions.

Look at the student's experiment in the above photo. He is performing a controlled experiment. He collected different types of gas in a balloon. He is adding the gases to separate test tubes to see if the pH of the cabbage juice in the test tubes changes. He will not add any gas to the control test tube. A control group allows scientists to determine whether changes observed during an experiment are a result of the changes in the dependent variable or changes in some other variable.

Quick Check

2. Which is the independent variable in an experiment investigating the effect of weight on the speed of vehicles?

The weight is the independent variable.

11
EXPLAIN

LA Support

Explain/Discuss Clarify the difference between the words *dependent* and *independent* as they relate to variables. Write the words and their meanings on the board. Have students say the word with you, and guide them in reading the definition. Confirm that students understand that the value or change in the dependent variable “depends” on the independent variable.

BEGINNING Students can explain in their own words the difference between dependent and independent variables.

INTERMEDIATE Students can identify the dependent and independent variables for a given experiment. For example, what happens when you place various types of metal in acid?

ADVANCED Students can design experiments and identify their dependent and independent variables.

▶ Use the Visuals

Refer students to the photo. Make sure students understand that the independent variable is the variable that is being controlled or manipulated and the dependent variable is the variable which is being watched for changes. Ask:

- **What does the visual represent?** a controlled experiment
- **What question is the experiment trying to answer?** What effects do various types of gases have on cabbage juice?
- **What is the same in each test tube?** cabbage juice
- **What is different in each test tube?** the type of gas that is being introduced
- **What is a control group?** a group in which no change is introduced
- **Where is the control group?** in the test tube labeled “control”
- **What gas will be added to the control group?** No gas is added to the control group.

▶ Develop Vocabulary

independent variable *Word Origin* Variable comes from the Latin word *variabilis* which means “changeable.” Variables in a scientific investigation are parts that can be changed to influence the investigation. For independent, the prefix *in* means “not” or “not dependent.”

dependent variable The word *dependent* indicates that the variable relies on something else.

How do scientists communicate?

► Discuss the Main Idea

Have students scan the page. Ask them to look for ways in which scientists can communicate. Ask:

- **Why is it important for scientists to communicate their findings to others?** It allows other scientists to know their findings and build on them or use them to answer other questions.
- **What types of things are important for the scientist to communicate?** The results of the investigation and the methods that were used should both be communicated to others.
- **What are some ways that scientists communicate with others?** publishing in scientific journals, presenting their research at conferences
- **What might happen if scientists did not communicate their findings?** Other scientists would not know about the findings, and not be able to replicate the work or build on it.

► Use the Visuals

Have students look at the photo of the scientist and the photo of the scientific journals on page. Discuss some ways in which scientists communicate their work with others. Ask:

- **What ways for scientists to communicate are shown in the photo?** presenting at science conferences and publishing in scientific journals
- **What are some other ways that a scientist can communicate their work?** Possible answers: they can post information on the Internet, teach at a college or university

How do scientists communicate?

After an investigation has been completed, other scientists will often perform the same investigation to make sure the conclusions were correct. Sometimes other scientists will revise the investigation or use the results to perform a related investigation. Scientific investigations are often revised and repeated many times.

It is important for scientists to communicate the results of the investigation as well as the methods by which the investigation was done. This way, the work can be repeated by others. Scientists often publish reports in journals, books, and on the Internet to show their work. Scientists also might attend meetings where they give presentations about their work.

Scientists evaluate the results of their investigations and the investigations of others critically. They ask questions, such as: "What data did the scientists use to support their conclusions?" "Are there other explanations?" "Have the results been repeated?" "Were the conclusions based on someone's opinion?"

Scientific explanations must be based on the information gathered in the investigation, not on opinion. Scientific explanations are accepted only after they have been shown to be reliable and lead to accurate predictions about future investigations. Many repeated experiments must yield consistent results before those results are accepted.



Scientific conferences and journals are two ways that scientists communicate their research.



12
EXPLAIN

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students explain in their own words what scientists should communicate about their research. They should also include things that should be avoided in their description.

ENRICHMENT Have students read and evaluate a scientific article from newspapers, magazines, or the Internet. They should answer the following questions as part of their evaluation of the article:

- What data did the scientist use to support their conclusions?
- Are there other explanations?
- Have the results been repeated?
- Were the conclusions based on someone's opinion?

Scientific Theories

After a scientific explanation has been accepted by the scientific community, a scientific theory is formed. A **scientific theory** is an attempt to explain a pattern observed repeatedly in the natural world. Theories are not guesses or someone's opinions, nor are theories vague ideas.

Theories in science are supported by observations and results from many investigations. Theories are the best explanations that have been found so far. However, theories may change as new information becomes available. Albert Einstein discovered the theory of relativity. This theory has held true for many years. A large amount of evidence supports it.

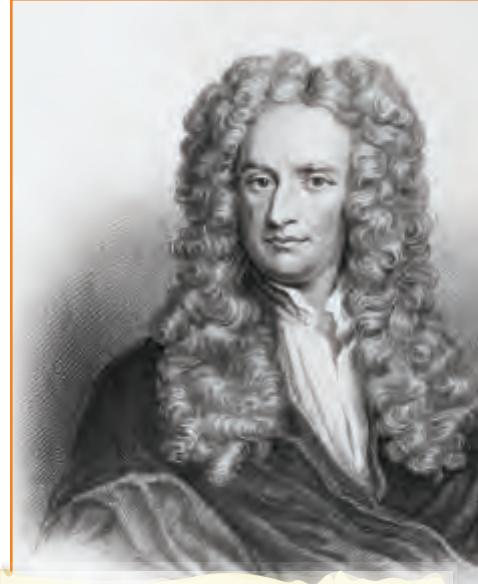
Scientific Laws

A rule that describes a pattern in nature is called a **scientific law**. For an observation to be a scientific law, it must be observed repeatedly. Then, the law stands until someone makes observations that do not follow the law. A law, unlike a theory, does not attempt to explain why something happens. It simply describes a pattern. Sir Newton's laws of motion describe how objects move.

Quick Check

3. All objects exert gravitational force. Is this a scientific theory or a scientific law? Explain.

This is a scientific law. Scientific laws describe a pattern in nature.



Newton's First Law

An object at rest tends to stay at rest, and an object in constant motion tends to stay in motion, unless acted upon by an unbalanced force.

Newton's Second Law

The unbalanced force on an object is equal to the mass of the object multiplied by its acceleration: $F = m \times a$.

Newton's Third Law

All forces occur in pairs, and these two forces are equal in strength and opposite in direction.

Each of Sir Newton's laws describe the motion of an object.

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EXPLAIN

Differentiated Instruction

Leveled Questions

EXTRA SUPPORT When do scientific laws change? when the pattern does not hold true

ENRICHMENT How do we know for certain that a bowling ball would continue to roll forever if there were no other forces acting on it? Explain. Because Newton's first law indicates that the ball would continue to stay in motion unless acted on by other forces such as friction or gravity.

► Discuss the Main Idea

Discuss the differences between scientific theories and scientific laws. Ask:

- **What is a scientific theory?** Theories try to explain a pattern observed repeatedly in the natural world. They are the best explanations that have been found so far for the patterns.
- **What is a scientific law?** It is a rule that describes a pattern found in the natural world.
- **How do scientific theories and scientific laws differ?** A theory attempts to explain why a pattern occurs. Laws describe patterns but do not explain them.
- **Are there exceptions to a scientific law?** no

► Explore the Main Idea

ACTIVITY Have students use the library, magazines, newspapers, or approved Internet sites to research Newton's three laws and their relationship with the motion of a skateboard. They should identify laws of motion with respect to riding a skateboard. They can use activities such as the rider pushing off with one foot, the skateboard moving when pushed, or a rider falling off when the skateboard hits a rock.

► Develop Vocabulary

scientific theory **Word Origin** Explain that the word *scientific* comes from the Latin word *scientificus* which means "pertaining to science." The word *theory* originates from the Greek word *theoria* which means "contemplation, speculation, ... things looked at." Explain that a theory cannot be proved and there may be exceptions to the observed pattern.

scientific law **Scientific vs. Common Use** Students might think of courtrooms and lawyers when they hear the word *law*. However, in science, a law is a rule that describes a pattern in nature.

How is science applied?

► Discuss the Main Idea

Begin a discussion of how science has affected humans and society. Have them read the page. Ask:

- What are some areas in which scientists have developed technology to help humans in addition to what is mentioned here? *Answers will vary.* Some ideas may include medicine, electricity, and computers.
- How was your life affected this morning by technology as you got ready for school? *Answers will vary.* Some ideas may include transportation, television, kitchen appliances, and electricity.

► Use the Visuals

Have students look at the time line on the page.

Ask:

- How did the sources of power help in the evolution of transportation over time? *It began with humans and animals providing the power source and evolved to other sources such as steam, burning fossil fuels, and electricity as technology developed.*
- What was the most significant development in technology of transportation over the years? **Explain.** Possible answer: The wheel is the most significant development in transportation technology; it is used in most forms of transportation. Accept all reasonable responses where students justify their answers.

► Develop Vocabulary

technology *Scientific vs. Common Use* In our society, technology seems to relate to computers or electronics. While these are included, technology encompasses many other fields involving science such as medicine, construction, farming, space travel, etc.

How is science applied?

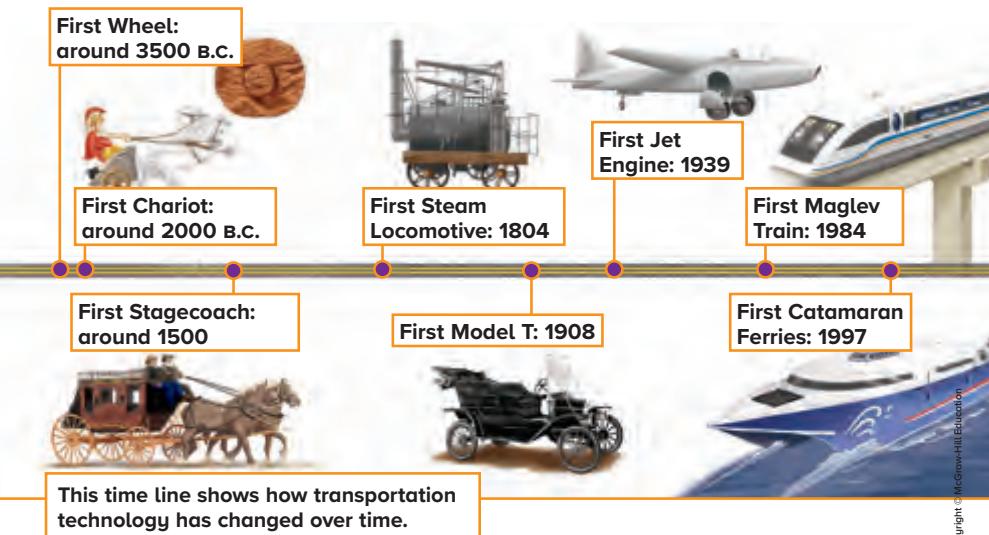
Although learning the answers to scientific questions is important, the answers do not help people unless that information can be applied in some way. **Technology** is the practical use of science, or applied science. Technology is how humans adapt nature to meet their needs and wants. It is the way we use tools, techniques, and instruments to learn more about our world. Science depends on technology.

The history of transportation is a good example of how technology and science go hand-in-hand. Early inventors had to understand scientific concepts like gravity and friction to make vehicles that worked.

As humans' understanding of the principles that affect transportation and manufacturing increased over time, vehicles became faster, more aerodynamic, and less expensive. The time line below shows how transportation has changed over time. As transportation technology progressed, humans' ability to travel increased. Humans are now able to travel faster and over greater distances.

The greater ability to travel also has allowed humans to gain more scientific knowledge. Humans are now able to travel all across the globe and even to outer space to conduct scientific investigations.

Transportation Technology



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EXPLAIN

LA Support

Discuss/Explain Clarify the meaning of the word *technology*. Write the word and its meaning on the board. Have students say the word with you, and guide them in reading the definition aloud. Ask students what the practical use of science is.

BEGINNING Students can identify how science and technology go hand-in-hand in the development of transportation.

INTERMEDIATE Students can identify some of the science that went along with the development of transportation technology.

ADVANCED Students can identify other areas of technology in which science contributes to the continued development.

Communication Technology

Communications is another industry in which technology has not only changed human lives but also increased scientific knowledge. As technology progressed, the ability to communicate increased.

Communication has become faster and more effective. What if scientists still had to use hand-written letters to communicate their scientific findings?

Long ago, if you wanted to communicate with someone across town or across the country, you had to use smoke signals or drums or send letters by pony express. Later, electricity allowed telegraph messages to be sent quickly over long distances. The invention of the telephone in 1876 made it possible to transmit sound over long distances. At about the same time, radio became a way to communicate. The invention of the television allowed images to be sent quickly over long distances.

Today, computer chips, MP3 players, and smart phones allow people to send many different types of information, including text, pictures, videos, and documents, quickly over long distances.

Quick Check

4. How has improved transportation and communication technology changed science?

Possible answers: It makes

communication of research

more readily available for all. It

allows scientists to do more in

shorter periods of time.

Communication Technology



1844: The first telegraph in the United States was sent.



1876: The first telephone call was made.



1920: A radio station begins a schedule of radio programs.



1958: The first computer chip was made.



1927: The first television images were broadcast in England.



mid-1990s: MP3 players became popular.

Today: Smart phones combine many different technologies.

Communication has changed over time.

15
EXPLAIN

Classroom Equity

Arranging desks in a U-shape or a circular design can help encourage students who might ordinarily be reluctant to participate. Before you hold a discussion about technology in communication, consider shifting students' desks into a circular pattern to encourage everyone's participation.

Discuss the Main Idea

Continue the discussion of technology by discussing how science helps to improve technology in the field of communications. Ask:

- How has communication technology affected our lives today? Possible answer: It allows for fast communication over long distances.
- What invention allowed images to be sent quickly over distances? television

Explore the Main Idea

ACTIVITY Have students use the library, magazines, newspapers, or approved Internet sites to research the ongoing development of technology in communications. Have them describe some ways in which communication will continue to be faster and more efficient.

Use the Visuals

Have students look at the photos on the page. Ask:

- In what year was the first telephone call made? 1876
- In what year was the first computer chip made? 1958

What are the branches of science?

► Discuss the Main Idea

Discuss the various branches of science and what part of the natural world each branch studies. Ask:

- What are the major branches of science? **life, Earth, and physical science**
- Which branch of science includes the study of astronomy? **Earth science**
- Which branch of science includes chemistry? **physical science**
- Do these branches of science overlap each other? If so, what is an example? **Possible answer: Yes; chemistry, a physical science, develops various medicines for life sciences to use to treat illness.**

► Use the Visuals

Have students refer to the photos. Ask:

- What is being studied in the life science photo? **plants**
- What might the scientists be studying in the Earth science photo? **Possible answer: geology, the study of rock formations**

Branches of Science



life science



Earth science



physical science

What are the branches of science?

Science is often divided into three branches—life sciences, Earth sciences, and physical sciences. Each branch asks different types of questions and focuses research efforts on different topics.

The study of living things is called life science. Life scientists study plants, animals, where they live, and how they interact.

The study of Earth and space is called Earth science. Earth scientists study rocks, soils, oceans, black holes, clouds, rivers, planets, or the atmosphere. Earth science also includes the study of weather and the climate systems that affect Earth.

Physical science is the study of matter and energy. Matter is anything that takes up space and has mass. The ability to cause change in matter is energy. Living and nonliving things, such as plants, animals, rocks, and the atmosphere, studied by life and Earth scientists are made of matter. Physical science is divided into two fields—chemistry and physics. Chemistry is the study of matter and its interactions. Physics is the study of energy and its ability to change matter.

Quick Check

5. Which branch of science might study how diseases spread in a population?

life science

16
EXPLAIN

Homework Activity

Scientific Research

Have students find a natural occurrence at their home. Have them write an inference regarding the occurring event. Have them spend 15 minutes observing the phenomena and writing observations. They should write a theory explaining the occurrence. They should be prepared to present their research to the class.

Teacher Notes

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 1 Lesson Review

Visual Summary

Complete the lesson summary in your own words.



Science Possible answer: Science is a way of

learning about the natural world.



Scientific Investigations Possible answer: Scientists

learn about the natural world by making models, conducting experiments, and doing field studies.



Technology Possible answer: Technology is the

application of science to meet human needs.

Technology allows us to learn more about the world.

Think, Talk, and Write

1 Vocabulary The application of science is technology.

2 Classify Explain the difference between an independent variable and a dependent variable.

Independent Variable	Dependent Variable
the factor a scientist changes in an controlled experiment	factor being observed for changes in a controlled experiment

3 Critical Thinking Give an example of how you use technology every day. What scientific concepts needed to be understood to develop this technology?

Possible answer: I watch television every day. The study of physics has enabled images to be sent quickly over long distance.

4 Test Prep Scientific theories are

- A** guesses why something happens.
- B** supported by observations and results from many investigations.
- C** scientists' opinions.
- D** rules that describe patterns in nature.

5 Test Prep The variable that is changed in a controlled experiment is called the

- A** independent variable.
- B** dependent variable.
- C** control variable.
- D** experimental variable.

Essential Question What do scientists do?

Possible answer: Scientists try to answer questions about nature through use of the scientific method.

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your thinking changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

Reading in Science

Objective

- Identify cause-and-effect relationships in an article.

Voyager Discoveries

Genre: Nonfiction

Have students skim the article and look at the illustrations. Ask:

- What do you think this article is about? Possible answer: A spacecraft that travels to other planets and collects data about the planets.

Before Reading

Draw a rough model of the solar system on the board. Have volunteers write the planet names on the diagram and identify the planets *Voyager* traveled to. Ask:

- What was the purpose of the *Voyager* Interstellar Mission? to gather data about the planets in the outer solar system

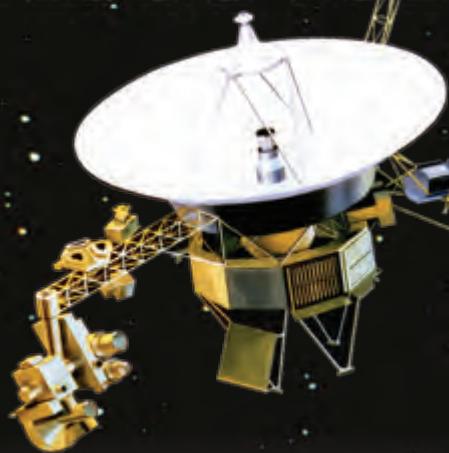
Have students read the first sentence of the introductory paragraph. Ask:

- Why would NASA want to explore distant planets? NASA wants to know more about the other planets in order to learn more about our solar system.

Reading in Science



Voyager Discoveries



In 1977 NASA launched the *Voyager* Interstellar Mission to explore Jupiter, Saturn, Uranus, Neptune, and their moons. Each of the mission's trips had to be very precisely planned. Speeds and distances had to be accurately calculated. The two *Voyager* spacecraft had to be close enough to each planet to collect data and to get a boost from that planet's gravity in order to be propelled toward their next destination. At the same time, the spacecraft had to be far enough away from the planets that they would not go into orbit around them. All of NASA's careful planning worked. The *Voyager* mission has provided scientists with new and closer looks at our farthest neighbors.

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EXTEND

LA Support

Draw Have students draw a rough diagram of the solar system and label Earth, the Sun, the Moon, and the other planets.

BEGINNING Student can use their diagrams to trace the route that *Voyager* traveled.

INTERMEDIATE Student can name the planets *Voyager* passed on its travels and give the dates for each visit in chronological order.

ADVANCED Student can explain some of the discoveries *Voyager* made.

**Jupiter—1979**

Images show Jupiter's rings. Volcanic activity is observed on Io, one of Jupiter's moons. Europa, another moon, may have an ocean under its icy crust.

**Saturn—1980**

Scientists get a close look at Saturn's rings. The rings contain structures that look like spokes or braids.

**Uranus—1986**

Scientists discover additional dark rings around Uranus. They also see ten new moons. *Voyager* sends back detailed images and data on the planet, its moons, and its dark rings.

**Neptune—1989**

Large storms are seen on the planet. One of these storms is Neptune's Great Dark Spot. Scientists thought Neptune was too cold to support this kind of weather.

After observing these planets, the *Voyager* spacecraft kept traveling. They are the first human-made objects to go beyond the heliosphere. The heliosphere is the region of space reached by the energy of our Sun. It extends far beyond the most distant planets in the solar system.

**Write About It**

Cause and Effect What caused the *Voyager* spacecraft to be propelled from one planet toward the next?

The pull from the planet's gravity

would propel the *Voyager*

spacecraft to its next destination.

Cause and Effect

- ▶ Look for the reason why something happens to find a cause.
- ▶ An effect is what happens as a result of a cause.

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EXTEND

Integrate Reading**Build a Spacecraft**

Have students work in small groups to construct a cardboard version of the spacecraft *Voyager*. Ask:

- **What are the most important features of the *Voyager*?** the computers and scientific gear that allow scientists to find out what the planets in our solar system are like

Have students compare models of the *Voyager* and make improvements based on these comparisons.

During Reading

Read the article with students. Ask:

- **Why was it important for *Voyager* to get close to a planet?** It needed to get close to gather data and to use the planet's gravity for a boost to travel to the next planet.
- **What problem did getting close to a planet pose?** If it got too close, it could have been captured by the planet's gravity and gone into orbit around it.
- **What new information did *Voyager* send back to Earth?** Possible answers: volcanoes erupting on Io, large storms on Neptune

After Reading

Remind students that in cause-and-effect relationships, the cause is what makes things change and the effect or effects are the changes that happen. Remind students that cause-and-effect sentences often include the word *because* or *so*. *Because* indicates a cause. *So* indicates an effect or effects. Write the following sentences on the board. Call on students to identify the cause and effect in each sentence.

Because the Voyager mission had to be very precisely planned, speeds and distances had to be accurately calculated.

The Voyager had to be far enough away from the planets so it wouldn't go into orbit around them. Scientists have gathered new information about planets because of the Voyager mission.

Have students look through the article to find other cause-and-effect relationships and share them with the class.

Stop Here to

Plan Your Lesson

Lesson 2 The Scientific Method

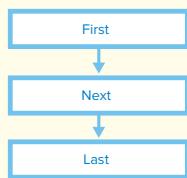
Essential Question

What process do scientist use to gather information?

Objectives

- Identify the steps in the scientific method.
- Learn how scientists formulate and test a hypothesis.

Reading Skill Sequence



You will need a sequence graphic organizer.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Discuss the Main Idea

Develop Vocabulary

3 Close

Think, Talk, and Write

Teacher Notes

Lesson 2 The Scientific Method

Objectives

- Identify the steps in the scientific method.
- Learn how scientists formulate and test a hypothesis.

1 Introduce

► Assess Prior Knowledge

Have students discuss what they know about the scientific method. Ask:

■ **How do scientists conduct investigations?**

Scientists conduct investigations following a series of steps called the scientific method.

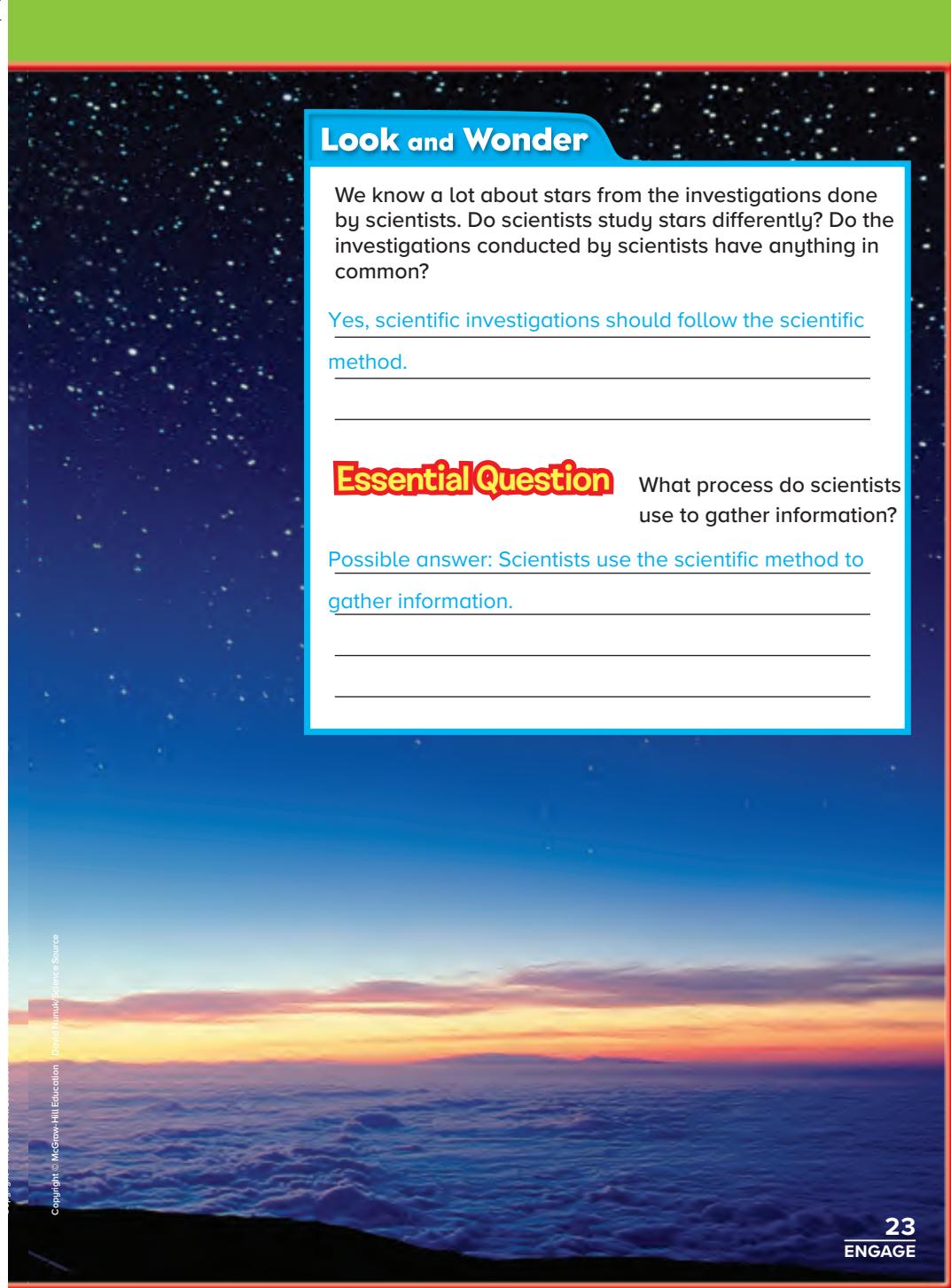
■ **What is the scientific method?** The scientific method is a series of steps that scientists use when conducting an investigation.

■ **Why do scientists use it?** The scientific method helps scientists explain natural phenomena. It also makes it possible for other scientists to repeat their procedures reliably. This way, the work can be checked independently.

Lesson 2

The Scientific Method





Look and Wonder

We know a lot about stars from the investigations done by scientists. Do scientists study stars differently? Do the investigations conducted by scientists have anything in common?

Yes, scientific investigations should follow the scientific method.

Essential Question What process do scientists use to gather information?

Possible answer: Scientists use the scientific method to gather information.

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Look and Wonder

Invite students to share their responses to the Look and Wonder statement and questions:

- Do the investigations conducted by scientists have anything in common?

Write ideas on the board and note any misconceptions that students may have. Address these misconceptions as you teach the lesson.

Essential Question

Have children read the Essential Question. Tell them to think about it as they read through the lesson. Advise children that they will return to this question at the end of the lesson.

Explore



whole class



20 minutes

Plan Ahead Select a secret object to place inside a box before students arrive. You may want to do several objects in different boxes so that students can work in pairs or groups. Have extra empty boxes available that are the same as the box with the secret object.

Purpose This activity helps students understand how a scientist gathers information for a scientific investigation.

Structured Inquiry

Discuss with the class the types of things they will do to make a scientific guess to identify the secret object.

- Ask the class for a list of properties and how they will test each property. Write their responses on the board. Connect this process to the previous lesson by asking what scientific process they are using.
- Observe** Students should test each property and record their observations.
- Predict** After they have written their prediction down, have each person or group share the prediction. Write the predictions on the board.

Explore

How do scientists gather information?

Purpose

How do you think scientists gather information to answer their questions? In this activity, your teacher will place a classroom object in a box and you will think like a scientist to determine what is inside.

Procedure

- Obtain a box from your teacher with a classroom object inside. You will not be able to open the box to see what is inside. Scientists often cannot directly answer their questions. They must decide what observations or evidence they can gather that will help them answer their questions.
- Make a list of properties that you can observe without opening the box. Also list how you will test each property.
- Observe** Test each property and record your observations.
- Predict** Based on what you have observed, predict what is in the box.

Answers will vary. Accept reasonable

responses.

Answers will vary. Accept reasonable

responses.

Answers will vary. Accept reasonable

responses.

Materials



- box with mystery object
- classroom objects
- balance with set of masses



Step 3

Inquiry Activity

Draw Conclusions

5 Test to see if your prediction was correct. Obtain the object that you think is in the box. Place it in an identical box. Find the mass of each box using a balance. Are the masses the same?

Answers will vary.

6 Interpret Data If the masses are the same, does that mean your prediction is correct?

Answers will vary. Many students who find that the masses are the same might conclude the objects are the same.

Explore More

Can you gather additional evidence to verify your prediction? Make a list of additional evidence that you can gather without opening the box. After gathering more evidence, can you be sure that your prediction is correct?

You cannot be sure that your prediction is correct until you open the box to see what the object is.

6 Interpret Data Point out to students that different objects can have the same masses. You might also wish to point out that the same objects can also have different masses. Discuss with the class the idea of a scientific theory.

Guided Inquiry

Explore More

Gather a list of any additional evidence the class could think of to help with their prediction. Discuss with the class how some answers to questions led to more questions.

Open Inquiry

Have students relate this scientific investigation with how a scientist should approach other investigations.

Ask: How should a scientist approach a scientific investigation?

Teacher Notes

2 Teach

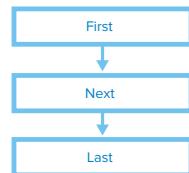
Read and Respond

Main Idea Have students examine the photos in the lesson. Ask them what they think they will learn about.

Vocabulary Have students review the vocabulary words and identify any unfamiliar words. Then ask volunteers to define each word.

Reading Skill Sequence

Graphic Organizer Have students fill in a Sequence graphic organizer as they read through the lesson. They can use the Reading Check questions to identify each step in the sequence.



What do scientists do?

► Discuss the Main Idea

Ask students to think about what a scientist does. Ask:

- What process do scientists use to investigate and answer questions? **scientific method**
- What is one thing that is important for all scientists to do when conducting investigations? **Possible answer:** keep careful records
- Why is using the scientific method important to a scientist's research? **Possible answers:** It helps ensure that the research can progress successfully. Other scientists can repeat the procedures and, in this way, their results can be independently checked.

► Develop Vocabulary

scientific method *Word Origin* The word *method* originates from the Latin word *methodus* which means “way of teaching or going.” The scientific method is a method that is followed by scientists when conducting a scientific investigation.

hypothesis *Word Origin* The word *hypothesis* is Greek in origin. *Hypo* means “under” and *thesis* means “an unproven statement or idea.” In ancient Greece, the hypothesis was the basis of a debate or argument—the underlying idea, statement, or premise.

Read and Respond

What do scientists do?

Scientists ask many questions about the world around them. The scientific method is used by all kinds of scientists to investigate and answer these questions. The **scientific method** is a series of steps that scientists use when conducting an investigation.

The **scientific method** helps scientists explain natural phenomena. It also makes it possible for other scientists to repeat their procedures reliably. This way, the work can be checked.

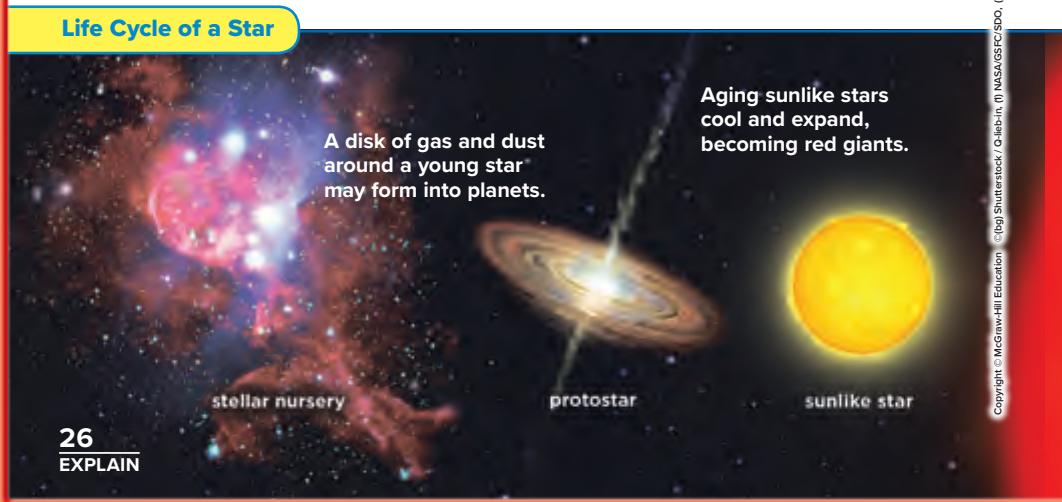
Scientists do not always follow all the steps of the scientific method in order. However, they always keep careful records of what they have done and observed. Then they can refer to their notes as they do further research.

Orsola De Marco and Mordecai-Mark Mac Low are scientists. They use the scientific method when they study stars. From their observations, scientists know that over billions of years, stars change. Stars form, mature, and eventually die. The life cycle of a star is shown below.

De Marco, Mac Low, and other scientists have observed stars and formed hypotheses about them. A **hypothesis** (hi•PAH•thuh•sus) is a possible answer or prediction that can be tested.



Underline the parts of the text that tell how the scientific method helps scientists.



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Science Background

Scientific Method

The scientific method begins with observations. Scientists develop a question related to their observations and use what they already know to form a hypothesis. They make a plan to test their hypothesis. They collect data by making observations, conducting experiments, and/or making and using a model. They organize and analyze their data. The hypothesis is either supported and then subjected to further testing, or rejected and replaced with a new hypothesis.

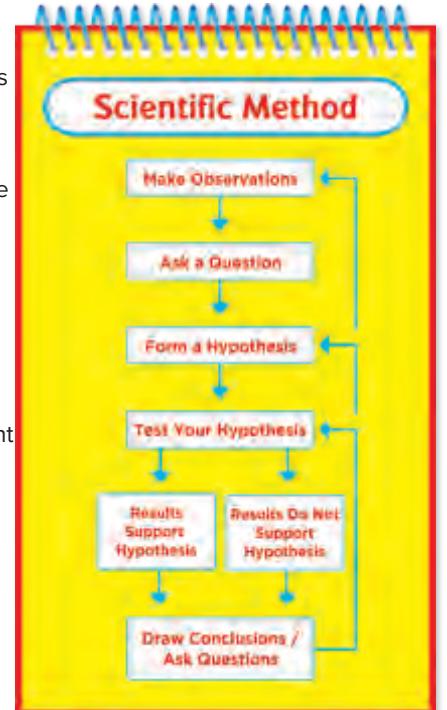
Scientists have observed that some stars have a companion star. The two stars orbit each other and are called a binary. In some binaries, the two stars can be a billion kilometers apart. In others, the two stars orbit so tightly that it is difficult to see that they are separate.

Sometimes De Marco observes tightly orbiting binaries in which one of the stars is a white dwarf. The distance between them is less than the size of the original red giant that became the white dwarf. Why does this happen?

Scientists hypothesize that the red giant “ate” its companion star. The companion star spiraled in toward the giant, driving away the giant’s outer gas layers. The red giant became a white dwarf, and the companion star ended up in a tight orbit.

Quick Check

1. The scientific method allows scientists to follow the same procedure.
2. A hypothesis is worthless if it is not testable.



Read a Diagram

How does a white dwarf’s size compare to that of a red giant?
It is much smaller.

red giant

They die as white dwarfs—Earth-size stars with half the mass of the Sun.

white dwarf
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EXPLAIN

► Discuss the Main Idea

Have students read the pages, then identify the initial step scientists take when using the scientific method. Ask:

- **What is a binary star?** Possible answers: A binary star is two companion stars that orbit each other. Their orbits can be billions of kilometers apart or so close that it is difficult to see that they are separate.
- **Red giants are huge stars that collapse into smaller, weaker stars called white dwarfs. What has De Marco observed about some white dwarfs and their companion stars?** Possible answer: She observed that the distance between the white dwarf and its companion star was less than the size of the original red giant.
- **What hypothesis have scientists formulated about binaries?** Their hypothesis is that the red giant “ate” its companion star.

► Use the Visuals

Call on a volunteer to read aloud the flow-chart that can be used for the scientific method. Ask:

- **Why do some of the arrows “circle” back around to a previous step in the scientific method?** Sometimes the steps lead scientists to different observations, questions, or hypotheses rather than conclusions.

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students make and label the stages in the life cycle of a star, including its formation in a stellar nursery, average star, red giant, planetary nebula, and white dwarf. Ask volunteers to use their diagrams to describe the life cycle of a star to the rest of the class.

ENRICHMENT Have students research the life cycle of a massive star, including its formation in the stellar nursery, red super giant, supernova, and its final stage as a neutron star or black hole. Have students draw and label a diagram showing the life cycle of a massive star. Call on volunteers to display their diagrams and use them to describe the massive star life cycle to the rest of the class.

How do scientists test their hypothesis?

► Discuss the Main Idea

Have students describe the steps of the scientific process that De Marco and Mac Low have followed so far. Lead students to understand that a hypothesis is an explanation, prediction, or answer to a question being explored. Explain that once scientists have a hypothesis, they can think of a plan to collect data that will help them accept or reject the hypothesis. Ask:

- **What data does De Marco collect?** She measures the distance between two stars in a binary or the time it takes for them to orbit each other.
- **What strategy does De Marco use to collect data?** She uses a telescope to view the stars and take measurements.
- **Why can't De Marco and Mac Low just use observations of the universe to test their hypothesis?** Possible answer: The universe is vast, and it is highly unlikely that they can find a red giant that they can observe as it eats its companion star.
- **What does Mac Low use to simulate a red giant eating its companion star?** He creates a computer model that simulates this process and runs the model over and over with changing variables.

► Develop Vocabulary

data *Word Origin* Data is the plural of the Latin word *datum* which means “(thing) given.” As information is gathered in an experiment, the data becomes the given information that is used to answer questions.

How do scientists test their hypothesis?

De Marco and Mac Low want to test their hypothesis. To do this, they need to collect data. **Data** (the singular is *datum*) are information that is gathered during an investigation. Data can be recorded in the form of descriptions, tables, charts, graphs, or drawings. Scientists carefully record everything that happens, including what they observe and what they measure.

De Marco spends weeks looking through a telescope like the one shown below. She measures distances

between the two stars in binaries by observing how they move. She watches and records how long the two stars of a binary take to orbit each other. Then she uses this information to calculate the distances between the stars and combines her data with data reported by other scientists.

The universe is so vast that a scientist could spend a lifetime at a telescope and never find a star eating its companion. So, De Marco and Mac Low have to use a computer model to test their hypothesis. The model can then be compared to De Marco's observations.



◀ interior of Kitt Peak Observatory

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EXPLAIN

LA Support

Explain Review the different types of scientific investigations discussed in Lesson 1. Relate these investigations to the work done by De Marco and Mac Low. Ask: *How did De Marco and Mac Low collect data?* Write the type of investigation across the board. Ask: *How did they conduct this investigation?* Write students' answers under each investigation. Allow students to find the answers in the book.

BEGINNING Students can point to the correct investigation on the board when presented with an example of each.

INTERMEDIATE Students can use phrases or short sentences to explain how the scientists used each investigation.

ADVANCED Students use their own words to explain how the scientists used each investigation and why they needed to make a model.

Their model is a computer program that shows natural processes at work. "I need a model that uses the laws of physics to predict the orbits of the stars after they merge," Mac Low explains. "Fortunately, fundamental processes such as gravity and pressure do not only apply on Earth. They apply across the universe." These forces are an important part of the model. Mac Low also enters the initial values for the key variables of his model—for example, the masses of the stars that make up the binary and the distance between them. He runs the model many times, changing the initial values for the variables each time.



Kitt Peak Observatory, located near Tucson, Arizona

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Science Background

Gravity

Any object at rest remains at rest until a force acts on it, while any object in motion remains in motion until a force (including friction) acts on it. Gravity is a force that massive objects exert on other objects in their neighborhood, causing them to move toward the massive object. If an object is moving sideways to the pull of gravity fast enough, it can go into orbit around the massive object, or two massive objects can orbit each other.

ENGAGE EXPLORE EXPLAIN EVALUATE EXTEND

Quick Lab

To learn how to form a hypothesis, complete the Quick Lab in the activity workbook.

Quick Lab



15 minutes

Forming a Hypothesis

See the Quick Labs in the Activity Lab Manual.

Objective Complete a simple experiment to demonstrate how to form and test a hypothesis.

Materials large pot partially filled with water, 1 can of diet soda, 1 can of regular soda

2 Observe Have your students predict what they think will happen before placing the cans in the pot.

3 Form a Hypothesis Remind students that it is acceptable to have varying hypotheses. Only one hypothesis should be selected and tested at a time.

4 Interpret Data Students should find that the diet soda and regular soda contain different ingredients. Discuss the differences in nutritional facts of the two cans. Diet soda is usually made with a small amount of aspartame, an artificial sweetener. Regular soda is made with a large amount of sugar. The small amount of aspartame used in diet sodas will have a negligible effect on the mass, enabling the can to float.

5 Students might not yet understand the concept of density. However, they should make the connection that the two cans of soda contain different ingredients, causing one can to float and the other to sink. You might wish to show them how much aspartame and how much sugar are in each can. Remind students that hypotheses often must be revised as more information is gathered or discovered. This is all part of the scientific method.

How do scientists analyze data?

► Discuss the Main Idea

Call on volunteers to review the steps of the scientific method that De Marco and Mac Low have followed so far and what they have done at each step. Point out that the next step is to analyze the data that have been collected. Call on a volunteer to read the steps in Analyzing the Data. Ask:

- **What are some ways to organize data so that it can be analyzed?** Possible answers: Data can be organized in a table, graph, diagram, map, model, or a sequence of images.
- **How did Mac Low organize the data he collected?** He created visualizations that show what happens when stars swirl into the center of a red giant.
- **Once they had their data, what did De Marco and Mac Low look for?** Answers may include: They looked for patterns in Mac Low's predictions and De Marco's observations that they could compare.

► Develop Vocabulary

Review key terms with a word-study activity. Point out to students that often multisyllabic words are difficult to pronounce and that dividing the word into syllables will help in the pronunciation. Write the following words on the board: *binary*, *hypothesis*, *kilometers*, and *visualization*. Have students use the dictionary to determine where the syllables break. Have them practice pronouncing the words.

How do scientists analyze data?

What happens when your investigation is over? After your investigation is over, you have to figure out what your results mean. To do this, you analyze your data to look for patterns. You must review all of the recorded observations and measurements from your investigation. Organizing results into tables and graphs helps scientists analyze their data. You can draw the tables and graphs or use computers to make them.

For De Marco and Mac Low, each run of the model takes approximately a week to finish using a supercomputer. Each run predicts a final distance between the two stars. After all the models are run, Mac Low has a range of outcomes that reflect the different sets of initial values for the key variables (mass and distance between two stars prior to run).

Quick Check

3. What methods did De Marco and Mac Low use to test their hypothesis?

De Marco observes binary stars through a telescope and measures the time it takes the stars to orbit each other.

Mac Low uses a computer model to simulate distance between stars after they merge to form a binary star.

4. How do scientists use the work of others to help them with their own research?

Answers may vary. Possible answer: A scientist can use other conclusions as part of their study if the conclusions are reliable.

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EXPLAIN

Science Background

Computer Models

The creation of simulations involves applying the laws of physics to predict how nature will behave. A model of a physical event—such as the development of a binary star system—involves describing the event in mathematical equations. For very complex processes, supercomputers can be used to solve the equations of the model. Supercomputers are made up of individual computers or computer chips and boards hooked together. Results can be computed in a matter of weeks and months rather than years or centuries.

De Marco and Mac Low organize their data so they can compare Mac Low's predictions to De Marco's observations.

Mac Low does this by creating visualizations of the data that his model generated. Visualizations are images or movies that represent complex sets of data. Visualizations of Mac Low's runs show what happens as stars of different masses and initial distances swirl into the center of a red giant.

Analyzing the Data

- 1 Organize the data as a chart such as a table, a graph, a diagram, a map, or a group of pictures.
- 2 Look for patterns in the chart that show connections between important variables in the hypothesis being tested.

► Make sure to check the data by comparing it to data from other sources.

Quick Check

5. What steps did Mac Low take to analyze his data?

Possible answer: Mac Low used a supercomputer to make visual models, then compared his data to De Marco's data.

6. Why is it important to check your data?

Answers may vary. Possible answer: It is important to check to see if the data supports the hypothesis or if a new hypothesis is necessary.

► Explore the Main Idea

ACTIVITY Have students use blank index cards to create flip books showing how a red giant might eat its companion star and what happens to the stars as a result. Have students pay special attention to the sequence in the process.

Differentiated Instruction

Leveled Questions

EXTRA SUPPORT What did De Marco and Mac Low do with the data they collected? They compared their data to see if Mac Low's predictions matched De Marco's observations.

ENRICHMENT Why do you think Mac Low chose to present his data as a visualization? Possible answers: A tremendous amount of numbers is generated by Mac Low's model on the supercomputer. These data are too complex to analyze simply by looking at the numbers, so a visualization is necessary.

How do scientists draw conclusions?

► Discuss the Main Idea

Point out that the final step in the scientific method is to draw conclusions. Call on a volunteer to read aloud the steps in Drawing Conclusions. Ask:

- **What did the data show that De Marco and Mac Low compared? It showed that many of the observations match the computer model.**
- **What do scientists do if the data does not support their hypothesis? Scientists might wish to modify their hypothesis or form another one.**
- **Why is it important for De Marco and Mac Low to share their results? Other scientists can use the results to further their own research, and they may want to reproduce their work to make sure it is correct.**

► Explore the Main Idea

ACTIVITY Have students work in four small groups to prepare skits about Mac Low and De Marco. Assign groups one aspect of Mac Low and De Marco's research to present: Form a Hypothesis, Test a Hypothesis, Analyze the Data, and Draw Conclusions. Suggest that they include a narrator and be creative in preparing the skit so that everyone in the group can participate. When groups are ready, have them present the skits, in order, to the rest of the class. Then discuss with the class whether all aspects of Mac Low and De Marco's work were presented.

How do scientists draw conclusions?

After analyzing the data, it is time to draw a conclusion. A *conclusion* is a statement about whether or not the hypothesis is valid based on the data collected.

De Marco and Mac Low compare the model predictions to the observations. If the results from the model and the observations agree, that is evidence in favor of their hypothesis. If the results disagree, either the hypothesis is flawed or the model is incomplete. "So far, we have found some preliminary predictions in the model that match observed data," says De Marco.

If the data do not support your hypothesis, you might need to modify the hypothesis or form another one. If an experiment supports your hypothesis, you might have other questions that can be tested.

Recall that scientists tell other scientists as well as members of the public about what they have learned. By making their findings public, other scientists can also benefit when they work. Scientists rarely, if ever, work alone.

Drawing Conclusions

- 1 Decide if the data clearly support or do not support the hypothesis.
- 2 If the results are not clear, rethink how the hypothesis was tested and make a new plan.
- 3 Record the results to share with others.

► **Make sure to ask new questions.**

Quick Check

7. How do scientists use their hypothesis and the data they collect to draw conclusions?

Scientists test to see if the data confirms or disproves the hypothesis. Based on what the data demonstrates, conclusions can sometimes be drawn.

8. Explain why a scientific investigation is still valuable even if the hypothesis is not supported by the data.

The experiment still answers a question.

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Homework Activity

Using the Scientific Method

Have students outline how they would investigate this question using the scientific method: *How does the amount of salt in water affect the temperature at which water will boil?* When students have completed the assignment, call on volunteers to present their outlines to the rest of the class. Discuss with the class whether or not the scientific method was appropriately utilized in their plan and have them suggest what is missing or what needs to be clarified.

Teacher Notes

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 2 Lesson Review

Visual Summary

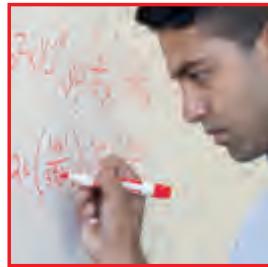
Complete the lesson summary in your own words.



Hypotheses Possible answer: Hypotheses are statements about the natural world that can be tested.



Analyze Data Possible answer: Scientists analyze data by looking for patterns. They may organize data in a charts, graphs, or diagrams.



Draw Conclusions Possible answer: After an investigation, scientists decide if their hypothesis was supported and communicate their results with others.

Think, Talk, and Write

1 Vocabulary A statement that can be tested to answer a question is called a(n) hypothesis.

2 Sequence Explain how scientists form hypotheses.

Possible answer:

Identify the pattern in nature they want to know more about.



Establish what they already know about it.



Make a prediction about it that can be tested.

3 Critical Thinking What method did De Marco and Mac Low use to test their hypothesis?

Possible answer: De Marco used a telescope and made observations and

Mac Low used a computer to model the data.

4 Test Prep Which is a hypothesis?

- A The ball rolled 5 meters in 21 seconds.
- B If the ramp is steeper, then the ball will roll faster.
- C The ball is red and made of rubber.
- D The speed of the ball is calculated by dividing distance by time.

5 Test Prep If the results from your investigation do not support your hypothesis, what should you do?

- A Repeat the investigation until it agrees with your hypothesis.
- B Do not do anything.
- C Modify your hypothesis.
- D Change your data.

Essential Question What process do scientists use to gather information?

the scientific method

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your thinking changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

Focus on Skills

Objective

- Investigate whether hot water, warm water, cool water, or cold water freezes fastest.

Materials hot water, cool water, warm water, cold water, plastic cups, thermometer, graduated cylinder, labels, freezer

Plan Ahead Make sure you have access to a freezer with plenty of room for plastic containers. Prepare cold water by adding ice to a pitcher of water and keeping it in a refrigerator until the ice melts. The cold water and cool water should have temperatures around 18°C and 35°C, respectively. Provide tap water from a hot-water tap. The warm water and hot water should have temperatures around 52°C and 70°C, respectively. This experiment will work well only if the cups are placed in equally cold spots in the freezer. Try to keep all the cups the same distance from the vents and door.

EXTEND This activity will allow students to compare how long it takes hot, warm, cool, and cold water to freeze.

Focus on Skills

Inquiry Skill: Use Variables

Since hot water has more energy to get rid of before it freezes, it shouldn't freeze as fast as cold water. That's what many people thought. But scientists wanted to know for sure, so they did a series of experiments and recorded their observations. In these experiments the scientists changed only one thing at a time. That way they knew what caused the outcome they observed. What they changed is called the independent variable. They learned that sometimes hot water freezes faster than cold water. This is called the Mpemba effect.



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EXTEND

Integrate Writing

Read About the Mpemba Effect

Have students use the Internet, encyclopedias, and other science sources to find information about the Mpemba effect. Encourage students to discuss their findings in class. Ask:

- Who discovered the Mpemba effect? Where? When?
- How does the kind of container affect the Mpemba effect?
- What other factors are involved in the Mpemba effect?

Tell students to write a paragraph that compares the variables that were manipulated and controlled and that responded with the conditions needed for the Mpemba effect to occur.

Skill Builder**► Learn It**

When you **use variables**, you change one thing at a time to see how it affects the outcome of the experiment. The thing you change is the independent variable. The outcome is the dependent variable. The way the dependent variable changes depends on the way the independent variable changes.

For this experiment the independent variable is the starting temperature of the water. The time it takes the water to freeze is the dependent variable. You will change the starting temperature of the water and record how this affects the time it takes the water to freeze.

Inquiry Skill: Use Variables**► Learn It**

Tell students that an independent variable is also called a manipulated variable, the one you change on purpose. A dependent variable is also called a responding variable, one that changes because of the test. Ask:

- **How many independent variables should an experiment have?** **only one**

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EXTEND**Teacher Notes**

► Try It

- 3 Help students realize that other possible independent variables in the experiment have been controlled, or held constant. Have students list factors that are the same in each cup.
amount of water, kind of cup, the freezer
- 5 Explain that an experiment like this one can have two or more dependent or responding variables.

Focus on Skills

► Try It

Materials hot water, cool water, plastic cups, thermometer, labels, graduated cylinder, freezer

- 1 Fill a cup with 120 milliliters of hot water. Label it *Hot Water*. Fill a cup with 120 mL of cold water. Label it *Cold Water*. Fill a cup with 80 mL cold and 40 mL hot water. Label it *Cool Water*. Fill a cup with 80 mL hot and 40 mL cold water. Label it *Warm Water*.
- 2 Record the temperature of each cup of water on your table. This is the independent variable.
- 3 Place all the cups in a freezer at the same time. The cups should be close together and on the same level.
- 4 Check the freezer every 10 minutes. Record when the water in each cup starts to freeze. Record when the water in each cup is completely frozen. These are both dependent variables.
- 5 Record your data on the table.
Answers will vary.

Time to Freeze

Temperature	Starts Freezing	Ends Freezing
Hot water (°C)		
Warm water (°C)		
Cool water (°C)		
Cold water (°C)		

Skill Builder

► Apply It

1 Which water froze first: cold, cool, warm, or hot water? Repeat the experiment to confirm your findings.

Students should find that the hot water froze first.

2 Scientists changed the independent variable to learn about the Mpemba effect. What did you learn from your results? Do you agree that the Mpemba effect occurs?

Answers will vary depending on student

results.

3 What do you think would happen if you used icy or even hotter water? Are you still changing the same independent variable? **Use variables** and record data about the investigation. Use the data to help you develop an opinion about how water freezes.

Possible answer: If you used icy or even hotter water,

you would still be testing the same independent

variable: starting temperature.

► Apply It

Have students analyze the data they collected.

1 Explain that scientists routinely repeat experiments several times to be sure that their findings are reliable. Ask:

■ **What does *reliable* mean?** It means that the same result happens every time, and that you can depend on that outcome happening every time an experiment is conducted in the same way.

2 It should be expected that the hot water will freeze first, due to the Mpemba effect.

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EXTEND

Teacher Notes

Stop Here to

Plan Your Lesson

Lesson 3 Tools of the Scientist

Essential Question

How do scientists collect, analyze, and communicate data?

Objectives

- Understand how to collect, organize, and communicate data appropriately.
- Explain how to stay safe when conducting a scientific investigation.

Reading Skill Draw Conclusions

Text Clues	Conclusions

You will need a draw conclusions graphic organizer.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Develop Vocabulary

Discuss the Main Idea

3 Close

Think, Talk, and Write

Teacher Notes

Lesson 3 Tools of the Scientist

Objectives

- Understand how to collect, organize, and communicate data appropriately.
- Explain how to stay safe while conducting a scientific investigation.

1 Introduce

► Assess Prior Knowledge

Have students discuss how scientists organize the data they collect during a scientific investigation. Ask:

- What are some variables you might measure in a scientific investigation? *Answers will vary.* Possible answers: mass, height, volume, time, distance, temperature
- How would you organize the data you collect during a scientific investigation? *Answers will vary.* Possible answer: The data can be organized in a table.

Lesson 3

Tools of the Scientist



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ENGAGE

Look and Wonder

Scientists use several different types of tools to gather information. How do scientists use the information they gather?

Possible answers: to confirm/disprove hypotheses, answer questions, and formulate conclusions

Essential Question

How do scientists collect, analyze, and communicate data?

Answers will vary. Accept reasonable responses that describe the scientific process of collecting, analyzing, and communicating data.

**Look and Wonder**

Invite students to share their responses to the Look and Wonder statement and question:

■ How do scientists use the information they gather?

Write ideas on the board and note any misconceptions that students may have. Address these misconceptions as you teach the lesson.

Essential Question

Have children read the Essential Question. Tell them to think about it as they read through the lesson. Advise children that they will return to this question at the end of the lesson.

Explore



individuals



30 minutes

Plan Ahead Use a meterstick to measure the room and several key items in the room so that you can know if students are accurate with their measurements.

Purpose This activity helps students understand scale and scale drawings.

Structured Inquiry

2 Make sure students record their measurements in a table. This will help them to stay organized when they change units from meters to centimeters. An example of the table is as follows:

Object	Measure in Meters	Multiply by 2	Measure of Scale Drawing (in cm)
South wall	3	3×2	6

3 **Use Numbers** Students should fill in the rest of the table changing all measurements from meters to centimeters by multiplying by 2.

4 Encourage students to use a straight edge and be very precise in their drawing.

Explore

Materials



How can you model your classroom?

Purpose

A scale drawing shows an object with accurate sizes except that all of the measurements have been enlarged or reduced by a certain amount, called the scale. In this activity, you will represent your classroom in a scale drawing.

Procedure

1 **Measure** Use a meterstick to measure the length and width of your classroom in meters. Note the locations and sizes of doors, windows, and desks.

2 Record the lengths of each item in a data table.

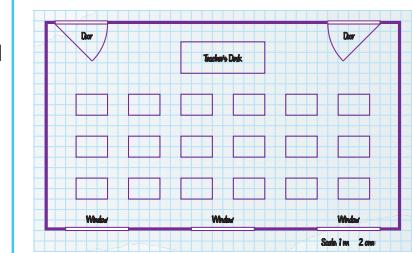
Answers will vary.

Object	Measure in Meters	Multiply by 2	Measure of Scale Drawing (in cm)

3 **Use Numbers** In your scale drawing, each 1 meter will be equal to 2 centimeters. Multiply each measurement in your table by 2 cm and record the numbers in your table. Your scale is 1 m = 2 cm.

4 Draw the floor plan on graph paper. Be sure to indicate the scale on your drawing.

Step 4

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EXPLORE

Inquiry Activity

Draw Conclusions

5 Infer What would your drawing look like if you used a different scale?

Answers will vary depending on students' data. Accept reasonable responses.

6 Communicate How does your drawing compare to those of your classmates? Are the objects the same sizes? Explain. How could you improve your drawing?

Answers will vary.

Explore More

Sketch your room at home from memory, estimating the measurements for objects in your room and the room's width and length. Compare this sketch to your scale drawing of your classroom.

Answers will vary.

Open Inquiry

How would a scientist use a scale drawing to represent a microscopic organism?

Answers will vary.

Teacher Notes

5 **Infer** Discuss with the class how a change in the scale would affect the drawing. Discuss the effects of changing the scale to $1\text{ m} = 1\text{ cm}$ and $1\text{ m} = 3\text{ cm}$.

6 Communicate Group students in groups of 3 or 4. Have them compare their drawings, discuss any differences, and share their results with the class.

Guided Inquiry

Explore More

Discuss with the class how to estimate measurements from memory. Have students share their drawings with their group.

Open Inquiry

Have students relate this process of using scale drawings with how a scientist might use this skill in an investigation involving extremely small organisms.

How would a scientist use a scale drawing to represent a microscopic organism?

2 Teach

Read and Respond

Main Idea Have students read the page and identify the types of data that scientists use to support or disprove hypotheses.

Vocabulary Have students read aloud the vocabulary terms. Ask them to share what they already know about the meanings. Record responses on the board.

Reading Skill Draw Conclusions

Graphic Organizer

Have students fill in the Draw Conclusions graphic organizer as they read through the lesson. They can use the Reading Check questions to identify each conclusion.

Text Clues	Conclusions

What are types of data?

► Discuss the Main Idea

Discuss the difference between qualitative and quantitative data, including examples of each. Ask:

- What are some things that would be measured using quantitative data? *Answers will vary.* Possible answers: height, age, length, weight
- What are some things that would be measured using qualitative data? *Answers will vary.* Possible answers: texture, color, smell

► Develop Vocabulary

quantitative data *Word Origin* The root word for quantitative is *quantity* which originates from the Latin word *quantitativus* and relays the measure of a quantity. This data can be measured using some quantity or amount.

qualitative data *Word Origin* The root word for qualitative is *quality* which originates from the Latin word *qualitativus* and means pertaining to or concerned with quality. This data cannot be measured using some quantity, so it is not numeric.

Read and Respond

What are types of data?

You learned that the information collected during an investigation is called data. In a scientific investigation, the data collected by scientists are related to the hypothesis. Data allow scientists to answer questions and can support or disprove their hypotheses.

Qualitative and Quantitative Data

There are two general types of data: quantitative and qualitative. **Quantitative data** are data that can be measured. They are numbers or quantities. Length, width, height, mass, and weight are examples of quantitative data. **Qualitative data**, on the other hand, are descriptive data that cannot be measured. Colors, textures, smells, and tastes are examples of qualitative data. How would you describe the objects below?



Volume is an example of quantitative data. Color is an example of qualitative data. ▼

Science Background

Qualitative vs. Quantitative Which type of data is better? It is important to realize that there are advantages and disadvantages to both types of data. Quantitative is more objective, while qualitative is more subjective. However, there are many things that cannot be measured quantitatively. It is important to use each type of data in appropriate situations.

Description and Explanation

Descriptions are one type of data. A **description** is a summary of observations. A description can be spoken or written. Descriptions can include different types of observations about an object or an event including the smells, colors, or sounds. Scientists use different types of data, including descriptions, to develop explanations. An **explanation** is an interpretation of observations. Scientists might explain how or why something occurred.

Precision and Consistency

One way to evaluate quantitative data is to determine whether they are precise. **Precision** is how close repeated measurements are to each other. Measuring tools can determine the precision of measurements. The consistency of the person making the measurements also can affect precision. **Consistency** is the ability to repeat a task with little variation.

Precision in Measurement



Read a Photo

Which ruler is more precise?

Clue: Which ruler uses a smaller scale?
the top ruler

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EXPLAIN

LA Support

Explain Discuss the difference between a description and an explanation. Have a volunteer read the words and definitions aloud. Write two columns on the board. One column is for descriptions and one for explanations. Give two examples of each. Ask the class to give several examples of each.

BEGINNING Students understand the definition of a description and an explanation.

INTERMEDIATE Students can identify whether a given statement is a description or an explanation.

ADVANCED Students can provide both definitions and examples of descriptions and explanations.

Quick Lab

To learn how to measure distance and time, complete the Quick Lab in the activity workbook.

Science Notebook

You will record the data that you collect in your science notebook. Take thorough notes at the time of your scientific investigations. Important details can be forgotten if you wait several hours or days before you write down your observations. Also, be sure that you keep your notebook organized. This will help you find data that you have collected in the past. Always start your entries by recording the date.

Quick Check

1. What can you do to be consistent when recording data in your science notebook?

Possible answer: You can use the same layout and format for your log.

2. What factors might cause variation in data collected during an investigation?

Possible answers: human error, changes in the environment, changes in the factors

Quick Lab

small groups

30 minutes

Measuring Distance and Time

See the Quick Labs in the Activity Lab Manual.

Objective Practice precision and consistency in measuring distance and time.

Materials 1 stopwatch and 1 metric ruler or measuring tape per group

- 2 If possible have students perform this quick lab outside on a track or in a less used hallway. Remind students to mark the starting point and end point as precisely as possible. If students are able to travel farther than the space available, reduce the time to 5 seconds for everyone.
- 4 Possible answers: stepper walked faster or slower in different trials, human error in measuring or marking the start and stop points

► Discuss the Main Idea

Have students identify different ways to describe and communicate data. Ask:

- **What is the difference between a description and an explanation?** A description is simply a summary of the observations. An explanation is an interpretation of why something occurs.
- **How could you increase the precision of a measuring tool?** Make the units on the tool smaller.
- **Why is a science learning log important?** Data can be recorded in an organized way for future reference.

How do scientists communicate data?

► Discuss the Main Idea

Discuss the various ways that scientists communicate data. Ask:

- What are some visual ways in which scientists can organize and communicate data? **tables and graphs**
- What is an advantage to organizing data in a graph? **It easily and quickly gives us a picture of the relationship between the variables involved.**
- What role do statistics play in communicating information about data? **Statistics summarize and help to evaluate the data.**

► Use the Visuals

Discuss the three types of graphs shown. Ask:

- When is a line graph most appropriate? **When you want to show the relationship between two variables.**
- When is a circle graph most appropriate? **When you want to show how a complete set of data is divided into parts.**
- When is a bar graph most appropriate? **When you want to show the relationship between several variables.**

How do scientists communicate data?

Everyone who deals with numbers, compares measurements, or collects data needs an organized way to collect, analyze, and display the data. Tables, graphs, and statistics make it easier for scientists to understand their own data and to share it with others.

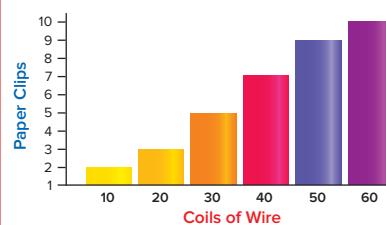
Graphs

Graphs are used to organize and summarize data in a visual way. When scientists analyze data, relationships between the data are often seen more clearly when the data is shown in a graph. Three common types of graphs are bar graphs, line graphs, and circle graphs and maps.

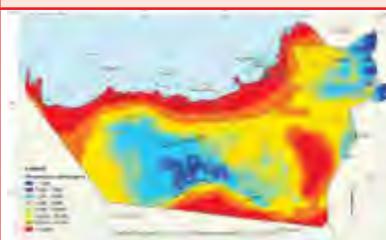
Tables

Tables display information in rows and columns so it is easier to read and understand. Tables also make it easier to see data at a glance.

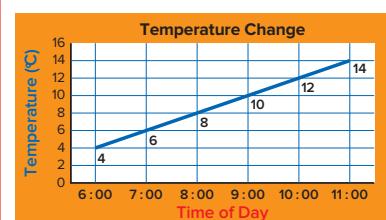
The data in a table could be presented in a paragraph, but it would be harder to pick out the facts and make comparisons. The columns and the rows have headings that tell you what kind of data are in each part of the table. Tables are often used when collecting data as well.



Bar Graphs Bar graphs use bars to show the relationships among variables. This graph shows how the number of coils of wire wrapped around a nail affects the number of paper clips an electromagnet can pick up.



Graphical Representations by Maps
Graphical representations are used by maps in the diagram to show the percentage of groundwater salinity in the United Arab Emirates.



Line Graphs Line graphs show the relationships between two variables. Line graphs have a line connecting data points. This graph shows the relationship between temperature and time.

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EXPLAIN

LA Support

Explain Review the different graphs. Have three different students read aloud the description for the three graphs shown. Write on the board anything that the students can tell you about each type of graph.

BEGINNING Have students find graphs in newspapers, magazines, or an approved Internet site. Students can identify each graph and describe when it is most appropriate to use each one.

INTERMEDIATE When given different sets of data, students can determine which type of graph would best represent the data.

ADVANCED When given different sets of data, students can determine which type of graph would best represent the data and draw the graph.

Statistics

In addition to tables and graphs, statistics are often used to summarize and evaluate data. The mean, median, and range are used to summarize a set of quantitative data.

The **mean** of a set of data is the sum of the numbers in a data set divided by the number of entries in the data set. The **median** is the middle number in a set of data when the data are arranged in numerical order. The **range** in a set of data is the difference between the highest and lowest values.

Scientists collect large amounts of data during investigations. Even in repeated investigations, data often vary. Data can vary due to inconsistent measurement or data collection, inaccurate measurement, or uncontrolled variables. Although scientists try to make their data as accurate as possible, some variation is acceptable. Range is used as a measure of the amount of variation in a data set. Median and mean are used to summarize varying data. Statistics allow scientists to judge the significance of data.

Quick Check

3. How does organizing data help scientists communicate?

Possible answer: Organized data

helps other scientists go directly to the part of the data that is useful to them.

Data are often summarized by calculating the mean, median, and range. ▶

Calculating Statistics

Mean Monthly Air Temperature in a city	
Month	Temperature (°C)
January	9.9
February	11.6
March	15.1
April	19.1
May	23.0
June	26.6
July	27.7
August	27.6
September	25.1
October	19.8
November	14.4
December	10.8

Calculating Mean

- Find the sum of the numbers in the data set.

$$9.9 + 11.6 + 15.1 + 19.1 + 23.0 + 26.6 + 27.7 + 27.6 + 25.1 + 19.8 + 14.4 + 10.8 = 230.7$$
- Divide by the number of entries in the data set.

$$230.7 / 12 = 19.2^{\circ}\text{C}$$

Calculating Median

- Order the numbers in the data set from smallest to largest.

$$9.9, 10.8, 11.6, 14.4, 15.1, 19.1, 19.8, 23.0, 25.1, 26.6, 27.6, 27.7$$
- Identify the middle number in the data set. If the data set has an even number of entries, add the two middle numbers and divide by 2.

$$(19.1 + 19.8) / 2 = 19.5^{\circ}\text{C}$$

Calculating Range

- Identify the highest and lowest numbers in the data set.
 Highest = 27.7
 Lowest = 9.9
- Subtract the lowest number from the highest number.

$$27.7 - 9.9 = 17.8^{\circ}\text{C}$$

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EXPLAIN

Use the Visuals

Discuss the mean, median, and range of the data shown in Calculating Statistics. It may be helpful for students to see you work through the calculations step by step on the board. Ask:

■ **What does the median describe?** the middle value in a set of numbers

■ **How do you find the median of the data set?**

Arrange the numbers from least to greatest and find the middle value. If there are two middle values find the mean of these.

■ **What are the steps for finding the mean?** Add all of the numbers together and divide the sum by the number of entries in the data set.

■ **How do you find the range of the data set?**

Subtract the lowest number from the highest number in the data set.

Develop Vocabulary

mean *Word Origin* Explain that it comes from the old French noun *meien* which means “that which is halfway between extremes.” The mean is the number that is approximately halfway between the high and low number of the data set.

median *Word Origin* Point out that the word *median* comes from the Latin word *medianus* which means “of the middle.” Reinforce that the median of a data set is the middle number between the high and the low number of the data set.

range *Scientific vs. Common Use* Ask students to define range. If they refer to a cooking range or a mountain range, point out that it is a statistical number that represents the difference between the highest and the lowest values of a data set.

Differentiated Instruction**Leveled Questions**

EXTRA SUPPORT Carrie would like to know how the temperature varies in New Orleans in June. What statistical number will answer her question? **range**

ENRICHMENT If the range of test scores is 21 and the lowest score is 64, what is the highest test score? **85**

If Jack's test scores are 92 and 88, what score does he need on the third test to have a mean test score of 93? **99**

How can we stay safe in the lab?

► Discuss the Main Idea

Discuss things that can be done to be safe in the lab. Ask:

- What things can be worn to protect yourself in the lab? **safety goggles, gloves, apron**
- What other things should you do to stay safe in the lab? **Possible answers: Know where the safety equipment is located; read and follow directions; always wash hands before and after an investigation.**

Lab Safety

It is important to wear protective clothing and equipment when conducting scientific investigations.



Read a Photo

How is this student staying safe while conducting an investigation?

Clue: Look at what she is wearing.
She is wearing an apron, gloves,
and safety goggles.

How can we stay safe in the lab?

In your science class, you will perform many types of investigations. Before performing these investigations, you must learn how to keep yourself and others safe by using safe practices.

In the laboratory and in the field, you must always think before you act and follow your teacher's instructions. Always wear the correct protective clothing and equipment for the investigation that you are performing. Know the location of safety equipment and how it should be used. Always read the directions before starting an investigation. If you have questions, ask your teacher. You should always wash your hands before and after an investigation.

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EXPLAIN

When working with any type of animal, it is important to use caution and always treat the animal with care. Even small animals can be dangerous and become stressed when not handled properly. Your teacher will instruct you about the proper treatment of animals. Always wash your hands after handling animals.

Quick Check

4. Why is it important to follow directions when conducting scientific investigations?
to stay safe in the lab

Homework Activity

Gathering, Organizing, and Communicating Data

Have students outline how they would gather, organize, and communicate data regarding the following topic. *How does the outdoor temperature at noon fluctuate in March outside your school? What is the average outdoor temperature at noon for March outside your school?* Students should include a description of any tools they would use, the process for collecting data, any tables, graphs, or statistics they would use. The outline should be written into their science learning log. Discuss with the class several ideas to generate a good scientific plan.



Teacher Notes

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 3 Lesson Review

Visual Summary

Complete the lesson summary in your own words.



Data Possible answer: Data consists of different types of information collected and used by scientists to answer scientific questions.



Scientific Tools Possible answer: Scientists collect data with scientific tools and organize and communicate data with tables, graphs, and statistics.



Lab Safety Possible answer: You can stay safe when conducting investigations by following directions and wearing protective equipment.

Think, Talk, and Write

1 Vocabulary Scientists use consistency so that tasks are repeated with little variation.

2 Draw Conclusions How can you make sure your measurements are precise?

Text Clues	Conclusions
Measurements are made using tools.	Different measurement tools will determine the level of precision.
Precision is how close repeated measurements are to each other.	The smaller the unit, the more precise the measurement.

3 Critical Thinking What safety equipment should be worn while working with dangerous chemicals?
safety goggles, gloves, and an apron

4 Critical Thinking Which are examples of qualitative data?

- A color and mass
- B color and smell
- C smell and volume
- D weight and mass

5 Test Prep Which statistic is the middle number in a data set?

- A mean
- B median
- C range
- D mode

Essential Question How do scientists collect, analyze, and communicate data?

Students should discuss the methods described in the lesson.

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your thinking changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

Focus on Skills

Objective

- Use numbers to calculate a student's age on other planets.

Materials paper, pencils, calculator

Plan Ahead Make sure students have reviewed the use of division, decimals, and ratios before starting the exercise.

EXTEND This activity will teach students to make calculations and use numbers to describe differences in orbits.

Focus on Skills

Inquiry Skill: Use Numbers

When scientists **use numbers**, they add, subtract, multiply, divide, count, or put numbers in order to explain and analyze data.

The orbits of each planet in the solar system have different radii. This means each planet takes a different amount of time to revolve around the Sun. As the radius of the planet's orbit increases, the revolution time increases. What would your age be if you lived on a different planet?

► Learn It

The diagram of the planets shows the time each planet takes to revolve around the Sun in Earth days or years. Scientists **use numbers** to compare the revolution time of the other planets in our solar system to that of Earth. You can do that by dividing the revolution time of a planet by the revolution time of Earth.

For example, it takes Earth $365\frac{1}{4}$ days to travel around the Sun. Mars takes 687 days to complete its revolution. If you divide the time it takes Mars to make a revolution by the time it takes Earth to make a revolution, you get 1.88. Mars takes almost twice as long as Earth to complete one revolution.

If you were 62 years old in Earth years, how old would you be in Mars years? The ratio of Mars's revolution to Earth's is 1.88. Divide your age by the Earth-planet ratio to calculate your age on a specific planet.

Planet	Revolution (days)	Earth-Planet Ratio	Age on Planet
Mercury			
Venus			
Earth	365	1	62
Mars	687	1.88	33
Jupiter			
Saturn			
Uranus			
Neptune			

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EXTEND

Integrate Writing

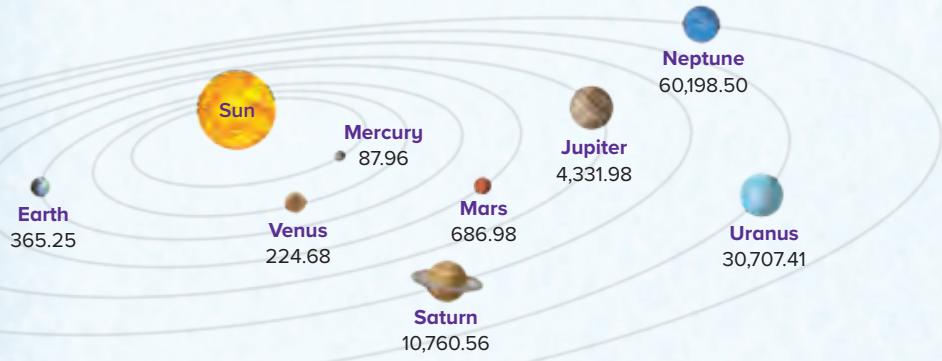
Describe Numbers Using Words

Sometimes when there is a lot of data to communicate, scientists use words to describe the information contained in the numbers. This usually takes the form of a summary paragraph. Have students create a summary paragraph for their results. Ask:

- How can you describe your results?
- What information is most important and would be most quickly understood?
- How are writing and using numbers both useful to scientists?

Skill Builder

Number of Days Each Planet Takes to Revolve Around the Sun



Inquiry Skill: Use Numbers

► Learn It

Explain to students that numbers can give meaning and accuracy to scientific research. Ask:

- **How do people use numbers in everyday life?** Possible answers: People keep track of the weather with numbers; they use numbers for money; they use numbers when measuring something.
- **Which tools are often used when working with numbers?** Possible answers: measurement tools, calculators, graph paper

Teacher Notes

► Try It

- 1 Have students copy the chart and its titles but not the data that is already there, because that data is for the previous research.
- 2 Go over the sample calculation as a class so that students can see how to make the calculations.

Focus on Skills

► Try It

- 1 Make a chart with titles like the one shown. Record the revolution data from the diagram on your chart.

Planet	Revolution (days)	Earth-Planet Ratio	Age on Planet
Mercury	87.96		
Venus	224.68		
Earth	365.25		
Mars	686.98		
Jupiter	4,331.98		
Saturn	10,760.56		
Uranus	30,707.41		
Neptune	60,198.50		

- 2 **Use Numbers** Calculate the Earth-planet ratio for all of the planets.

ratios: Mercury, 0.24; Venus, 0.62; Earth, 1.00; Mars, 1.88; Jupiter,

11.86; Saturn, 29.46; Uranus, 84.07; Neptune, 164.81

- 3 If you were 6 years old in Earth years, how old would you be in Mars years?

$6 \text{ years} / 1.88 = 3.19$ in Mars years

Teacher Notes

Skill Builder

► Apply It

1 Use Numbers Now calculate how old you would be if you lived on each of the planets.

Answers will vary depending on students' ages.

On which planet would you be the oldest in that planet's years?
On which planet would you be the youngest?

oldest on Mercury; youngest on Neptune

What can you infer about the revolution time of the planet and the age you would be on that planet?

As the revolution time of a planet increases or decreases

in relation to Earth, the age you would be on that planet.

decreases or increases

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Teacher Notes

Check students' calculations to make sure they are correct.

Stop Here to

Plan Your Lesson

Lesson 4 Making Measurements

Essential Question

How can the properties of objects be measured?

Objectives

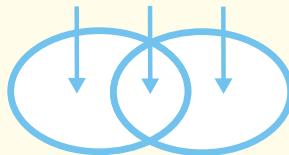
- Describe some properties of matter that can be observed, described, and measured.
- Measure properties of matter using tools, such as gram spring scales, metric rulers, metric balances, and Celsius thermometers.

Reading Skill **Compare and Contrast**

Different Alike Different

Different

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100



You will need a compare and contrast graphic organizer.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Develop Vocabulary

Discuss the Main Idea

3 Close

Think, Talk, and Write

Teacher Notes

Lesson 4 Making Measurements

Objectives

- Describe some properties of matter than can be observed, described, and measured.
- Measure properties of matter using tools, such as gram spring scales, metric rulers, metric balances, and Celsius thermometers.

1 Introduce

► Assess Prior Knowledge

Discuss with students that certain properties of matter can be measured. Ask:

- What properties of matter can you measure? Possible answers: height, weight, temperature
- What tools do you use to measure length, weight and temperature? Possible answer: ruler, scale, thermometer
- Why is it important to know how to measure matter? Possible answers: Measured amounts can be compared. Sometimes you might need to know how much of something you have.

Lesson 4

Making Measurements





Look and Wonder

Many properties of matter can be observed or measured with tools. What tools do scientists use?

Possible answers: scales, balances, rulers

Essential Question

How can the properties of objects be measured?

Possible answer: Objects can be measured using a ruler or measuring stick.

ENGAGE

EXPLORE

EXPLAIN

EVALUATE

EXTEND

Look and Wonder

Invite students to share their responses to the Look and Wonder statement and question.

- What tools do scientists use?

Write ideas on the board and note any misconceptions that students might have. Address these misconceptions as you teach the lesson.

Essential Question

Have children read the Essential Question. Tell them to think about it as they read through the lesson. Advise children that they will return to this question at the end of the lesson.

Explore



Small group



20 minutes

Plan Ahead Locate examples of dichotomous keys that you can show students. Have all of the necessary materials ready before the class assembles. Each student group will need several objects from each of the four categories: round objects that are shorter than 20 mm, such as pennies and dimes; round objects that are longer than 20 mm, such as quarters and checkers; objects with a volume smaller than 500 cm^3 , such as pencil erasers and dice; and objects with a volume greater than 500 cm^3 , such as cereal boxes and textbooks. Choose items that are rectangular prisms to make it easier for students to calculate volume.

Objective In this activity, students will use a dichotomous key to classify objects into groups according to their measurable properties.

Structured Inquiry

Purpose Students will observe and measure several physical properties of matter and then use a dichotomous key to classify the objects.

1 Observe Remind students that physical properties are characteristics that you can observe or measure. Encourage students to pay careful attention to the size and shape of each object.

2 Classify Show students examples of dichotomous keys. Help students understand that a dichotomous key is built from pairs of questions or statements about the characteristics of objects. If necessary, select one of the classroom objects and demonstrate for students how to answer each question in the key to classify the object.

Explore

How can you classify objects?

Purpose

A dichotomous key helps you classify or identify objects. It is a series of descriptions arranged in pairs. In this activity, you will compare objects and classify them with a dichotomous key.

Procedure

1 Observe Look at the objects your teacher has given you. Examine their properties. How are the objects different? How are they alike?

Answers may vary. Students should make

observations of the sizes and shapes of each object.

2 Classify Use the dichotomous key below to classify the objects into groups.

Dichotomous Key

1a. The object is round.....	Go to 2
1b. The object is not round.....	Go to 3
2a. The object is longer than 2 cm.....	Group A
2b. The object is shorter than 2 cm.....	Group B
3a. The object has a volume greater than 500 cm^3	Group C
3b. The object has a volume less than 500 cm^3	Group D

3 Repeat step 2 until each object has been classified into a group.

Materials



- various objects provided by your teacher
- metric ruler
- 4 index cards
- marker



Step 2

Inquiry Activity

Draw Conclusions

4 **Interpret Data** How could you describe the contents of each of the groups?

Answers may vary. Students should make observations

about the size and shape of each object.

5 **Infer** Why might a dichotomous key help scientists?

Accept all reasonable responses.

Explore More

What other properties of objects could you use to classify them? Make your own dichotomous key using two or three different properties to classify several items into groups. Then have a classmate use your key to classify the objects.

Accept all reasonable responses.

Some students may need a review of how to find the length and volume of a solid. Demonstrate how to measure length with a metric ruler. Remind students to line up one end of the object with the “0” mark on the ruler, and to measure the diameter of a round object. Explain to students that to find the volume of a rectangular solid you need to multiply its length by its width and height. You can also refer students to the student book page that explains “How is volume measured?” for a written explanation. Call students’ attention to the units used to express length and volume.

Teacher Notes

2 Teach

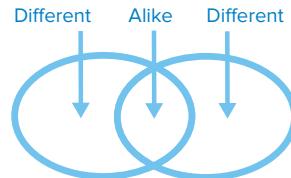
Read and Respond

Main Idea Ask students to read aloud the lesson headings to help them understand that the lesson is about how physical properties of matter can be observed, described, and measured.

Vocabulary Instruct students to read aloud the sentences containing the boldfaced vocabulary words. Then have students state the content of the sentence in their own words.

Reading Skill **Compare and Contrast**

Graphic Organizer Have students fill in a Compare and Contrast graphic organizer as they read through the lesson. They can use the Quick Check questions to identify each comparison.



How are physical properties observed and described?

► Discuss the Main Idea

Discuss the meaning of the vocabulary words. Discuss how these two words are related. An observation uses the senses to learn about an object, and a description uses observations to create a statement or picture to tell about the object.

- Why is it important to know how to observe matter? **Possible answer:** so matter can be compared, to describe objects
- What are some properties you can use to describe objects? **You can use physical properties** size, shape, weight and color.

Read and Respond

How are physical properties observed and described?

As you learned, some physical properties can be observed using just your senses. An **observation** is using your senses to notice things about an object or event. You can also use tools such as hand lenses and microscopes to make observations. These tools allow scientists to learn more about the natural world than can be observed using only their senses.

Detailed descriptions can allow scientists to communicate their findings to other scientists. A **description** is a statement or drawing detailing the physical properties of an object, organism, or event. A description is intended to give others a picture of the object.

To see small things more clearly, scientists use microscopes (MI•kruh•skohps). A hand lens is a handheld magnifying glass that makes objects look larger. A hand lens is a *simple microscope*, or a microscope with only one lens. Scientists use hand lenses to make more detailed descriptions of things such as rocks, insects, plants, and soil.



You can use a hand lens to make more detailed descriptions of objects, such as this butterfly.

Science Background

Standard Units

For a unit to be useful, it must always be the same. For example, a meterstick at two different locations must always measure the same length. The *meter* was first defined in terms of the circumference of Earth. A meter has also been defined both as the length of a metal bar kept at a constant temperature and as a multiple of a certain wavelength of light. None of these methods was accurate enough. A meter is now defined as the distance traveled by light in a certain fraction of a second.

Observing Cells

These cells are too small to be observed and described without using a microscope.

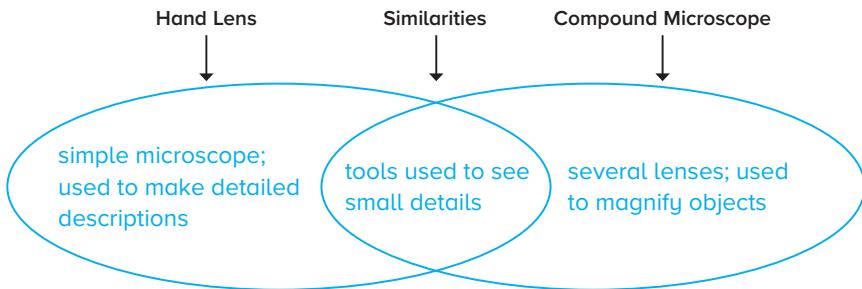


To magnify things that are very small, such as cells, scientists use *compound microscopes*. Compound microscopes have several lenses. You may have seen a compound microscope in your classroom. Some of the compound microscopes scientists use are very powerful. They can make a cell look hundreds of thousands of times larger!

Atoms are incredibly small. They cannot be seen with ordinary microscopes. Special electron microscopes are used to observe

 Quick Check

1. How do a hand lens and a compound microscope compare?



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EXPLAIN

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT

EXTRA SUPPORT Have small groups of students use a hand lens to observe three familiar objects. Have each student draw a picture of one of the magnified images and write a description that includes three observable properties of the object.

ADVANCED

ADVANCED Provide each student with a prepared slide of a thin section of onion skin, a lettuce leaf and/or a leaf of Elodea with a hand lens and a then a microscope (under low power). Have them describe in detail the differences in the observable properties they noticed.

► **Discuss the Main Idea**

Provide students with an opportunity to see and use a hand lens and a microscope. Have students share any past experiences with using these tools. Demonstrate how to hold and carry the microscope properly. Stress the need for never pointing the mirror directly at the Sun or another bright light. You might want to show a small group of students how to use the microscope and then have them work with others. Ask:

- How does a hand lens help scientists observe objects? It magnifies an image of the object so that scientists can make more detailed descriptions.
- Why are microscopes important in scientific work? Possible answer: Scientists can observe and describe the physical properties of very small objects, such as cells

► Academic Vocabulary

observation *Word Origin* Point out that the word *observation* comes from the Latin *observare* which means “to watch over.”

description *Word Origin* Explain that the word *description* comes from the Latin *descriptionem* which means “to write down, or to copy.”

How are physical properties measured?

► Discuss the Main Idea

Write the term *measurement* on the board. Explain that a measurement is a precise expression of a physical property. Display a student's backpack. Ask students to list some of the measurable properties of the backpack. As students respond record their answers on the board. Ask:

- Which properties can be used to measure a backpack? **Possible answers:** length, width, weight
- Why is it useful to use measurements when describing physical properties? **to be more precise**
- How do we find the measurable properties of an object, such as length or weight? **We use tools such as rulers and scales.**

How are physical properties measured?

As you have learned, many different physical properties can be used to describe an object. Your description of a ball might include words such as *round*, *red*, *smooth*, *big*, and *light*. The words *round*, *red*, and *smooth* are good descriptions of the ball. But *big* and *light* are not very precise words. A more precise way to describe the size and weight of the ball would be to give its measurements. A **measurement** is a precise expression of a physical property, such as length or mass, in specific units, such as centimeters or grams.

Most people throughout the world use the International System of Units (SI) to measure objects' physical properties. Standard metric units, such as centimeters, milliliters, and grams, are used in this system. These are the units you use in science class.

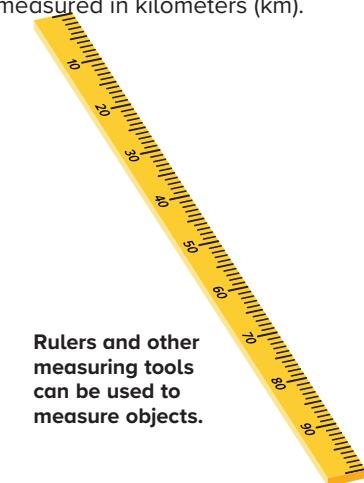


You might describe this ball as *big*, but how *big* is it? Measurements of its height and mass would give a more accurate description.

How do we take different types of measurements of an object? Specific tools and mathematical equations can help us.

Length, Width, and Height

To measure the length, width, or height of an object, you can use a metric ruler or tape measure. Depending on the size of the object, you may use millimeters, centimeters, meters, or even kilometers as the unit. A matchbox might be measured in millimeters (mm) or centimeters (cm). A table might be measured in meters (m). A road would likely be measured in kilometers (km).



Rulers and other measuring tools can be used to measure objects.

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EXPLAIN

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT What are some examples of objects you can measure with a metric ruler? **length of desk, height of a friend, width of a door**

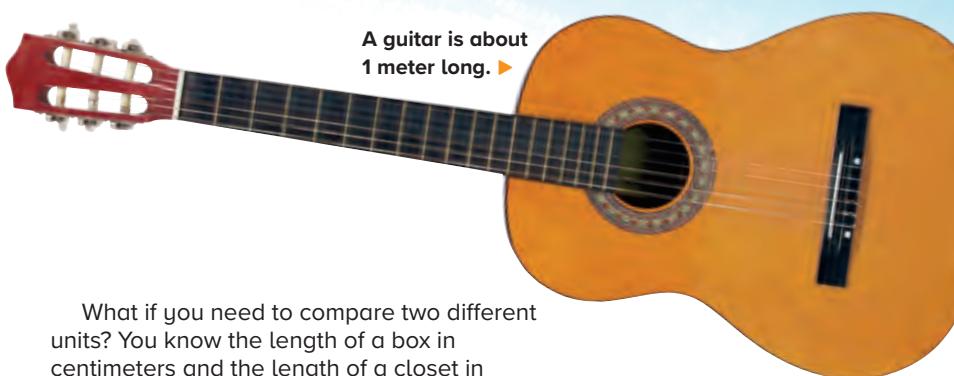
ADVANCED How is comparing the length of two objects different from comparing their colors? **Comparing length is comparing a measurable property. You need to use numbers and a tool such as ruler to find length. Comparing color is comparing an observable property. You use your sense of sight to state the color. You use words instead of numbers.**



A dirham is about 1 millimeter thick.



A button is about 1 centimeter wide.



A guitar is about 1 meter long.

What if you need to compare two different units? You know the length of a box in centimeters and the length of a closet in meters. To determine how many boxes will fit into the closet, you must convert the units, or change the units from one type to another.

You can convert to smaller or larger metric units by multiplying or dividing by powers of 10. To convert centimeters to meters, divide by 100. A box that is 47.3 cm long is 0.473 m long. To convert meters to centimeters, multiply by 100.

Quick Check

2. How does a centimeter compare to a kilometer?

A centimeter is 1/100,000 of a kilometer.

Common Metric Unit Prefixes	
Prefix	Meaning
Kilo- (k)	1,000
Deka- (da)	10
Deci- (d)	0.1
Centi- (c)	0.01
Milli- (m)	0.001

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EXPLAIN

Use the Visuals

Refer students to the pictures.

- How could you measure the distance around the red ball? Possible answer: Use a tool that measures length such as a tape measure.
- Which metric unit would you use to measure the thickness of a Dirham? millimeter
- Which metric unit would you use to measure the length of a guitar? meter

Address Misconceptions

A common misconception is that length measures only how tall something is.

FACT Any measurement that shows how far it is from one point to another is a measurement of length.

Have students name other terms that indicate measurements of length. Measurements such as height, depth, circumference, radius and width are measurements of length. Show students several objects of different shapes and ask them to list the properties of the object they could measure using a ruler.

Develop Vocabulary

measurement Point out to students that a measurement is made by comparing a quantity with a standard unit. For example, you compare the guitar's length with the units that fit across it.

How are mass and weight measured?

► Discuss the Main Idea

Ask students if they have ever used a balance to find mass. Have students talk about their experiences. Then show them a pan balance. Tell students that this object has two names. It can be called a pan balance or a metric balance depending on how it is used. A pan balance compares the mass of two objects. A metric balance uses standard pieces called gram masses to find the mass of an object. Ask:

- **How is a balance similar to a scale?** They both are instruments used for measurement.
- **How is a balance different from a scale?** A balance compares known masses to unknown masses.
- **What units do scientists use to measure mass?** grams, kilograms
- **How many grams in a kilogram?** 1,000

Quick Lab



small groups



15 minutes

Comparing Mass and Weight

See the Quick Labs in the Activity Lab Manual.

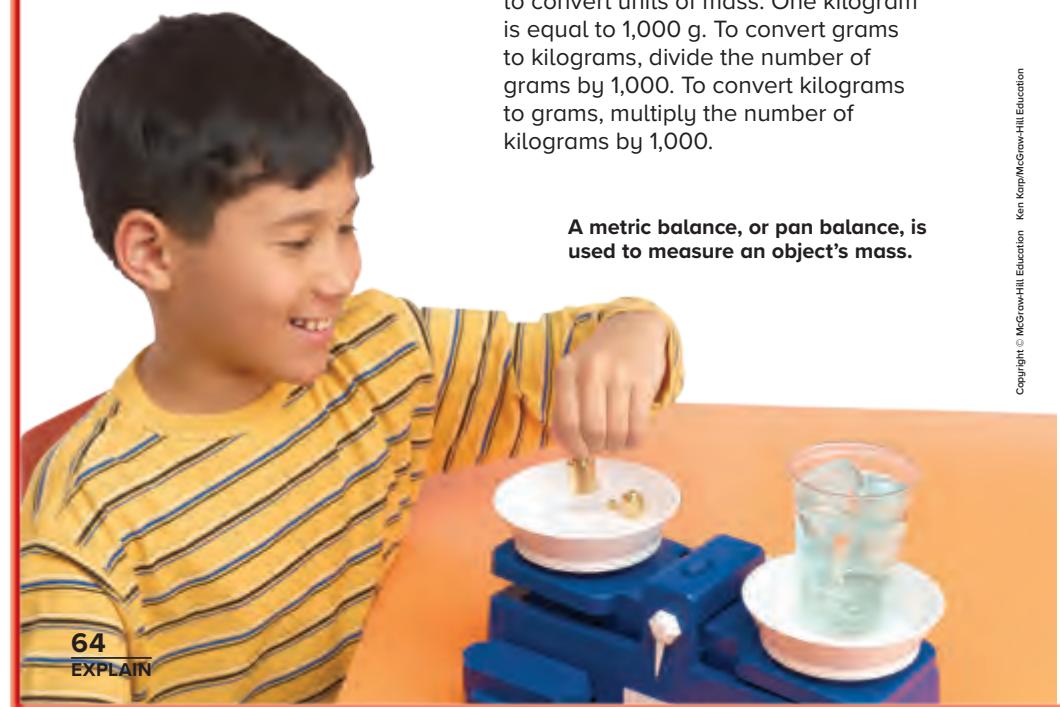
Objective Understanding the difference between mass and weight.

Materials balance with weights, spring scale, textbook, notebook, (If using hanging spring scales, spiral bound notebooks are recommended. String may also be needed.)

- 2 Have students record data in a data table. In most cases the textbook will have more mass than the notebook.
- 3 If using a hanging spring scale, have students tie string around the textbook both horizontally and vertically so that the book may be suspended safely from the hook. Spiral-bound notebooks may be suspended from the binding wire.
- 4 Accuracy of predictions will vary. **Objects with more mass also have more weight.**

Quick Lab

To compare mass and weight, complete the Quick Lab in the activity workbook.



A metric balance, or pan balance, is used to measure an object's mass.

LA Support

Ask Questions Ask students to name the tools shown in this lesson and tell what each is used to measure. Have students find the mass of several objects in the classroom and then report the results.

BEGINNING

Students can point to the photograph of each tool and say its name and what it measures.

INTERMEDIATE

Students can name the tool and use phrases and short sentences to state what it measures.

ADVANCED

Students can use full sentences to state what the tool measures and give the masses of the objects.

Weight

As you learned, weight is how strongly gravity pulls on an object. To measure an object's weight, we use a scale. Many scales use springs to measure weight. These are known as **spring scales**. When you step onto a spring scale, gravity pulls you downward. This compresses, or squeezes, the spring inside the scale. The more you weigh, the more the spring is compressed. Other types of spring scales measure an object's weight when you hang the object from the spring scale. Gravity pulls the object downward, stretching the spring.

Many countries use grams and kilograms to measure weight. However, scientists measure weight in newtons (N). On Earth, 1 kg is equal to about 9.8 N. To convert kilograms to newtons, multiply the number of kilograms by 9.8.

Amount of Matter

On Earth, both mass and weight can be used to compare amounts of matter. If the location of an object does not change, then the pull of gravity on the object does not change. As a result, the object's weight is proportional to its mass. If the mass of object A is twice the mass of object B, then the weight of object A is also twice the weight of object B as long as both objects remain on Earth. Using either measurement, you would describe object A as having twice the amount of matter as object B.

Quick Check

3. The pull of gravity on Jupiter is 2.53 times higher than that of Earth. Would your weight be higher or lower on Jupiter? What about your mass? Explain.

Possible answer: Your weight would be greater on Jupiter but your mass would be the same.



▲ Many bathroom scales are spring scales.



▲ Spring scales are often used in science to determine the weight of an object.

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EXPLAIN

Differentiated Instruction**Leveled Activities**

EXTRA SUPPORT How is weight different from mass? Weight depends on the pull of gravity. Mass is the same no matter what the gravity is.

ADVANCED Would you jump higher on Jupiter or on Earth. Why? I would jump higher on Earth, because the pull of gravity is less on Earth than on Jupiter.

Discuss the Main Idea

Explain to students that a spring scale is used to find weight. Weight is a different measurement from mass. Weight is based on the pull of gravity on the object. Mass is the amount of matter in the object. Scientists measure weight in newtons. There are about 9.8 kilograms in 1 newton. Ask:

- What can you use to measure weight? a scale
- How would your mass on the Moon compare with your mass on Earth? It would be the same.
- How would your weight on the Moon compare with your weight on Earth? It would be different. It would be less on the Moon than on Earth.

Develop Vocabulary

metric balance Point out to students that the term *metric balance* contains two words. A *balance* is a tool that compares the amount of matter in two objects. A *metric balance* uses standard pieces called gram masses to find the mass of an unknown object.

spring scales Explain to students that this term is also made up of two words. Draw a picture of a spring on the board. Tell students that a spring is an object that stores energy. A *scale* is a device used for weighing. A spring scale uses a spring to measure an object's weight. The more an object weighs the more the spring is compressed or pushed down by gravity.

How is volume measured?

► Discuss the Main Idea

Write the term *volume* on the board. Review with students that volume is the amount of space an object takes up. Tell students that they will learn three different ways to measure volume. Draw a rectangular solid on the board. Label the sides “6 cm”, “4 cm”, and “3 cm”. Demonstrate for students how to find the volume of a rectangular solid by multiplying the length, width and height. Ask:

- **What do you need to do first to find the volume of a book? use a metric ruler to find the length, width and height**
- **What is the second step? multiply the length by the width by the height**

► Explore the Main Idea

Bring in several different objects such as books and cereal boxes. Have students use a metric ruler to measure the length, width and height of the object. Then direct the students to multiply the three numbers together to calculate volume.

How is volume measured?

Recall that volume is the amount of space that matter takes up. Depending on the object, there are different ways to measure volume.

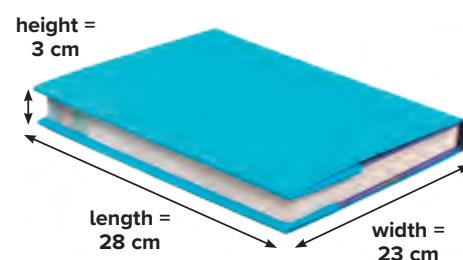
Regularly Shaped Solids

You can use a formula to find the volume of a solid object with a regular geometric shape. For a rectangular object such as a book, multiply its length by its width by its height.

$$\text{volume} = \text{length} \times \text{width} \times \text{height}$$

If your length, width, and height measurements are in centimeters, the volume will be in cubic centimeters (cm^3). A *unit cube* is a cube with sides that are each 1 unit long. It holds one cubic unit of volume. A unit cube with 1-cm sides has 1 cm^3 of volume. A book with a volume of $1,900 \text{ cm}^3$ equals 1,900 of these unit cubes. In other words, 1,900 1-cm unit cubes stacked together would take up the same amount of space as the book does.

A graduated cylinder is used to measure liquid volume. ►



Read a Diagram

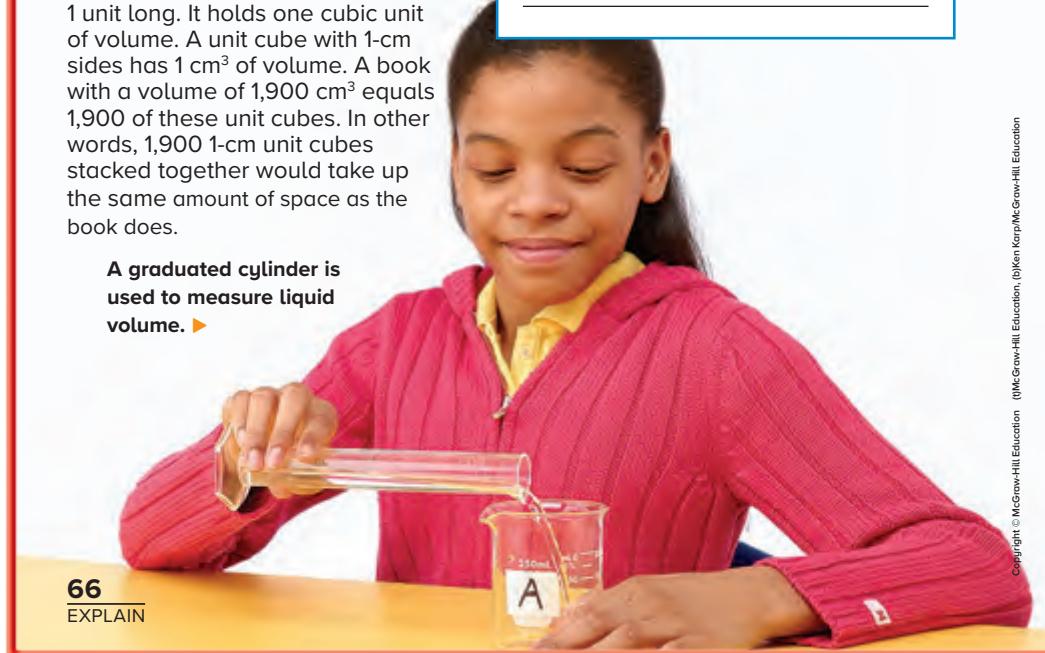
What is the volume of this book? Explain how you determined your answer.

Clue: Look at the book's dimensions.

$$\text{Volume} = \text{length} \times \text{width} \times \text{height}$$

$$\text{The volume of the book} = 28 \text{ cm} \times$$

$$23 \text{ cm} \times 3 \text{ cm} = 1932 \text{ cm}^3$$



LA Support

Make a Table Review how to find the volume of a regular solid. Provide groups of students with two boxes of different sizes. Ask them to use a metric ruler to find the volume of each box and then record their measurements in a table.

BEGINNING Students can point to each box and say its volume in metric units.

INTERMEDIATE Students can point to each box and use phrases and short sentences to say how they found the volume of each box.

ADVANCED Students can use full sentences to state how they found the volume of each box and to state the volume of each box.

Liquids

You can use a beaker or a graduated cylinder to find the volumes of liquids. A **graduated cylinder** is a tall, narrow, clear container used for measuring the volume of a liquid. Marks on the outside of it indicate the number of milliliters. When reading a liquid's volume, make sure to view the liquid at eye level. The volume of a liquid is expressed in milliliters (mL) or liters (L). In volume measurements, 1 L is equal to 1,000 mL. Multiply the number of liters by 1,000 to get the number of milliliters of a substance.

To find the volume of an irregularly shaped object, such as a rock, fill a beaker or graduated cylinder partway with water. Note the water level. Then place the object into the water. Read the new water level. Subtract the first water level from the second water level. This will give you the object's volume in milliliters. This method of finding volume is known as displacement. One milliliter is equal to 1 cm^3 . A rock with a volume of 50 mL has a volume of 50 cm^3 .

Quick Check

4. How is measuring the volume of a solid different from measuring the volume of a liquid?

A liquid must be measured
in a container, but a
solid can be measured
with a ruler and have the
dimensions multiplied.

Read a graduated cylinder at eye level.
This graduated cylinder contains 195 mL of liquid. ▶

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EXPLAIN**Differentiated Instruction****Leveled Activities**

EXTRA SUPPORT Have students practice measuring the volume of several different liquids using a graduated cylinder. Make sure that students are reading the volume at eye level.

ADVANCED Instruct these students to pour equal volumes of water into two graduated cylinders. Have them add a small object to one of the cylinders and compare the two volumes. Repeat with two or three other objects until students are familiar with the processes of finding the volume of irregularly shaped solids.

▶ Discuss the Main Idea

Discuss how to measure the volume of a liquid. Hold up a 10-mL graduated cylinder marked in millimeters. Point to the marks having numbers. Ask:

- What do these marks show? **a number of millimeters**
- How do you look at a liquid when measuring its volume? **at eye level**

▶ Use the Visuals

Call students' attention to the graduated cylinder. Tell students that this method of finding the volume of an irregularly shaped solid is known as *displacement*.

- How much liquid does this graduated cylinder contain? **about 195 mL**
- If the starting volume of liquid in this graduated cylinder was 150 mL, what is the volume of the rock? **45 mL**

▶ Develop Vocabulary

graduated cylinder Show students a graduated cylinder. Point out to students that the term graduated cylinder contains two words. Tell them that the word *cylinder* refers to the shape of the tool. This tool has two flat ends with one curved side. Graduated means that a tool contains markings or divisions.

How is temperature measured?

► Discuss the Main Idea

Discuss with students how they could measure the temperature in the classroom. Show students a thermometer. Throughout the world, the Celsius scale is most commonly used for measuring temperature. However, many thermometers have two scales on them, one for Celsius and one for Fahrenheit. If your thermometer has two scales, point them out to the students. Ask:

- Suppose you see a temperature written as “35 degrees”. Is this a complete measurement? Why? **No, the measurement must say what unit the temperature was measured in.**
- How is the Kelvin scale different from the Celsius scale? **It has no negative numbers, and does not use the word degrees.**
- At what temperature does water boil in degrees Celsius? and in kelvin? **100 °C; 373 kelvin**

How is temperature measured?

A thermometer is used to measure temperature. Commonly used temperature scales include the Fahrenheit scale (°F), the Celsius scale (°C), and the Kelvin scale (K). In science, most temperature measurements are in degrees Celsius. The Kelvin scale has no negative numbers. The Kelvin scale does not use the word “degrees.” It simply uses the term “kelvin,” such as “312 kelvin.”

There are many different kinds of thermometers. One kind is a liquid-in-glass thermometer. A clear glass tube contains a liquid. The liquid expands when it gets warmer. You read the temperature by looking at the mark at the level of the liquid.

Types of Thermometers



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EXPLAIN

A dial thermometer contains a coiled strip made of two metals. The strip expands when it gets warmer. A liquid crystal thermometer is a plastic strip filled with substances that change color at particular temperatures. An electronic or digital thermometer has an electronic sensor that detects the temperature of an object.

Read a Photo

How do the thermometers shown here compare?

Clue: Look at how each thermometer indicates temperature.

Each thermometer uses a different method for measuring temperature.

Some are more precise than others.



dial thermometer



liquid-in-glass thermometer



digital or electronic thermometer

LA Support

Developing Vocabulary Write the word *measurements* on the board and have students repeat it after you. Explain what measurements are, and why they are important. Write the terms *mass*, *weight*, *volume* and *temperature* on the board and discuss them with students. Ask students if they can name tools for measuring each property. Write their responses on the board. Elicit metric balance, spring scale, graduated cylinder and thermometer.

BEGINNING Students can point to or name different tools for measuring mass, weight, volume, and temperature.

INTERMEDIATE Students can use phrases and short sentences to describe how to use a metric balance, spring scale, graduated cylinder, and a thermometer.

ADVANCED Students can use full sentences to describe how to measure mass, weight, volume, and temperature.

Teacher Notes

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 4 Lesson Review

Visual Summary

Complete the lesson summary in your own words.



Observation and Description Possible answer:

Scientists learn about properties through observation and communicate them using description.



Properties of Objects Possible answer: Objects can

be described by properties such as length, weight, and mass.



Volume and Temperature Possible answer: Volume

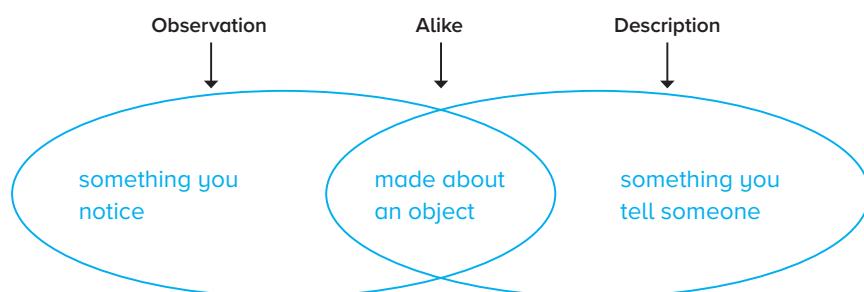
can be found by using a formula or displacement.

Temperature is measured using a thermometer.

Think, Talk, and Write

1 **Vocabulary** A tall, narrow, clear container used for measuring the volume of a liquid is a(n) graduated cylinder.

2 **Compare and Contrast** How are observation and description of an object the same? How are they different?



3 **Critical Thinking** Would a balance on the Moon, which has one-sixth the gravity of Earth, still read masses correctly? Why or why not?

Yes, because a balance measures the mass of an object, which doesn't change.

4 **Test Prep** Which property measures the space taken up by an object?

A volume C temperature
B mass D weight

5 **Test Prep** Which property depends on the pull of gravity?

A volume C temperature
B mass D weight

Essential Question How can the properties of objects be measured?

Quantitative properties can be measured with tools such as rulers, scales, balances, and thermometers.

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your thinking changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

Focus on Skills

Plan Ahead

Prepare a plan for students who are challenged using one or more senses. Provide a way for them to observe, measure and compare objects.

You will need to select and measure the mass, volume, and weight of a mystery object before beginning the activity.

If you do not have enough metric balances, graduated cylinders, or spring scales you may want to set up this activity with separate stations for measuring mass, volume, and weight. Pairs of students can then rotate through the stations.

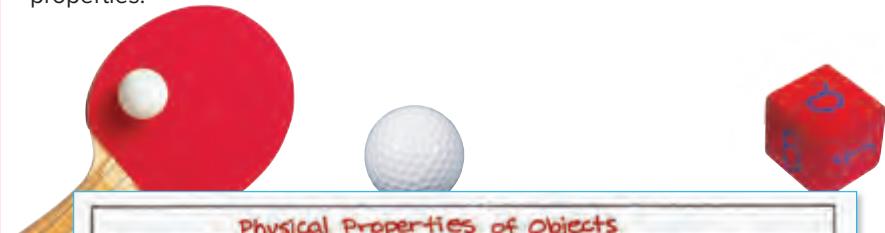
Objective In this activity, students will observe, measure, and compare the physical properties of several objects to identify a mystery object.

Materials metric balance with gram masses, graduated cylinder, water, spring scale, pencil, and a metric ruler. You will also need the following objects: wooden block, sugar cube, golf ball, table-tennis ball, piece of chalk, and a plastic spoon. If you do not have all of these objects you may substitute a similar object. For example, a super ball can be substituted for a golf ball, and plastic math cube could be substituted for either the wooden block or the sugar cube. You may also want to have some string available for students to use to attach the objects to the spring scale.

Focus on Skills

Inquiry Skill: Measure

Matter is the “stuff” that makes up all things. Millions of different things exist in this world. How do scientists distinguish one thing from another? One way is to **measure** and compare the objects’ common physical properties.



Physical Properties of Objects

Object	Color	Texture	Mass (g)	Volume (cm ³)	Density (g/cm ³)
wooden block					
sugar cube					
golf ball					
table-tennis ball					
sheet of paper					
piece of chalk					
plastic spoon					

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EXTEND

Integrate Math

Mystery Objects

Instruct each student to write a paragraph describing a mystery object. The paragraph should provide details about the object’s observable and measurable properties, but not its name. When students are finished writing, direct them to trade papers with a classmate and to identify their mystery object.

Skill Builder

► Learn It

To **measure** is to find the size, distance, time, volume, area, mass, or temperature of an object. It is important to record measurements. If you use a table to record information, you will be able to see your data at a glance.

Density is one physical property that can be measured. Density is the ratio of mass to volume. To find the density of an object, divide its mass by its volume. Mass can be measured in grams, and volume can be measured in cubic centimeters, so density can be stated in grams per cubic centimeter.



You can use water to find the volume of some objects.



The displaced water equals the object's volume.

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EXTEND

Inquiry Skill: Measure

► Learn It

- Review with students that an object's properties can be measured in several ways, such as length, volume, mass, or weight.
- Display each measuring tool and discuss their uses. For example, a metric balance is used to measure mass, a graduated cylinder is used to measure volume of a liquid, and a spring scale is used to measure weight.
- Remind students that a measurement is expressed by a number followed by the proper unit of measurement.

Teacher Notes

► Try It

Provide students with a description of the physical properties of the mystery object. Instruct students to create a table like the one on the student page with the set of properties.

Explain to students that they will observe and measure the properties of the objects listed in the data table. Direct them to write in the column headings. Guide them to use the properties listed in the Mystery Matter chart. Make sure they title their data table.

- 2 If needed, demonstrate for students how to measure mass using gram masses. Instruct them to place the object on one side of the balance. Then one by one they should place gram masses on the other side of the balance. When the two sides are even tell them to stop. Direct them to add the gram masses to find the actual mass of the object. Remind them to record the mass in the table.
- 3 Remind students that they will need to use a metric ruler to find the length, width, and height of the object.
- 4 Tell students to let you know if any water spills so it can be wiped up immediately.
- 5 If needed, demonstrate for students how to use a spring scale. Have students hold it by the top loop and then put the object on the bottom hook and slowly let it go. Wait for the object to stop moving. Read the number of newtons next to the tab. This is the object's weight. Students may need to use string to attach some of the objects to the spring scale.

Focus on Skills

► Try It

Of the objects listed in the table on page 86, which do you think matches the “mystery matter” described in this box? Find out whether you are right. Here’s how.

Materials wooden block, sugar cube, golf ball, table-tennis ball, sheet of paper, piece of chalk, plastic spoon, balance, gram weights, ruler, graduated cylinder, water, pencil

- 1 Observe the color and texture of each object. *Answers will vary.*
- 2 Record the information on the table below.

Object	Color	Texture	Mass	Volume	Density

- 3 **Measure** and record each object’s mass in grams using the balance and a standard mass set.
- 4 Find the volume of regularly shaped rectangular objects using this formula: $\text{volume} = \text{length} \times \text{width} \times \text{height}$. Record the results in your table.
- 5 To find the volume of the irregularly shaped objects, partially fill a graduated cylinder with water, and **measure** the volume. Put the object into the cylinder. If the object floats, use a pencil point to push it under the water. **Measure** the new volume. Then subtract the volume of the water alone from the volume of the water with the object in it. Record this as the object’s volume in your table.
- 6 Calculate the density of each object. Record the data in your table.

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EXTEND

Integrate Math

Measuring Matter

To complete the Focus on Skills Skill Builder, students will need to know how to use some common measuring tools and understand some common measuring units used in science. Write the words *mass*, *volume*, and *weight* on the board. For each word have students name a tool used to measure the property and at least two units of measurement. *mass*: metric balance, gram, kilogram; *volume*: graduated cylinder, cubic centimeter, milliliter; *weight*: spring scale, newton.

Skill Builder

► Apply It

1 Which object had the lowest density? Which was the “mystery matter”? Will a smaller object always be lighter than a larger one?

Answers will vary. Accept all reasonable responses.

- 2 Make a bar graph to display your density measurements. Draw a picture of each item, and then color in bars to compare at a glance the actual densities of the objects from least to greatest density.
- 3 Choose some items from your classroom. Predict which of them will have the lowest density. **Measure** the mass and volume of each object, and then calculate its density. Was your prediction correct?

Answers will vary. Accept all reasonable responses.

Teacher Notes

CHAPTER 1 Review

► **Visual Summary**

Have students look at the pictures to review the main ideas of the chapter.

CHAPTER 1 Review

Visual Summary

Visual Summary



Becoming a Scientist

Science is a way of learning about the natural



Scientific Method

The scientific method is a process scientists use to answer their questions.



Tools of The Scientist

Scientists perform investigations and make observations to collect precise data.



Making Measurement

Scientists use tools to make measurements.

76 Chapter 1 • Review

Teacher Notes

Vocabulary

Fill in each blank with the best term from the list.

consistency	mean
data	metric balance
dependent variable	scientific method
hypothesis	spring scale
independent variable	technology

1. The variable that is measured during an investigation is called the dependent variable.
2. A series of steps that scientists use when conducting a scientific investigation is called the scientific method.
3. Information gathered during a scientific investigation is called data.
4. Scientists use consistency to be sure that tasks and procedures can be repeated with minimal variation.
5. An object's mass is measured with a metric balance.
6. The mean of a set of numbers is the sum of the numbers divided by the number of entries in the data set.
7. The use of science to meet human wants and needs is called technology.
8. The independent variable in a controlled experiment is the variable that is changed.
9. A hypothesis in an investigation is a prediction that can be tested.
10. A spring scale is used to measure weight.

Depth of Knowledge

Level 1 Recall Level 1 requires memory of a fact, a definition, or a procedure. At this level, there is only one correct answer.

Level 2 Skill/Concept Level 2 requires an explanation or the ability to apply a skill. At this level, the answer reflects a deep understanding of the topic.

Level 3 Strategic Reasoning Level 3 requires the use of reasoning and analysis, including the use of evidence or supporting information. At this level, there may be more than one correct answer.

Level 4 Extended Reasoning Level 4 requires the completion of multiple steps and requires synthesis of information from multiple sources or disciplines. At this level, the answer demonstrates careful planning and complex reasoning.

CHAPTER 1 Review

CHAPTER 1 Review

Skills and Concepts

11. **Use Variables** When scientist want to study how well new medicines work, one group of patients receives the medicine, and the other group does not. Explain why.

The group that receives the medicine is the test group and the one that does not is the control group. At the end of the test you can compare the test group to the control group to see if the medicine worked.

12. **Infer** Why is it important for scientists to communicate information about their work and their progress?

Possible answer: By sharing information, scientists can learn more faster.

13. **Communicate** Explain why an experiment must be verified through multiple investigations before the findings can be accepted.

Possible answer: Multiple investigations rule out human error and other variables that may change the results of a test.

14. **Summarize** Describe three safety procedures that should be followed when conducting a scientific investigation.

Wear proper safety equipment such as safety goggles and aprons, wash hands before and after an investigation, and know the location of safety equipment and how to use it.

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Chapter 1 • Review

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Teacher Notes

15. Infer Explain what a scientist would do after she is finished collecting data.

Possible answer: After collecting data, a scientist would analyze the data

to determine if the hypothesis was correct or needs to be revised and retested.

16. Which type of display would best show the number of wins for each football team in your school district?

- A line graph
- B circle graph
- C bar graph
- D metric units

17. Predict Select a career in science that uses a type of technology. Explain how this career would be different if the technology had not been invented.

Answers will vary. Possible answer: Microbiologists use powerful

microscopes to study microorganisms. If the powerful microscopes had not been invented, they wouldn't be able to visually study microorganisms.



18. How do scientists perform scientific investigations?

Students should use information from the chapter to answer.

Scientists use the scientific method to design and conduct their investigations. They use the proper tools to measure the data and follow safety procedures. They also record their procedures and their results so other scientists can perform the same investigation to confirm their results.

Teacher Notes

Test Preparation

1. (B): the height from which the ball is dropped. The rubber ball and its mass do not change, so they are controlled variables. The height of each bounce is measured, so this is the dependent variable.
2. (D): City B has cooler spring temperatures than City A and receives more rainfall in April and May. The remaining three choices contradict information found in the table.
3. (A): grams. The tool is a balance that measures mass in metric units. Pound is not a metric unit, and meters and cubic centimeters are used for measuring length and volume respectively. Therefore, none of these are used to measure mass.
4. (D): circle graph. The composition of gases in Earth's atmosphere is best seen in a circle graph, showing how the whole atmosphere is divided into parts.
5. (A): The liquid in the middle beaker is darker in color than the other liquids. The only information that we can draw from the picture is the different shades of color, other information such as concentration, mass, and solutes in the liquids remains unknown. Answer choices B and C are also explanations, not descriptions.

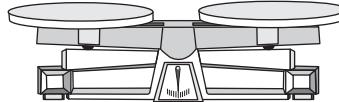
Test Prep

Circle the best answer for each question.

1. Hala is conducting an experiment to see if the height from which she drops a rubber ball will affect the height to which the ball bounces. Which is the independent variable in her experiment?
A the rubber ball
B the height from which the ball is dropped
C the height the ball bounces
D the mass of the ball
2. The table below shows the spring temperatures and rainfall averaged by month for two cities.

City A	March	April	May
Average Temperature	6°C	12°C	19°C
Average Rainfall	43cm	38cm	8cm

City B	March	April	May
Average Temperature	5°C	9°C	12°C
Average Rainfall	10cm	71cm	41cm

Which conclusion can be drawn from the data?
A City A has colder spring temperatures than City B.
B The spring temperatures in City A do not vary as much as the spring temperatures in City B.
C City A receives more rainfall than City B throughout spring.
D City B has cooler spring temperatures than City A and receives more rainfall in April and May.
3. Faris is conducting a scientific investigation using the tool below. Which metric system unit is Faris most likely to record with his data?

A grams
B pounds
C meters
D cubic centimeters
4. Which type of graph should be used to show the composition of gases in Earth's atmosphere?
A line graph
B scatter plot
C bar graph
D circle graph
5. Which is an accurate description of the liquids below?

A The liquid in the middle beaker is darker in color than the other liquids.
B The liquid in the beaker on the right is lighter in color because the liquid is more concentrated.
C The liquids all have the same mass.
D The differences in color are a result of the different solutes in the liquids.

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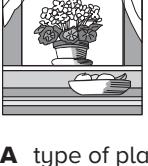
Chapter 1 • Test Prep

Teacher Notes

6. Why would scientists want to calculate the range of a set of data?

A to identify the middle number in the data set
B to understand the amount of variation in the data set
C to make sure the procedures were followed correctly
D to identify the lowest number in the data set

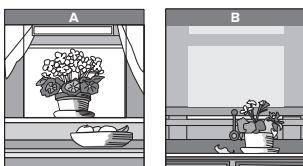
7. Which was the independent variable in the experiment below?



A type of plant
B health of plant
C amount of sunlight
D number of flowers

8. Which tool would a scientist use to find the volume of a small amount of water?

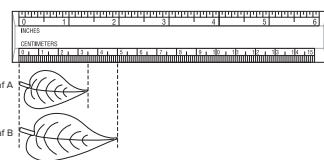
A graduated cylinder
B thermometer
C balance
D computer



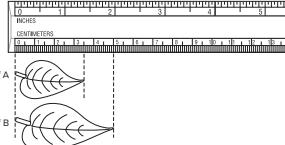
- A type of plant
- B health of plant
- C amount of sunlight
- D number of flowers

8. Which tool would a scientist use to find the volume of a small amount of water?

- A graduated cylinder
- B thermometer
- C balance
- D computer



9. What is the length of Leaf B in metric system units?



A 2 inches
B 2 centimeters
C 5 centimeters
D 2.5 centimeters

10. Which is an important safety rule to follow while conducting a scientific investigation?

A Ask questions only after you have finished completing the investigation.

B Read only the last step in an investigation.

C Avoid washing your hands after an investigation.

D Wear safety goggles and protective clothing when working with chemicals.

6. (B): to understand the amount of variation in the data set The range is the difference between the greatest and least values, so it shows the variation in the data, but does not ensure that procedures are followed correctly. The middle number of a data set is the median, while the lowest number is the minimum.

7. (C): amount of sunlight The type of plant and the number of flowers are the same, so they are controlled variables. The health of the plant is measured, so it is the dependent variable.

8. (A): graduated cylinder A graduated cylinder usually measures milliliters (mL) and would be a good choice for measuring an amount of water less than 100 mL. None of the other tools listed can measure volume.

9. (C): 5 centimeters Leaf B is 5 centimeters in metric units.

10. (D): Wear safety goggles and protective clothing when working with chemicals. Proper safety equipment should always be used, especially when working with chemicals. Students should also ask questions that may arise during an investigation, read all procedure steps before beginning, and wash hands before and after an investigation.

Teacher Notes

Careers in Science

Objective

- Summarize the responsibilities of astronomers.

Astronomer

Genre: Nonfiction Students should notice that the photograph shows a real person busy at his job. Ask: **What clues tell you that this page is about people at work?** The photo shows a man working at serious tasks.

Talk About It

- Ask: **What kinds of things do astronomers study?**
Possible answers: our solar system, the Moon, stars, comets, asteroids, the Sun

Learn About It

- Ask: **What skills do astronomers need?** math skills, a good understanding of physics, strong computer skills

Write About It

Have small groups of students research the training and/or education needed for this career. Have them write a report about their findings.

Careers in Science

Astronomer

Are you interested in looking for planets around distant stars or watching solar systems form? Astronomers study the stars and learn about the other planets and suns in the universe. As an astronomer, you would use telescopes and satellites to gather data about other solar systems. Then you would interpret that data to find out what the stars and the planets are made of and how old they are. To be an astronomer, you need to be good at math and physics, have strong computer skills, and obtain a doctoral degree in astronomy. After that, you might say the sky's the limit!



▲ Astronomers observe stars and planets.



Write About It

What might a day in the life of an astronomer be like? Write a journal entry from the point of view of an astronomer. Describe your daily routine and any discoveries you might make.

Students' journal entries may vary. Accept all reasonable responses.

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Integrate Writing

Career Journal

Ask students to research and write a journal entry about something that astronomers do, such as searching for undiscovered planets. Have students answer the following questions in their entry:

- How did they become interested in this field?
- What types of things do they do when they perform this work?
- What is the most challenging part of their job?
- What do they like the most about their job?

Teacher Notes

CHAPTER 2 Planner

Lesson	OBJECTIVES AND READING SKILLS	VOCABULARY
1 Reproduction PERIODS : 8	<ul style="list-style-type: none"> Explain sexual and asexual reproduction. Compare and contrast sexual and asexual reproduction. <p>Reading Skill Sequence</p>	sexual reproduction fertilization asexual reproduction vegetative propagation runners
2 Plant Life Cycles PERIODS : 8	<ul style="list-style-type: none"> Describe the life cycles of mosses and ferns. Learn about the angiosperm life cycle. Understand the conifer life cycle. <p>Reading Skill Cause and Effect</p>	pollination pollen embryo seed coat germination monocot dicot conifer
3 Animal Life Cycles PERIODS : 8	<ul style="list-style-type: none"> Define complete and incomplete metamorphosis. Discuss fertilization and explain how the processes of external and internal fertilization work. <p>Reading Skill Compare and Contrast</p>	metamorphosis complete metamorphosis larva pupa incomplete metamorphosis nymph external fertilization internal fertilization

PACING

Assumes a period is a 35- to 45-minute

Activity Planner

EXPLORE Activities

Explore PACING: 25 minutes

Objective Predict how a plant can grow without seeds.

Skills observe, interpret data, infer

Materials philodendron plant, scissors, hand lens, plastic cup, water, 2-week-old cutting in a plastic cup

 **PLAN AHEAD** Begin growing cuttings two weeks before the activity.

QUICK LAB Activities

Quick Lab PACING: 15 minutes

Objective Compare different types of asexual reproduction.

Skill communicate

Materials books, magazines, poster board

 **PLAN AHEAD** Gather research materials for research.



Explore PACING: 25 minutes

Objective Hypothesize about conditions needed to grow plants and test those hypotheses.

Skills experiment, observe, infer

Materials paper towels, 4 plastic cups, water, lima bean seeds, potting soil

 **PLAN AHEAD** Plan to spend five minutes per day for two weeks.

Quick Lab PACING: 15 minutes

Objective Observe different types of seeds and predict how they are dispersed.

Skills observe, predict

Materials different types of seeds, hand lens

 **PLAN AHEAD** Some seeds have sharp points. Show students how to handle with care.

Explore PACING: 20 minutes

Objective Examine data to determine how frogs change during their life spans.

Skills observe, interpret data, infer

Materials photographs of animals

 **PLAN AHEAD** Enlarge the photos to conduct a whole-class activity.

Quick Lab PACING: 15 minutes

Objective Model the process of external fertilization.

Skills make a model, infer

Materials glass bowl, gravel, water, 15 blue marbles, 15 red marbles

 **PLAN AHEAD** Set up the tank on an overhead if you wish to conduct a whole-class activity.



Academic Language

When learning, students need help in building their understanding of the academic language used in daily instruction and science activities. The following strategies will help to increase students' language proficiency and comprehension of content and instructional words.

Strategies to Reinforce Academic Language

- Use **Context** Academic language should be explained in the context of the task. Use gestures, expressions, and visuals to support meaning.
- Use **Visuals** Use charts, transparencies, and graphic organizers to explain key labels to help students understand classroom language.
- **Model** Use academic language as you demonstrate the task to help students understand instruction.

Academic Language Vocabulary Chart

The following chart shows chapter vocabulary and inquiry skills. **Vocabulary** words help students comprehend the main ideas. **Inquiry Skills** help students develop questions and perform investigations.

Vocabulary	Inquiry Skills
sexual	metamorphosis
reproduction	larva
fertilization	pupa
asexual	incomplete
reproduction	metamorphosis
vegetative	nymph
propagation	
runners	
pollination	
pollen	
embryo	
seed coat	
germination	
monocot	
dicot	
metamorphosis	
complete	

Vocabulary Routine

Use the routine below to discuss the meaning of each word on the vocabulary chart. Use gestures and visuals to model all words.

Define An *inherited trait* is a trait that offspring receive from their parents.

Example The color of my hair is an *inherited trait*.

Ask What is another *inherited trait* that we receive from our parents?

Students may respond to questions according to proficiency level with gestures, one-word answers, or phrases.

Vocabulary Activities

Help students understand how traits are inherited.

BEGINNING Write *Inherited Traits* on the board. Ask students: **Does your (mother/father) have (curly hair) like you? What traits come from your parents?** Have students say or point to traits, such as hair color. Prompt for less obvious traits, like smiling. Write responses under *Inherited Traits*. Have volunteers draw pictures next to each trait.

INTERMEDIATE Write *Inherited Traits* on the board. Ask pairs to find chapter examples to write or draw on the board. Create a cloze paragraph for students to complete: *We inherit eye _____.* *We inherit _____ color.* *Other _____ are thumb shape, smiles, and the way we walk.* *Heredity is passing _____ from parent to child.*

ADVANCED Write *Dominant Traits* and *Recessive Traits* on the board. Have students find examples in the chapter for each type of trait. Have groups create short paragraphs in which they define dominant and recessive traits, and provide examples for each.

Before reading this chapter, write down what you already know in the first column. In the second column, write down what you want to learn. After you have completed this chapter, write down what you learned in the third column.

Parents and Offspring		
What We Know	What We Want to Know	What We Learned
All living things reproduce.	How do living things reproduce?	Reproduction can be sexual or asexual.
Most plants grow from seeds.	How do plants reproduce without seeds?	Mosses use spores to reproduce.
Animals grow and develop during their life cycle.		Butterflies and moths go through complete metamorphosis.

► Assess Prior Knowledge

Before reading the chapter, create a **KWL** chart with students. Read the Big Idea question and then ask:

- What are some ways that living things reproduce?
- What changes take place during a plant's life cycle?
- What changes take place during an animal's life cycle?
- How are traits passed from parent to offspring?

Answers shown represent sample student responses.

Stop Here to

Plan Your Lesson

Lesson 1 Reproduction

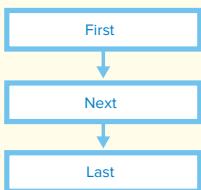
Essential Question

How do living things reproduce?

Objective

- Explain sexual and asexual reproduction.
- Compare and contrast sexual and asexual reproduction.

Reading Skill Sequence



You will need a sequence graphic organizer.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Discuss the Main Idea

Develop Vocabulary

3 Close

Think, Talk, and Write

Teacher Notes

Lesson 1 Reproduction

Objectives

- Explain sexual and asexual reproduction.
- Compare and contrast sexual and asexual reproduction.

1 Introduce

► Assess Prior Knowledge

Ask students to describe how plants and animals reproduce. Write their responses on the board.

Possible answers: Animal parents give birth to small animals. Some plants grow from seeds. Ask:

- How do plants produce new plants? Possible answers: Some plants grow from seeds. Some plants grow from other parts of plants.
- How do animal parents produce new animals? Accept all reasonable answers about sexual reproduction in animals.

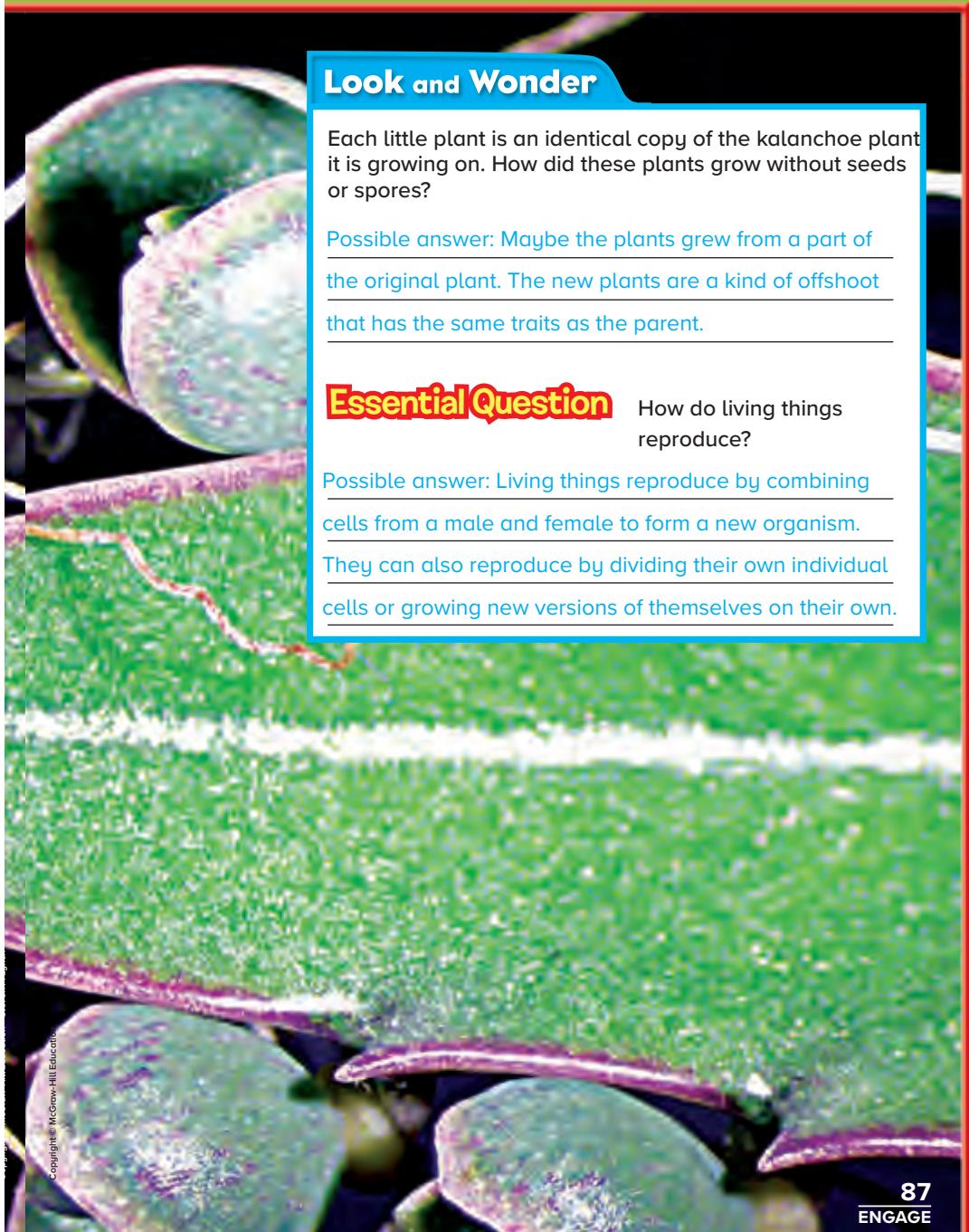
Lesson 1

Reproduction



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ENGAGE

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Look and Wonder

Each little plant is an identical copy of the kalanchoe plant it is growing on. How did these plants grow without seeds or spores?

Possible answer: Maybe the plants grew from a part of the original plant. The new plants are a kind of offshoot that has the same traits as the parent.

Essential Question

How do living things reproduce?

Possible answer: Living things reproduce by combining cells from a male and female to form a new organism.

They can also reproduce by dividing their own individual cells or growing new versions of themselves on their own.

ENGAGE

EXPLORE

EXPLAIN

EVALUATE

EXTEND

Look and Wonder

Invite students to share their responses to the Look and Wonder statement and question:

- How did these plants grow without seeds or spores?

Write ideas on the board and note any misconceptions that students may have. Address these misconceptions as you teach the lesson.

Essential Question

Have students read the Essential Question. Tell them to think about it as they read through the lesson. Advise students that they will return to this question at the end of the lesson.

Explore



pairs



25 minutes

Plan Ahead About two weeks before beginning the students' activity, bring in a cutting from a philodendron plant. Fill a clear plastic cup two-thirds full of water. Place the cutting in the cup with plastic wrap around the top. Place the cutting in a cool location out of direct sunlight. Roots should sprout from the stem within 10 days. Show your cutting to the class to demonstrate the activity or bring in enough cuttings for the students to do the activity.

Designate a spot in the classroom that is out of direct sunlight where students can observe their cuttings. Students will need to observe their cuttings for about 5 minutes each day for about 10 days.

Purpose In this activity students predict how a new plant can grow without seeds.

Structured Inquiry

- 1 Be Careful!** Caution students to be very careful when cutting the stem from the plant.
- 2 Observe** Students should observe that the stem has no roots but has bumps at equal intervals along the stem where the leaves grew.
- 3 Interpret Data** After two weeks, students should observe that the cutting has long, hairlike roots growing from the stem.

Explore

Materials



- philodendron plant
- safety scissors
- hand lens
- plastic cup
- water
- 2-week-old cutting in a plastic cup (optional)

Can some flowering plants grow without seeds?

Make a Prediction

You have learned that flowering plants use seeds to reproduce. Can some flowering plants reproduce without seeds? Can you use part of a plant to create a new plant? Make a prediction.

Possible prediction: A stem placed in water can grow into a new plant.

Test Your Prediction

1 Cut a piece of stem from the philodendron plant that measures 15 centimeters in length. Cut off the leaves that are closest to the plant. Leave two leaves at the very tip of the cutting.

2 Observe Look at your cutting with the hand lens. Record your observations.

Possible answer: The stem has no roots, but has bumps along the stem where the leaves grew.



3 Fill the plastic cup $\frac{2}{3}$ of the way with water. Place the cutting into the plastic cup.

4 Interpret Data Examine your cutting each day with the hand lens. Record your observations and any changes.

Answers will vary. Students should observe long, hair-like roots growing from the stem.



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EXPLORE

Alternative Explore

Can a new plant grow from a potato?

Materials potato with eye, hand lens, 4 toothpicks, clear plastic cup

Tell students that plants can grow from parts other than a cutting. Tell them that a potato is a tuber, which is an underground stem. A potato has small indentations or eyes. Have students predict if a new plant will grow from a potato. **New plants can grow from the eyes on a potato.**

Inquiry Activity

Draw Conclusions

5 Infer What happened to the cutting in the plastic cup with water?

Answers will vary. Possible answer: Roots began sprouting from the cutting.

— 10 —

6 Is it possible to grow a new plant without planting a seed? Explain.

Yes, a new plant began growing from the stem of the plant. It did not need

a seed to grow.

Explore More

Could other plants grow in a way that is similar to the philodendron plant? Plan an investigation to answer the question. Write a report of your results and present it to the class.

Answers will vary.

Open Inquiry

Do you think other parts of a plant could grow into another plant? Why or why not?

Possible answer: Yes, I think other parts could sprout a new plant because they all contain the genetic material of the plant and all have the potential to grow.

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EXPLORE

Guided Inquiry

Explore More

Students should write a prediction about other plants, such as the coleus plant, which may grow from a cutting, and then design an experiment to test their prediction. Swedish ivy is another plant that grows quickly and easily from a stem cutting.

Open Inquiry

Ask students to think about other parts of a plant that can grow into a new plant.

Teacher Notes

2 Teach

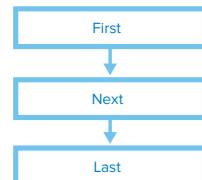
Read and Respond

Main Idea Have students look at the questions and the illustrations in this lesson. Discuss how the questions on each page relate to the illustrations.

Vocabulary Have student volunteers read aloud the new vocabulary words and their definitions. Record their responses on the board.

Reading Skill Sequence

Graphic Organizer Have students fill in a Sequence graphic organizer as they read through the lesson. They can use the Quick Check questions to identify each sequence.



What are sexual and asexual reproduction?

► Discuss the Main Idea

Tell students that this lesson describes the two ways that organisms reproduce. Ask:

- Which type of reproduction involves only one parent? **asexual reproduction**
- Which type of reproduction requires fertilization? **sexual reproduction**

Read and Respond

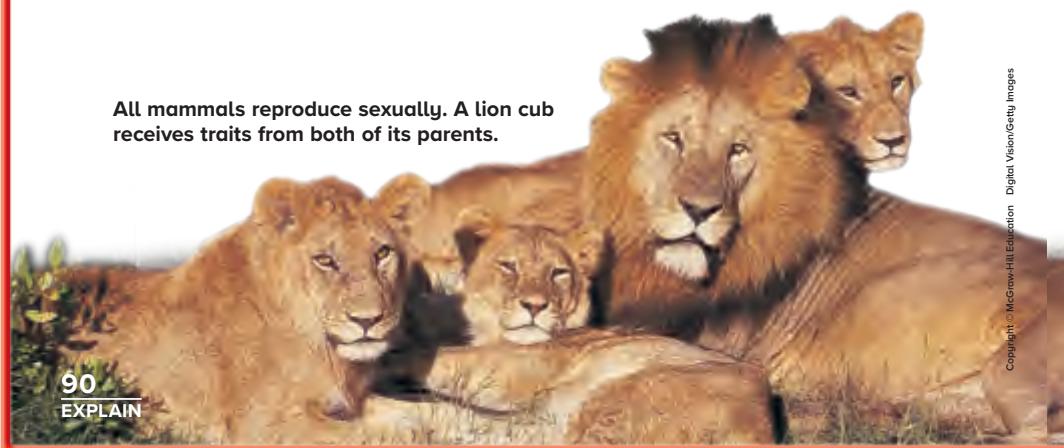
What are sexual and asexual reproduction?

Where do living things come from? Living things come from other living things. The survival of a species depends on its ability to produce new members. Every organism comes from a parent organism through the process of reproduction.

Reproduction (ree•pruh•DUK•shun) involves the transfer of genetic material from parent to offspring. The genetic material contains information that controls how the new individual will look and function. There are two main types of reproduction: sexual (SEK•shwul) and asexual (ay•SEK•shwul).

Sexual Reproduction

Sexual reproduction is the production of a new organism from two parents. A sperm cell from a male and an egg cell from a female join into a single unit in a process called **fertilization** (fur•tuh•luh•ZAY•shun). The fertilized egg cell contains genetic material from both parents. The fertilized egg then goes on to develop into a new individual. A trait is any characteristic of a living thing. For example, a plant may be tall and have pink flowers. Height and flower color are traits that may be passed to offspring from parents.



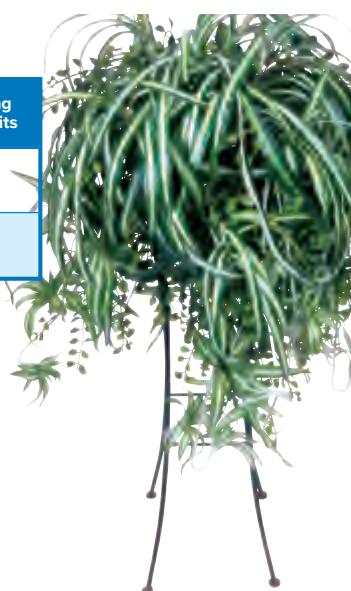
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Science Background

Parthenogenesis

Parthenogenesis is a type of asexual reproduction. The embryo or seed grows and develops without being fertilized by a male. Parthenogenesis usually results in an all-female population. But parthenogenesis in honey bee populations results in male bees. Other organisms that reproduce by parthenogenesis are lower plants, some invertebrates, and some vertebrates, including lizards and salamanders. Some fish and even turkeys reproduce this way.

Types of Reproduction	Number of Parents	Sex Cells	Offspring	Mixing of Traits
Asexual reproduction	1	not needed	identical to parent	no
Sexual reproduction	2	needed	different from parent	yes



Asexual Reproduction

Asexual reproduction is the production of a new organism from a single parent. It produces a new offspring that has the same genetic information as the parent. No male and female sex cells combine during asexual reproduction. The offspring are identical to the original parent.

You can find organisms that reproduce asexually in all six kingdoms. All members of the bacteria kingdoms and most unicellular protists reproduce asexually. Most fungi and many plants can reproduce asexually during a part of their lives and sexually during another.

Animals, such as jellyfish, corals, worms, and some echinoderms, can form new offspring asexually. Some kinds of lizards, frogs, fish, and insects can also reproduce asexually.

Quick Check

- What is the first step of sexual reproduction?

A sperm cell and an egg cell join to form a fertilized egg cell.

- Asexual reproduction produces an exact copy of the parent organism. When could this be a disadvantage?

Possible answer: This could be a disadvantage if the parent organism does not have desirable traits.



Multicellular organisms can reproduce asexually.

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EXPLAIN



Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students create a Venn diagram, labeling one circle *asexual reproduction* and the other circle *sexual reproduction*. Have them write words that belong to each category in the corresponding circle. Then have them write words that describe both processes in the overlapping section.

ENRICHMENT Have students research asexual or sexual reproduction in an organism of their choice. Have them write a report on how the organism reproduces. Encourage them to share their reports with their classmates.

Use the Visuals

Have students study the photos of organisms and their offspring on the student pages. Encourage them to pay particular attention to how the offspring are similar and are different from the parents. Ask:

- What type of reproduction produced the young spider plants? **asexual reproduction**
- Why do the lion cubs look similar to their parents? **during sexual reproduction they received traits from both parents**

Develop Vocabulary

sexual reproduction Explain that *reproduction* is based on the word *reproduce*, which means to “make new things,” or make new organisms from two parents.

fertilization Explain to students that *fertilization* in life science is the joining of an egg cell and a sperm cell to form a new offspring.

asexual reproduction Write the terms *sexual reproduction* and *asexual reproduction* on the board, one above the other. Underline the prefix *a-*. The prefix, which means “not,” is the only difference between the two terms.

Address Misconceptions

A common misconception is that asexual reproduction is limited to microorganisms such as bacteria and protists.

FACT **Multicellular organisms can reproduce asexually.** Students should note that animals such as hydras and sponges reproduce asexually by budding and that animals such as sea stars can grow from pieces of the original organism.

Quick Lab



pairs



15 minutes

Asexual Reproduction Poster

See the Quick Labs in the Activity Lab Manual.

Objective Compare different types of asexual reproduction.

Materials books, magazines, poster board

- 1 Encourage students to look up different types of asexual reproduction by using the key words *splitting, budding, and vegetative propagation*.
- 2 Bacteria and many protists reproduce by splitting. Hydra and other cnidarians reproduce by budding. Strawberries and some kinds of grasses reproduce by vegetative propagation.
- 3 Alike: All forms of asexual reproduction use one parent to produce offspring. Different: Each form of asexual reproduction uses a different method to form their offspring.

How do organisms reproduce asexually?

► Discuss the Main Idea

Show students photos of organisms that reproduce asexually and their offspring. Ask students to describe the offspring. Students should recognize that the offspring are exactly like the parent. Ask:

- How do you know that the offspring from asexual reproduction will be exactly like the parent? **Possible answers:** They inherit the genetic material of the parent. They have the same traits as the parent.
- What are some different kinds of asexual reproduction? *splitting, budding, developing from unfertilized eggs, vegetative propagation*

Quick Lab

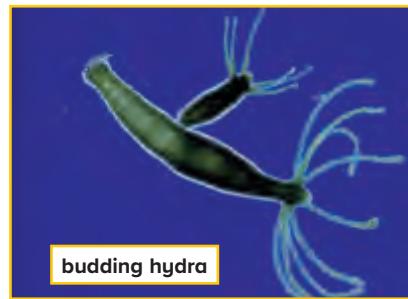
To learn more about asexual reproduction, complete the Quick Lab in the activity workbook.

How do organisms reproduce asexually?

There are several methods of asexual reproduction shared by a wide variety of organisms. All forms of asexual reproduction eliminate the need for an organism to find a mate. They all produce genetic copies of the parent organism.



bacterium splitting



budding hydra

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EXPLAIN

Splitting

Most unicellular protists and bacteria reproduce simply by splitting into two cells. Before splitting, the organism copies its own genetic material. The two new offspring organisms will then have a copy of the genetic material they need to carry out life processes. Some bacteria can divide into two new organisms every 10–20 minutes.

Budding

Some organisms, such as cnidarians, sponges, and some fungi, can reproduce through *budding*. During budding, a small part of the parent's body grows into a tiny and complete version of the parent. And continues to grow. In other organisms, such as coral, the newly formed bud remains attached to the parent.

LA Support

Compare and Contrast Make a chart on the board with three columns and four rows. Label the middle column *asexual reproduction* and the right column *sexual reproduction*. Write these words in the left column, rows 2–4: *parents, traits, fertilization*.

BEGINNING Student can repeat the words on the board.

INTERMEDIATE Student can fill in the chart with the words *one and two (parents), same and different (traits), and no and yes (fertilization)*.

ADVANCED Student can summarize the information on the chart to describe asexual reproduction and sexual reproduction.

**Quick Check**

3. Describe the steps in bacteria reproduction.

The organism produces a copy of its genetic material.



The organism splits into two individuals.

Other Forms of Asexual**Reproduction in Animals**

Some species of fish, insects, frogs, and lizards go through asexual reproduction in a different way. The females of these animals produce eggs. Normally these eggs would be fertilized by male sex cells, but in some cases, fertilization never takes place. The eggs just develop into a new animal without fertilization. For example, when queen honeybees lay eggs, some are fertilized and others are not. The fertilized eggs develop into females, or worker bees. The unfertilized eggs become males, or drone bees.

Strawberry Reproduction**Read a Photo**

What part of the strawberry plant can produce new plants without seeds?

Clue: Look at the photo. What part of the original plant is attached to the new strawberry plant?

the stem

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EXPLAIN

Read a Photo

What part of the strawberry plant can produce new plants without seeds?

Clue: Look at the photo. What part of the original plant is attached to the new strawberry plant?

the stem

► Develop Vocabulary

vegetative propagation Tell students that **vegetative** in this case means “growing.” Explain to students that vegetative propagation is a type of reproduction that uses the growing tissues of the plant, which are called vegetative tissue.

runners **Scientific vs. Common Use**

Explain to students that plant runners are specialized horizontal stems that move along the surface of the soil, eventually growing a new plant. In common usage, runners are athletes.

► Use the Visuals

Have students look at the photos of splitting and budding on the student page. Discuss how the processes are similar and how they are different. Ask:

■ **What is the most important difference between the processes?** **Splitting** occurs as single-celled organisms split into two cells. **Budding** involves a small part of the parent’s body that grows into a new individual.

Differentiated Instruction**Leveled Questions**

EXTRA SUPPORT What is splitting? **a type of asexual reproduction in which the organism simply splits into two cells after it makes a copy of its genetic material** What is budding? **a type of asexual reproduction in which a small part of the parent’s body grows into a tiny and complete version of the parent**

ENRICHMENT Which type of reproduction results in more genetic variation in the offspring: budding or vegetative propagation? **They are both types of asexual reproduction, which means the offspring are identical to the parent in both processes.**

How do sexual and asexual reproduction compare?

► Discuss the Main Idea

Ask students to identify the differences between asexual and sexual reproduction. Record responses on the board. **Asexual reproduction:** only one parent, offspring identical to the parent; **Sexual reproduction:** two parents, offspring have a combination of the parents' traits Ask:

- **What is an advantage of asexual reproduction?** It is convenient. It does not require another organism to reproduce.
- **Why is it an advantage for an organism to be the product of sexual reproduction?** Possible answer: It provides variety in the offspring and in a species. Offspring might be better suited to environmental changes than the parents.

► Develop Vocabulary

Have students write paragraphs using all of the vocabulary words from this lesson.

How do sexual and asexual reproduction compare?

You might wonder why some organisms reproduce asexually while others reproduce sexually. Asexual reproduction is convenient. An organism that reproduces asexually does not have to depend on another organism. It can live in isolation and still reproduce. Organisms that reproduce asexually tend to be well suited to their environment and produce equally well-suited offspring.

So why do organisms bother with sexual reproduction? One major advantage of sexual reproduction is that it promotes variety in a species. Sexual reproduction can give rise to offspring that are better suited to environmental

changes than parents. The offspring produced are not identical to either parent. Some are smaller, larger, or faster than others.

For example, the ability to run fast is an advantage for some organisms, such as mice. Slower mice are more likely to be captured and eaten by other animals, such as owls or snakes. Faster mice might survive more frequently than slower mice. Over time, fast mice will reproduce and pass on this trait to their offspring.

Quick Check

4. What is an advantage of asexual reproduction?

One advantage is that asexual reproduction can occur without a mate.

Variation



Read a Photo

How can you tell that these kittens are not the result of asexual reproduction?
The kittens all look different, which means _____
they have traits from both parents. They
are the result of sexual reproduction.

Homework Activity

Research Invertebrate Reproduction

Have students research a specific invertebrate and how it reproduces. Ask them to write and illustrate a report that answers the following questions: Does the animal reproduce sexually and asexually or by only one means? How many parents are involved in reproduction? How do the traits of the offspring compare with the parents?

Teacher Notes

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 1 Lesson Review

Visual Summary

Complete the lesson summary in your own words.



Reproduction Possible answer: Living things come

from other living things through reproduction.



Asexual Reproduction Possible answer: Splitting,

budding, and vegetative propagation are methods of asexual reproduction used by a variety of organisms.



Sexual Reproduction Possible answer: Sexual

reproduction promotes variety in a species.

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EVALUATE

Formative Assessment

Approaching Have students write in their own words a description of asexual reproduction and sexual reproduction.

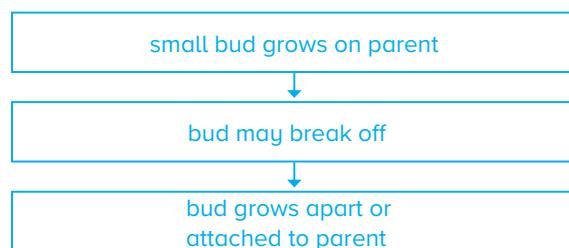
On-Level Have students make a table that compares the processes of asexual reproduction and sexual reproduction.

Challenge Have students create a chart or table that summarizes the characteristics of different types of asexual reproduction (splitting, budding, vegetative propagation) and sexual reproduction.

Think, Talk, and Write

1 Vocabulary A runner is a form of asexual reproduction called vegetative propagation.

2 Sequence What happens after a bud forms on an organism?



3 Critical Thinking What are the advantages of sexual reproduction?

Sexual reproduction produces individuals with new traits that may be better suited to changes in the environment.

4 Test Prep Which best describes budding?

- A offspring develop from a fertilized egg
- B offspring develop on a parent
- C offspring develop from a stem
- D offspring develop from two parents

5 Test Prep Which organisms reproduce by splitting?

- A bacteria
- B strawberries
- C jellyfish
- D honeybees

Essential Question How do living things reproduce?

Budding, splitting, and vegetative propagation are types of asexual reproduction, which requires only one parent. Some organisms reproduce sexually when a male sperm cell joins with a female egg cell.

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your understanding of reproduction changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

Writing in Science

Objective

- Write an explanation of the reproductive process.

How Do Sea Stars Regenerate?

Learn It

Explanatory writing is used to provide information. Explanatory writing should provide details and information in a clear, logical order. Ask:

- How is explanatory writing important in textbooks? Textbooks use explanatory writing in order to teach in the clearest possible way.

Try It

- Ask students to explain what is being taught in the selection. List their answers on the board.

Apply It

- Tell students to read the selection and notice how the order in which the information is given is an important part of the explanation.
- Have students make a chart that illustrates the order of the information given in this selection. Tell them to number the order of the pieces of information in the selection.

Writing in Science

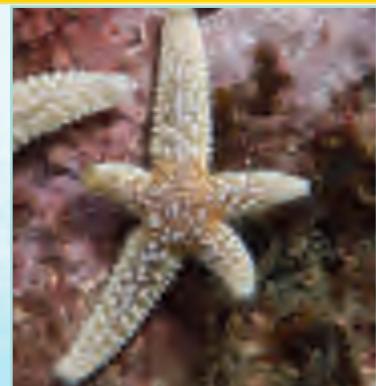
How Do Sea Stars Regenerate?

What's so amazing about sea stars?

They have the ability to asexually reproduce and heal themselves through regeneration! How does this process work? The sea star's body provides an important clue. It is made of a central disk and five or more arms, or rays. The rays are extensions of the main body and contain part of the central disk.

What happens when the sea star's body is split in two? First, skin cells cover the wound. Then stem cells work to fix the problem. These cells divide and become the types of specialized cells needed to create new body parts. Finally, the two halves regenerate and become two new sea stars. At times a sea star's body may be split into four. Then each part repairs itself and becomes four new sea stars.

Sometimes, an entire arm, or ray, is broken off. Then, if the ray contains at least one fifth of the central disk, it regenerates and becomes a copy of the original sea star. What happens to the sea star with the cut-off arm? It regenerates and grows a new one. Regeneration is a slow process. It can take over a year.



This new sea star is regenerating from a ray.

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EXTEND

Integrate Writing

Asexual and Sexual Reproduction

- Have students find out how sexual reproduction takes place and give examples of organisms using this method of reproduction.
- Have students use the information in this selection, and their own research, to write an article that explains how sexual and asexual reproduction take place. Ask them to include examples.



Write About It

Explanatory Writing Explain how sea stars produce offspring using regeneration. Choose another animal that reproduces asexually. Write an explanation of how this process takes place.

Answers will vary.

Explanatory Writing

A good explanation

- ▶ gives clear details about a main idea;
- ▶ lists what happens in an organized and logical way

Explanatory Writing

A good explanation

- ▶ gives clear details about a main idea;
- ▶ lists what happens in an organized and logical way;
- ▶ uses time-order words to make the description clear



Write About It

- Help students find suitable animals to use for this exercise. Students may also use suitable plants or microorganisms if necessary.

Stop Here to

Plan Your Lesson

Lesson 2 Plant Life Cycles

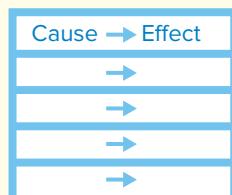
Essential Question

How do plants grow, develop, and reproduce?

Objective

- Describe the life cycles of mosses and ferns.
- Learn about the angiosperm life cycle.
- Understand the conifer life cycle.

Reading Skill Cause and Effect



You will need a cause-and-effect graphic organizer.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Use the Visuals

Discuss the Main Idea

Develop Vocabulary

3 Close

Think, Talk, and Write

Teacher Notes

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Lesson 2 Plant Life Cycles

Objectives

- Describe the life cycles of mosses and ferns.
- Learn about the angiosperm life cycle.
- Understand the conifer life cycle.

1 Introduce

► Assess Prior Knowledge

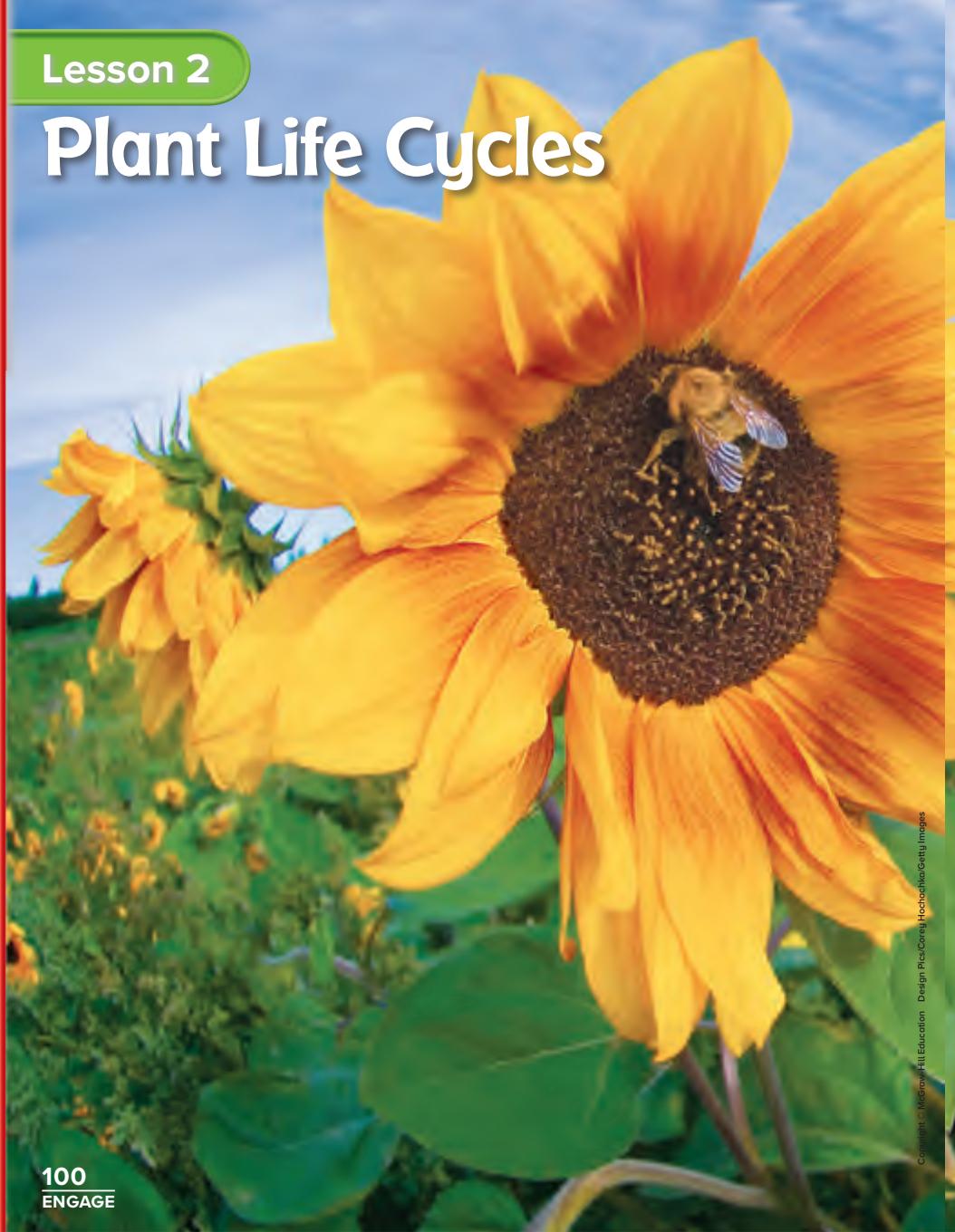
Have students describe the ways that plants reproduce by asexual reproduction. Record responses on the board. **Possible answers:** from a stem cutting; by vegetative propagation; by runners

Ask:

- What kind of reproduction takes place when a plant grows from a seed? **sexual reproduction**
- How do you think a seed is formed? **Accept all reasonable answers.** Students should recognize that a seed forms as a result of sexual reproduction in which a sperm cell joins with an egg cell.

Lesson 2

Plant Life Cycles



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ENGAGE

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Warm Up

Start with a Demonstration

Show students seeds such as sunflower, pumpkin, squash, beans, corn, avocado, peas, and others that show a variety in shape, size, and color. Have students examine some of the seeds with hand lenses. Have students list similarities and differences between the seeds. Ask:

- What characteristics do all the seeds have in common? Students might recognize that all the seeds have a hard outer covering and something/food stored inside.
- Why do plants produce seeds with such great variety? **Possible answer:** Plants themselves grow in a variety of places with different growing conditions. They produce seeds that can grow the best in a given location.



Look and Wonder

One sunflower can produce more than 1,000 seeds! What conditions do these seeds need to grow into new sunflower plants?

Possible answer: They will need water, food for energy, and enough room to live and grow. Plants also need sunlight to grow and develop.

Essential Question

How do plants grow, develop, and reproduce?

Possible answer: Most plants reproduce when they are pollinated and can produce a seed. This seed then uses sunlight and water to grow into a new plant.

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ENGAGE

ENGAGE

EXPLORE

EXPLAIN

EVALUATE

EXTEND

Look and Wonder

Invite students to share their responses to the Look and Wonder statement and question:

- What conditions do these seeds need to grow into new sunflower plants?

Write ideas on the board and note any misconceptions that students may have. Address these misconceptions as you teach the lesson.

Essential Question

Have students read the Essential Question. Tell them to think about it as they read through the lesson. Advise students that they will return to this question at the end of the lesson.

Explore



pairs



25 minutes

Plan Ahead If students start with bean seeds, they will need to observe the beans for about 5 minutes each day for 5 days and the planted seeds for about 5 minutes each day during the following week.

Purpose In this activity students form a hypothesis about whether a seed needs moist or dry conditions to grow and then conduct an experiment to test the hypothesis.

Structured Inquiry

- 1 Tell students to write their names on their cups before they add the paper towels and the seeds.
- 4 **Experiment** After two to three days students should observe a shoot and/or a root growing from the moist seed but not the dry seed.

Explore

How do flowering plants reproduce?

Form a Hypothesis

Do seeds require moist or dry conditions to grow? Write your answer in the form "If seeds are placed in a moist environment, then..."

Possible hypothesis: If seeds are placed in a moist environment, then they will grow.

Test Your Hypothesis

- 1 Moisten a paper towel and place it at the bottom of a plastic cup.
- 2 Place 1 lima bean seed inside the cup with the paper towel. Fold the paper towel over the seed.
- 3 Repeat steps 1 and 2 with a dry paper towel.
- 4 **Experiment** Place the cups in a sunny spot and observe them daily for 5 days. Record your observations in this table.



Answers will vary. Students should observe that only the wet seed sprouts and grows.

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EXPLORE

Alternative Explore

Which seed sprouts first?

Materials bean, sunflower, corn seeds, paper towels, plastic cups

Tell students that in this activity they will form a hypothesis about which seed will sprout the fastest. Then they will conduct an experiment to test their hypothesis.

2 Teach

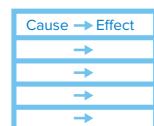
Read and Respond

Main Idea Have students preview the lesson by looking at the illustrations on each page. Show students a plant in different stages of its life cycle: a young plant, a plant with flowers, a plant with seeds, and seeds. Explain to students that in this lesson they will learn about the life cycles of different plants.

Vocabulary Have students read each vocabulary term and its definition aloud. To help them remember the meaning of each term, have them write a complete sentence for each vocabulary term.

Reading Skill Cause and Effect

Graphic Organizer Have students fill in a Cause and Effect graphic organizer as they read through the lesson. They can use the Quick Check questions to identify each cause and effect.



What are seedless plant life cycles?

► Discuss the Main Idea

Show students examples of a living moss and a living fern. Have hand lenses available for students to use while making their observations. Ask:

- What similar characteristics do both of these plants have? *Accept all reasonable answers, such as that they are green and they have branches.*
- How are these plants different from most plants you see every day? *Accept all reasonable answers.* Students should recognize that mosses do not have roots and that neither plant has flowers or seeds.

Read and Respond

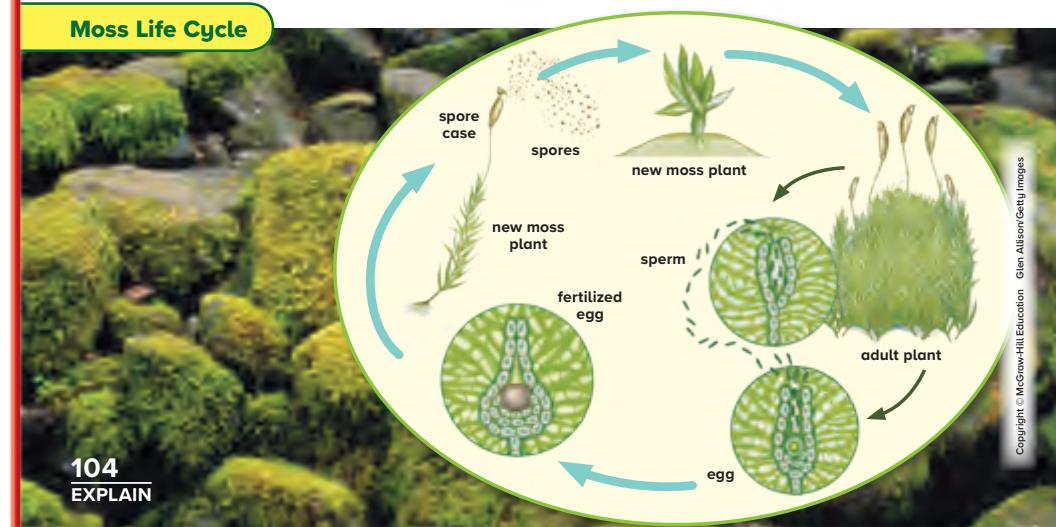
What are seedless plant life cycles?

All living things have life cycles. A *life cycle* is a series of differing stages of development. Plant life cycles include both an asexual and a sexual stage. This process of alternating between asexual and sexual reproduction is called an *alternation of generations*.

Moss Life Cycle

The life cycle of moss begins with asexual reproduction. Moss plants grow thin brown stalks with capsules at the top. The capsules contain tiny spores. Spores are cells that can develop into new plants without fertilization. When the capsule opens, spores are released and carried by the wind. Spores that land in shady, moist soil are likely to grow.

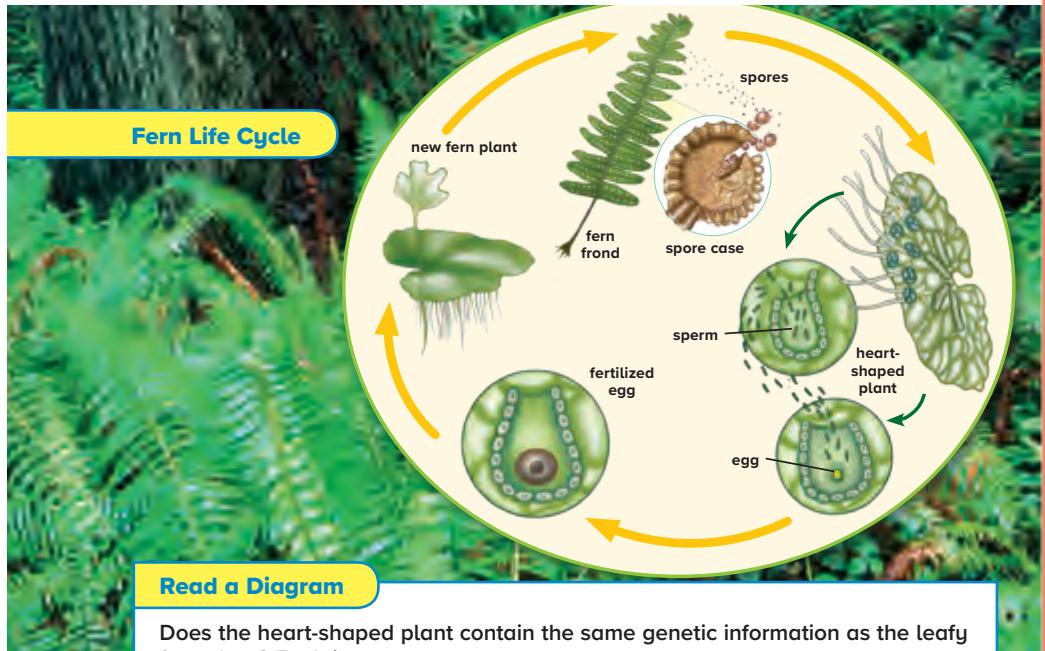
In the sexual stage, the spore develops into the green, carpetlike adult plant. The adult plant has male structures that produce sperm and female structures that produce eggs. Sperm gets carried by water to the female structure where fertilization takes place. The fertilized egg grows on the female structure. It develops into a brown stalk with a spore capsule, and the cycle continues.



Science Background

Plant-Pollinator Interactions

Pollination by animals is the most successful form of pollination. It took a while for this process to develop because flowers and pollinators both had to evolve to meet the needs of the other. The sights and smells of flowers attract the pollinators. Birds do not have an acute sense of smell so the flowers they pollinate do not have to be perfumed. Bats are attracted to plants with strong, musty smells.



Read a Diagram

Does the heart-shaped plant contain the same genetic information as the leafy fern plant? Explain.

Yes, the heart shaped plant comes from the spores produced by the leafy fern plant. Spores are the asexual stage of reproduction, so the heart-shaped plant has the same genetic information as the leafy plant.

Fern Life Cycle

Like mosses, ferns begin their life cycle with asexual reproduction. Ferns produce spores on the undersides of their fronds, or leaves. Spores are usually in clusters inside a spore case. When the spore case opens, the spores are released.

Fern spores that find the right conditions grow into small heart-shaped plants with male and female structures. Here, the fern undergoes sexual reproduction. The heart-shaped plant produces male and female sex cells.

If a male sex cell fertilizes a female sex cell, the fertilized egg forms a new plant. The new plant develops into a leafy fern plant. Spore cases on the fern's fronds produce spores, and the cycle continues.

Quick Check

- What causes the stalk and spore capsule to form in mosses?
The fertilized egg develops on the female structure and forms the stalk and a spore capsule.

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EXPLAIN

Explore the Main Idea

ACTIVITY Provide students with fern leaves on which spore cases are clearly visible on the underside of the fronds. Have students examine the spore cases and fronds with a hand lens. Have students draw and label what they observe.

Use the Visuals

Have students study the diagram of the moss life cycle on the student page. Have them identify the place on the diagram that corresponds to each of the questions below. Ask:

- What stage is the beginning of the moss life cycle?
asexual reproduction
- How does a moss reproduce without fertilization?
Spores that form at the tips of stalks can grow into new individuals without fertilization.
- How does sexual reproduction take place in a moss?
Male branches produce sperm. Female branches produce eggs. Rainwater carries the sperm to the eggs, where fertilization takes place. The fertilized egg grows into a plant that produces spores.

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students draw a Venn diagram, labeling one circle *moss life cycle* and the other circle *fern life cycle*. Have them write words that describe each life cycle in the corresponding circle. Then have them write words that describe both life cycles in the overlapping area.

ENRICHMENT Have students use encyclopedias or other reference books to research the life cycle of a fern or a moss. Have them create a labeled diagram of a life cycle that includes information on the plant's scientific name, the location or areas where the plant lives, and how much time the plant spends in each stage of the life cycle. Have students share their diagrams with the class.

What are the parts of a flower?

► Discuss the Main Idea

Show students flowers or photographs of flowers that are different in structure, shape, size, and color. Ask students to describe the flowers. Record their responses on the board. **Possible answers:** They are fragrant; they have petals; some are flat; some have petals around a center. Ask:

- **What function do flowers perform?** Plants grow flowers for reproduction.
- **In what ways are all the flowers similar?** All flowers have male and/or female parts that are similar in structure.

► Develop Vocabulary

Have students write a brief definition of each of the following terms: *complete flower*, *incomplete flower*, *perfect flower*, and *imperfect flower*.

► Explore the Main Idea

ACTIVITY Have students work in pairs and use approved Internet sites or reference books to choose a flower to draw. Have them make a drawing that shows and labels the parts of the flower, identifying the reproductive parts as male or female. Then have them classify the flower according to the four types shown on the student page.

► Use the Visuals

Have students look at the parts of a flower. Ask:

- **In what part of the flower does fertilization take place?** inside the ovary
- **What part of the flower produces pollen grains?** the anther

What are the parts of a flower?

There are over 300,000 identified plant species on Earth. About 250,000 of these are angiosperms. What makes flowering plants so numerous? Flowering plants are efficient food-makers. They are tough and grow fast, but mostly, flowering plants are good at producing offspring. They are the only group that produces flowers, seeds, and fruits.

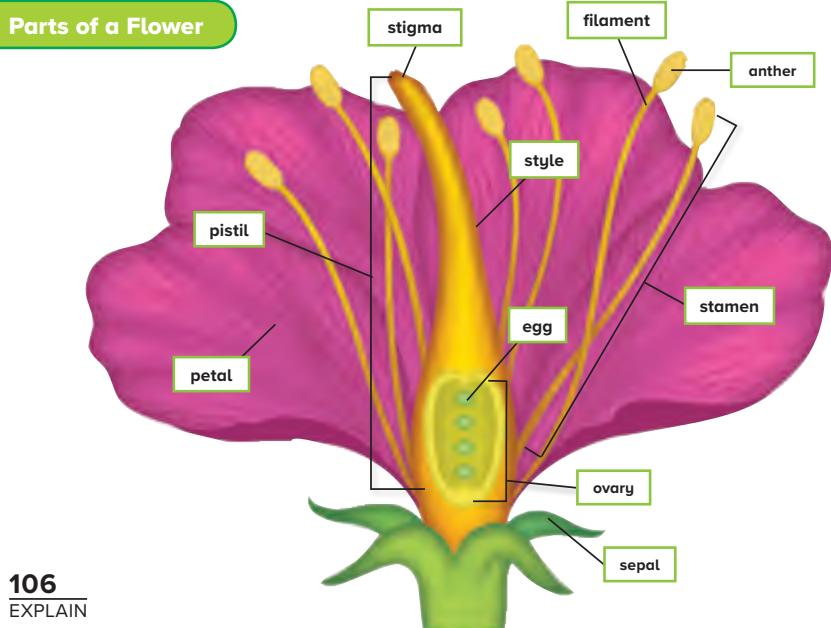
Flowers are the reproductive organs of angiosperms. They produce both sperm and egg cells. All angiosperms produce flowers, but not all flowers are alike. A *complete flower* has all of the four main parts: petals, sepals,

stamens, and pistils. *Petals* are the brightly colored outer parts of a flower. *Sepals*, which are usually green, are found below petals. *Sepals* cover and protect the flower's parts when it is just a bud. A *stamen* (STAY•mən) is the male part of the flower, while the central *pistil* is the flower's female organ.

Flowers usually have more than one stamen. Each stamen is made of a *filament* (FIH•luh•munt) and an *anther*. The *filament* is the thin stalk portion of the stamen. The *anther* is at the top of the filament. It produces pollen grains, which contain sperm cells.

The *pistil* is made of a *stigma* (STIG•muh), a *style*, and an *ovary*. The *stigma* is the opening at the top of the pistil. The *style* is the long, necklike structure that leads down to the *ovary*. The *ovary* houses the egg cells, and it is the place where fertilization occurs.

Parts of a Flower



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EXPLAIN

LA Support

Create a Picture Dictionary Have students pronounce the following words by repeating them after you: *petals*, *sepals*, *stamens*, and *pistils*. As you say each word, point to the part it identifies in a diagram of a flower.

BEGINNING Students work in pairs to draw their own pictures of a complete flower. Have them point to each part and say the name to their partner, then switch roles and repeat.

INTERMEDIATE Students work in pairs to draw their own pictures of a complete flower, label the parts, and write a short definition of each part.

ADVANCED Students work in pairs to write a description of the similarities and differences between a complete flower and an incomplete flower, and illustrate their descriptions.

Types of Flowers



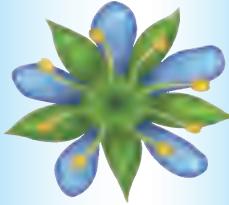
perfect/complete flower



perfect/incomplete flower



imperfect/incomplete flower (female)



imperfect/incomplete flower (male)

An *incomplete flower* is missing one or more of the flower parts of a complete flower. A *perfect flower* has both stamens and a pistil—the male and female parts. Typical perfect flowers include lilies, gladioli, tulips, and most fruit blossoms.

A flower can be incomplete and perfect. A windflower, for example, does not have petals, but it has both male and female structures and sepals. The windflower's sepals have a petal-like appearance.

Imperfect flowers lack either a stamen or a pistil. In other words, these flowers are either male or female. Some plants, such as willow trees, produce only male or female flowers. Other plants produce separate male and female flowers on the same plant. For example, a single corn plant will have both male flowers and female flowers.

Quick Check

2. What is the main effect of being an imperfect flower?

An imperfect flower does not produce both egg and sperm cells.

Read a Chart

How do complete and incomplete flowers differ?

Complete flowers have petals, sepals, stamens, and pistils. Incomplete flowers are missing one or more of these parts.

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EXPLAIN

▶ Use the Visuals

Have students study the illustrations of different flowers on the student page. Ask:

- **What makes a flower perfect?** It contains both a stamen and a pistil, male and female parts.
- **How can a flower be both incomplete and perfect?** It can be missing one part, such as petals or sepals, but still have a stamen and a pistil.
- **Why are some flowers described as imperfect?** They contain only male or female parts, not both.

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students draw a Venn diagram, labeling one circle *incomplete flowers* and the second circle *complete flowers*. Have them write words that belong to each type of flower in the corresponding circle. Then have them write words that describe both incomplete and complete flowers in the overlapping section.

ENRICHMENT Have students use arts and craft supplies to make drawings or models of four different types of flowers: complete flower, incomplete flower, perfect flower, and imperfect flower. Have them share their models or drawings with the class.

What is the angiosperm life cycle?

► Discuss the Main Idea

Ask students to identify stages that might occur in the angiosperm life cycle. Record their responses on the board. **Possible answers:** seed; seedling or young plant; mature plant; plant that produces flowers; plant that produces seeds; dead plant Ask:

- **Why is it important for a plant to have flowers?**
Possible answer: Flowers are needed for fertilization. Fertilization is necessary for sexual reproduction to occur.
- **What event takes place before fertilization occurs?** pollination
- **How does pollination occur?** through pollinators such as insects, birds, and other animals; by the wind

► Develop Vocabulary

pollination **Word Origin** Tell students that the word *pollination* is a noun that comes from the verb *pollinate*. *Pollinate* comes from a Latin word that means “fine powder.”

pollen **Word Origin** Tell students that *pollen* is similar to *pollination*. The word comes from the Latin word *pollin* that means “fine dust” or “fine powder.”

► Use the Visuals

Have students study the illustration of the angiosperm life cycle on the student page. Review with students that a cycle has no distinct beginning or distinct end. Ask:

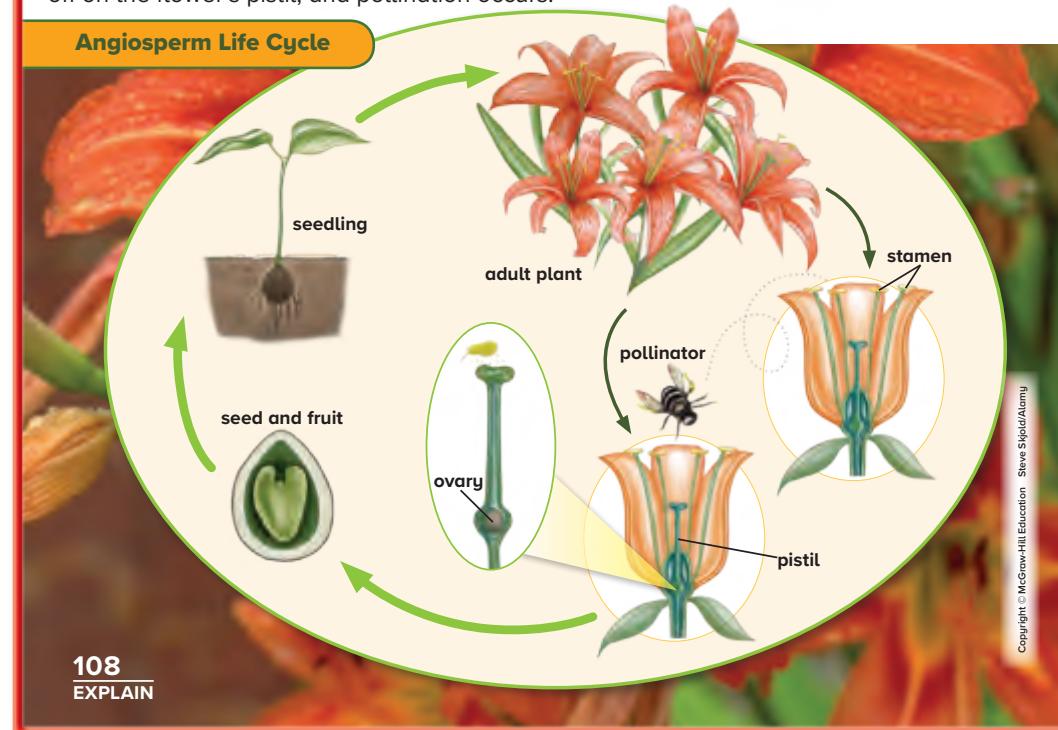
- **Where in the flower is pollen produced?** in the anther
- **Where does fertilization take place?** inside the ovary
- **What happens during fertilization?** a sperm cell from the male part joins with an egg cell from the female part

What is the angiosperm life cycle?

Before fertilization can occur, pollination (pah•luh•NAY•shun) must take place. **Pollination** is the transfer of pollen (PAH•lun) from the stamen to the pistil. **Pollen** is a yellow powder that contains sperm cells. The trouble is that pollen cannot move on its own. How do plants get pollinated?

One way is through pollinators, such as bees, birds, and other animals. Why should these animals want to help out in the job of pollinating a flower? Because pollinators get something out of it: nectar. **Nectar** is a sweet liquid produced by flowers to attract pollinators. Flowers also have colorful petals, interesting shapes, and scents that appeal to pollinators.

As flowers open, bees and other pollinators arrive. Pollinators are attracted to the sugary nectar. As the pollinator drinks the nectar, grains of pollen rub off on its body. When the pollinator goes on to the next flower, some of that pollen rubs off on the flower’s pistil, and pollination occurs.

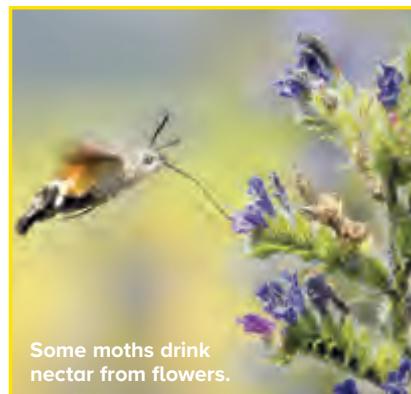


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Animals are not the only means of flower pollination. Some flowering plants rely on the wind to blow pollen from stamen to pistil. Wind-pollinated plants include grasses and some trees.

You can usually tell how a flower gets pollinated by looking at it. Large, scented blossoms are usually pollinated by animals. Their colors and scents attract pollinators. Wind-pollinated plants do not attract animals, so their flowers tend to be small and dull.

Pollination can be carried out in a number of ways. *Self-pollination* occurs when a perfect flower with both male and female parts pollinates itself. *Cross-pollination* occurs when the pollen from one plant pollinates a flower on a different plant. Note that both self-pollination and cross-pollination can be carried out by the wind or an animal pollinator. Once pollinated, sperm cells from the pollen move down the style of the pistil to the ovary. Fertilization takes place when the sperm and egg cell combine to form a seed.



Some moths drink nectar from flowers.

Quick Check

3. Can pollination take place without fertilization? Explain your answer.

Yes, pollination means that the pollen has reached the female part of the flower. For fertilization to occur, male sex cells in pollen must move down the style and fertilize the egg in the ovary.

Some plants, such as grasses, rely on the wind for pollination to take place.



FACT Plants use sexual reproduction.

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EXPLAIN

Differentiated Instruction

Leveled Questions

EXTRA SUPPORT What is the function of the flower in the life cycle of an angiosperm? *fertilization and reproduction*

ENRICHMENT Which plants have more variation in their offspring—plants that self-pollinate or plants that cross-pollinate? *Plants that cross-pollinate have offspring with more variety because the seed is formed from an egg and a sperm from different plants.*

► Discuss the Main Idea

Ask students to list the different ways they think pollination occurs. Record student responses on the board. **Possible answers:** by birds; by bees and other insects; by animals; by the wind Ask:

- **What can animals get from flowers?** **Possible answer:** Animals that pollinate flowers get food from the flower in the form of nectar.
- **What advantage does a wind-pollinated plant have over an animal-pollinated plant?** *The wind-pollinated plant does not have to depend on animals being present for pollination to occur.*
- **Why do wind-pollinated plants have smaller flowers than animal-pollinated plants?** *Wind-pollinated flowers do not need to attract animals for pollination so they don't have to be as large or as colorful.*

► Address Misconceptions

FACT **Plants use sexual reproduction.** Review Lesson 1 where students learned that organisms in all kingdoms can reproduce both asexually and sexually. Sexual reproduction is not limited to animals.

What is in a seed?

► Discuss the Main Idea

Show students a variety of seed packets that are readily available from garden centers and grocery stores during the spring. Have them read the information on the packets about how to plant the seeds and what the seeds need to germinate. Ask:

- **What do all of the seeds need to germinate?** Possible answers: water, soil, warm temperatures
- **What do you think is inside the seeds?** Students should recognize that the seeds, regardless of size, contain a small embryo plant surrounded by a food supply.
- **Why do you think seeds have a seed coat?** Possible answers: to protect them from the environment; to protect them from drying out

► Develop Vocabulary

embryo *Word Origin* Tell students that *embryo* comes from the Greek word *embruon*, which means “fetus.” Explain that a seed contains a tiny plant called the embryo.

seed coat *Scientific vs. Common Use* Explain to students that they wear a coat when they want protection from cold, wind, rain, or snow. Explain that the coat on a seed protects the seed from the environment.

germination *Word Origin* Tell students that *germination* comes from the Latin word *germinare*, which means “to sprout forth” or “to bud.”

monocot *Word Origin* Explain to students that the prefix *mono-* in this word comes from the Greek word *monos*, which means “alone” or “single.” A monocot plant has only one cotyledon.

dicot Tell students that the prefix *di-* in this and other words means “two.” A dicot plant is one with two cotyledons in the seed.

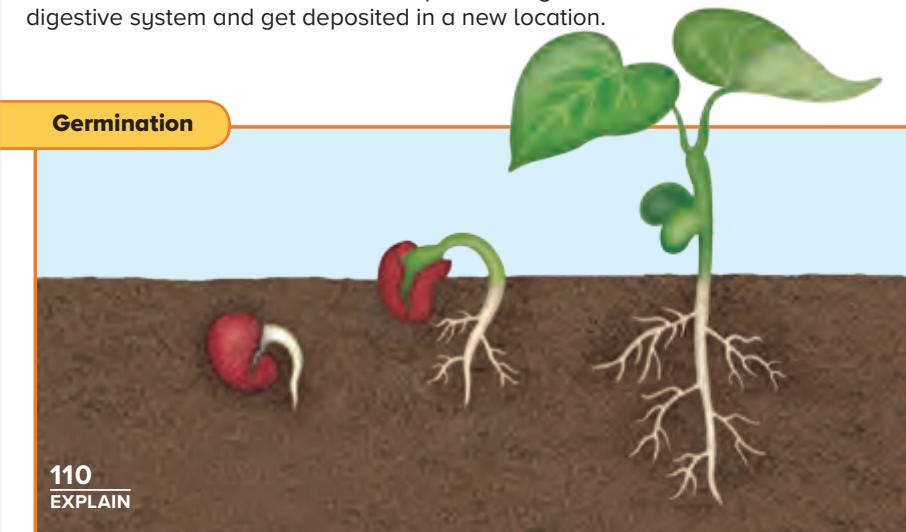
What is in a seed?

Inside the ovary of a flower, the fused sperm cell and egg cell develop into an embryo (EM•bree•oh). An **embryo** is the beginning of a new offspring. As it grows, the embryo is packaged inside a seed. As the seed develops, the ovary enlarges until it becomes a fruit. The fruit protects the seeds inside it.

The seed itself has three main parts. The tiny embryo is the offspring that can grow into a new plant. Surrounding the embryo is its food supply, or **cotyledon** (kah•tuh•LEE•dun). The new, growing embryo lives off this food supply until it gets big enough to make food on its own. Finally, the entire seed is surrounded by a tough outer covering called a **seed coat**.

Once formed, seeds must be *dispersed*, or spread, to a favorable location in order to germinate. **Germination** (jur•muh•NAY•shun) is the development of a seed into a new plant. Seeds can wait to sprout—sometimes for years—until conditions favor growth. These conditions include water, sunlight, and space to grow.

Seeds are dispersed in many ways. Some seeds have fuzzy, parachute-like structures that help them float or get carried by the wind to a new location. Certain seeds, like a coconut, can float and are dispersed by water. Other seeds use animals for dispersal. Burrs have sticky hooks that cling to an animal’s fur or feathers and get carried to new locations. The most common seed-dispersal method is for the plant to surround the seed with a sweet, fleshy fruit. When a fruit is eaten, the seeds pass through the animal’s digestive system and get deposited in a new location.



Classroom Equity

Encourage participation by all students. Start at the back of the room and call on every other student. Alternatively, have each student write a question and answer based on the text. Ask one student to be moderator, and, using the questions, call on other students to answer them.

Types of Flowering Plants

Monocots



flower parts in multiples of three

Dicots



flower parts in multiples of four or five

Quick Lab

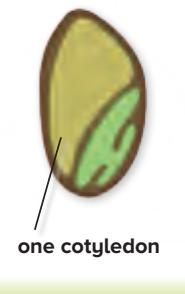
To learn more about seeds, complete the Quick Lab in the activity workbook.



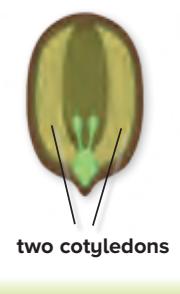
parallel veins



branched veins



one cotyledon



two cotyledons

Quick Check

4. Why are seeds able to wait for the proper conditions to germinate?

Seeds have tough seed coats
for protection and to keep from
drying out. They also contain
a food supply.

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EXPLAIN

Differentiated Instruction

Leveled Questions

EXTRA SUPPORT What kind of plants have seeds with only one cotyledon? **monocots**

ENRICHMENT Why are fruits important in seed dispersal?

Fruits are sweet and fleshy and taste good to animals. When animals eat the fruit, the seeds inside the fruit pass through the animal's digestive system and are deposited in a new location away from the parent plant.

Quick Lab

Comparing Seeds

See the Quick Labs in the Activity Lab Manual.

Objective Observe different types of seeds and predict how they are dispersed.

Materials different types of seeds (e.g., bean seed, maple seed, burdock seed, coconut seed in husk), hand lens

- 1 Have students use hand lenses to observe the seeds.
- 3 Possible predictions: Burr-like seeds stick to the fur of animals or to the clothing of people. Wispy seeds are carried by the wind. Heavy seeds are eaten. Coconut seeds are carried by water.

► Discuss the Main Idea

Show students two different plants and their seeds—one a monocot, such as a corn plant, and the other a dicot, such as a bean plant. Ask:

■ How can you tell which plant is a monocot and which is a dicot? **Monocots have parallel veins in their leaves and seeds with only one cotyledon. Dicots have leaves with branched veins and seeds with two cotyledons.**

► Use the Visuals

Have students study the illustrations of monocots and dicots. Ask:

■ How can you identify the dicots in the chart? **Dicot plants have seeds with two cotyledons, leaves with branched veins, and flower petals in groups of four or five.**

Quick Lab



small groups



15 minutes

What is the conifer life cycle?

► Discuss the Main Idea

Show students photos of different kinds of gymnosperms, including pines, spruces, firs, cypress, and ginkgoes. If possible show students cones and leaves from some of these gymnosperms. Ask:

- **How are all gymnosperms alike?** Possible answer: They have cones as reproductive parts rather than flowers.
- **How do gymnosperms differ from angiosperms?** Possible answers: Gymnosperms produce cones instead of flowers. The seeds of gymnosperms are naked and not protected by fruit.

► Develop Vocabulary

conifer *Word Origin* Tell students that *conifer* comes from two Latin words that mean “cone bearing.” Review with students that conifers produce seeds on cones instead of inside flowers.

► Use the Visuals

Have students study the diagram of the conifer life cycle. Ask:

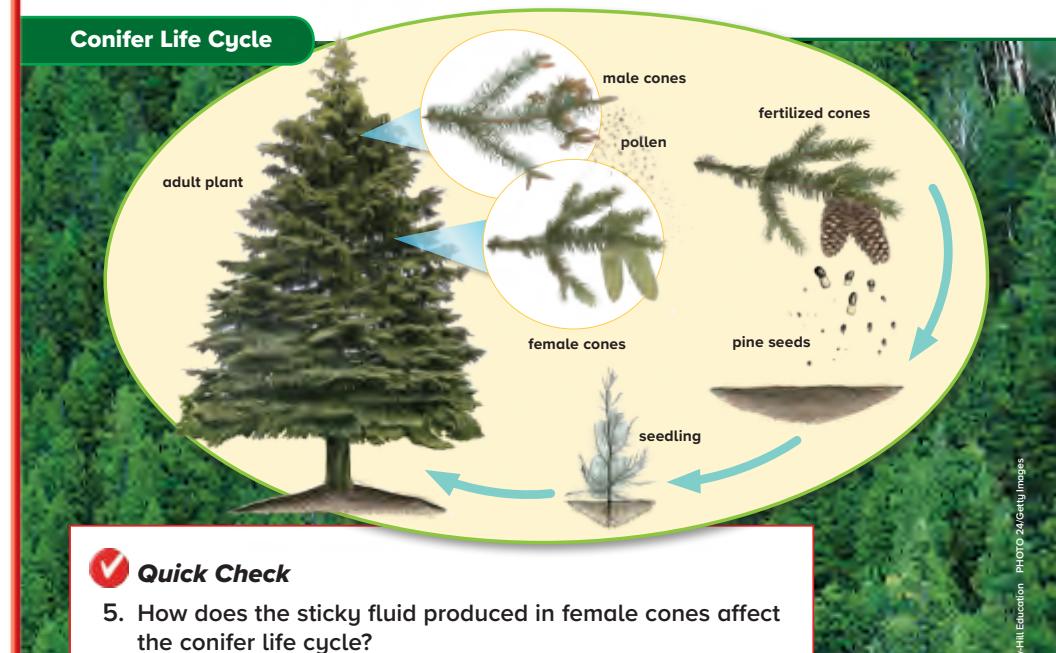
- **What is happening between the two drawings on the left?** Pollen is falling from a male cone to the sticky substance on the female cone.
- **What is falling in the drawing on the right?** pine seeds

What is the conifer life cycle?

A **conifer** (KAH•nuh•fur) is a gymnosperm, a plant that has seeds but not flowers. Conifers include evergreens, such as pines, firs, cedars, redwoods, and other cone-bearing trees. Gymnosperms differ from angiosperms in two key ways. First, gymnosperms produce cones for reproduction rather than flowers. Second, gymnosperms have “naked” seeds. Their seeds are not packaged inside a fruit like the seeds of flowering plants.

Most conifers produce both male and female cones. The smaller male cone releases clouds of powdery pollen that blow in the wind. The larger female cone produces a sticky fluid. Pollination occurs when the pollen lands on the sticky fluid. After fertilization occurs, the developing egg remains attached to the female cone, where it matures into a seed.

How do conifer seeds get dispersed? The seeds have winglike structures that help them whirl their way to the ground. Strong winds can blow seeds far from the tree they were released from. Under the right conditions, these seeds can then grow into new trees.



Quick Check

5. How does the sticky fluid produced in female cones affect the conifer life cycle?

Pollination occurs when pollen grains land on the sticky fluid.

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EXPLAIN

Homework Activity

What are different kinds of conifers?

Have students use encyclopedias or approved Internet sites to research different kinds of conifers and their relatives, such as yews, pines, cypress, cycads, spruces, firs, and ginkgoes. Tell them to research where each kind of plant lives, how big it grows, how long it lives, and other characteristics about the plants. Ask students to draw an illustrated table that compares and contrasts the different types of conifers. Have them share their finished tables with the class.

Teacher Notes

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 2 Lesson Review

Visual Summary

Complete the lesson summary in your own words.



Plant Life Cycles Possible answer: All living things

have life cycles. Plant life cycles include an
alternation of generations.



Angiosperms Possible answer: Flowers are the

reproductive organs of angiosperms. Angiosperm
embryos are packaged in seeds.



Conifers Possible answer: Conifers are seed plants

that produce cones rather than flowers.

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EVALUATE

Formative Assessment

Approaching Have students create a glossary that defines in their own words each of the vocabulary terms introduced in the lesson plus any other key words they wish.

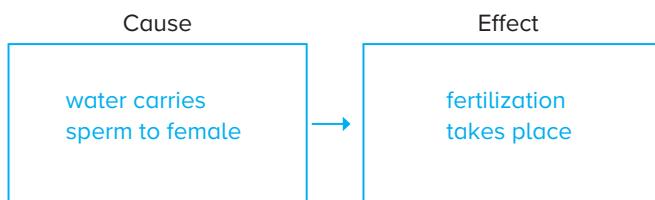
On-Level Have students create a plant life cycles notebook. Have them draw and label the life cycles for mosses, ferns, flowering plants/angiosperms, and conifers/gymnosperms.

Challenge Have students make one index card for each type of flower they learned about in this lesson. Have them list the parts in each type of flower and the function of each part. On the other side, have them draw the appropriate type of flower.

Think, Talk, and Write

1 **Vocabulary** Plants with flower petals that appear in groups of three are monocots.

2 **Cause and Effect** What effect does water have in the moss life cycle?



3 **Critical Thinking** Can fertilization take place without pollination occurring in flowering plants?

Fertilization cannot take place without pollination.

4 **Test Prep** Flowers that are wind-pollinated are generally
 A small and dull.
 B colorful and small.
 C dull and scented.
 D large and colorful.

5 **Test Prep** Which is not part of a seed?
 A embryo
 B seed coat
 C cotyledon
 D stamen

Essential Question How do plants grow, develop, and reproduce?

Plants such as mosses and ferns reproduce using spores. Angiosperms are flowering plants that produce seeds. Conifers produce seeds, but they have cones. Plants grow and develop in different ways.

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your understanding of plant reproduction changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

Focus on Skills

Objective

- Observe a flower and draw a diagram.

Materials flower, paper, pencil, colored pencils or markers, hand lens

Plan Ahead Gather a variety of flowers that are readily available from your garden or the local supermarket, such as daisies, tulips, lilies, and irises.

EXTEND Students observe real flowers and draw diagrams of their observations.

Inquiry Skill: Observe

► Learn It

Explain to students that when they make an observation, they need to use their senses of sight, smell, sound, and, if a teacher permits, touch, but never taste. Using the diagram of the flower on the student page, point out to students how to add labels to a diagram.

Focus on Skills

Inquiry Skill: Observe

You just learned about plant life cycles and plant structures. For example, flowering plants reproduce sexually by forming seeds when sperm from pollen fertilizes an egg cell inside the pistil.

Perfect flowers have both a pistil (female part) and stamen (male part). Imperfect flowers have either a pistil or a stamen but not both. How do scientists know this? They **observe** real flowers!

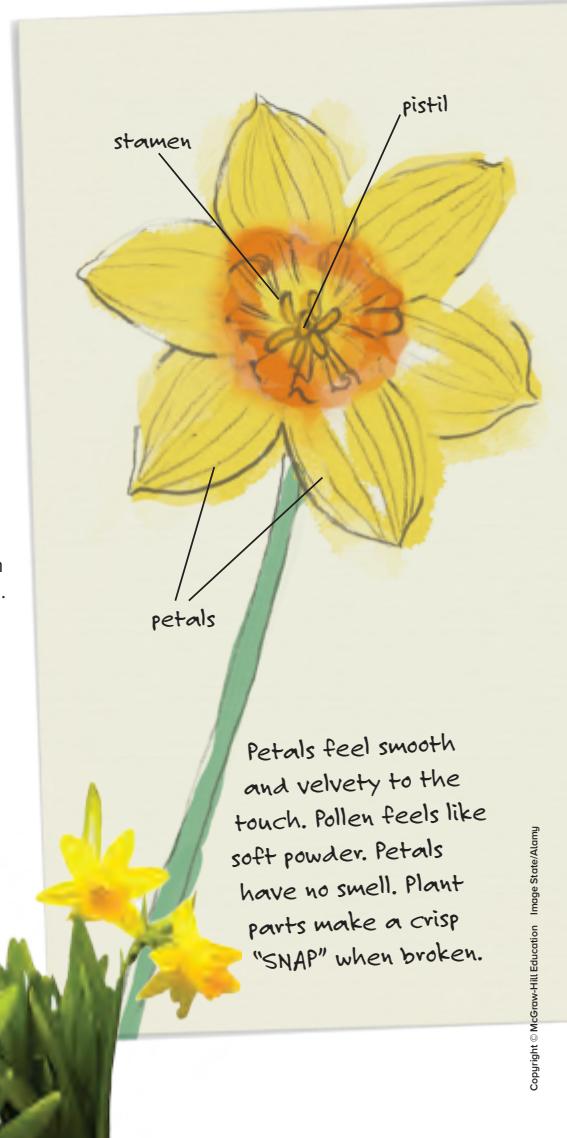
► Learn It

When you **observe**, you use one or more of your senses to learn about an object. It is important to record what you **observe**. One way is to draw a diagram with labels to identify exactly what you saw. You can record other observations, such as odors and sounds, under the diagram. Then you can use the information to help identify other plants and their parts.

This diagram is a record of someone's observations. Each flower part is labeled. Note the observations under the diagram.



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EXTEND



Integrate Writing

Write a Description of a Flower

Have students write a description of the flower they used for their observations and diagrams. Tell students to compare their written descriptions to their diagrams. Ask:

- Is it easier or more difficult to describe the flower in writing or with a diagram?
- How does it help to have a written description as well as a diagram?
- Why do you think scientists use diagrams when they want to explain something accurately?

Skill Builder

 Try It

Materials flower, paper, pencil, colored pencils or markers, hand lens

- 1 **Observe** Look at a flower.
- 2 Make a diagram like the one shown on the previous page. Be sure to include labels and to color your flower and its parts.
- 3 Write any other observations about your flower under the diagram.

Answers will vary.

► Apply It

1 Now it is time to use your diagram and other observations to answer questions. Which senses were used to **observe** this flower? Is this a perfect or imperfect flower? How can you tell?

Answers will vary. Students can use sight, touch, and smell to observe the flower. The flower is perfect if it has both stamen and pistils.

- 2 Continue to use your observation skills. Choose an object in your classroom, such as a stapler, a pencil sharpener, a TV, or the intercom system.
- 3 **Observe** Look at the object you chose. Make a diagram of the object. Include labels to identify any parts and how they are used. Write other observations, such as how it feels to the touch or the sound it makes.

Answers will vary.

4 Share your diagram and observations with your classmates.

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EXTEND

► Try It

- 1 Give each student or pair of students a flower to diagram. Help students to identify the flowers you provide by name before they begin their observations and diagrams.
- 2 You may want to have references available that illustrate the parts of different kinds of flowers. Encourage students to label all the parts of the flower they observe.
- 3 When students have completed their diagrams and recorded their observations, display the diagrams in the classroom for all students to observe.

► Apply It

Have students make observations and diagrams of common classroom objects or other organisms in the classroom.

- 1 Students should say they use their senses of sight, smell, and touch to observe the flower. If the flower has both stamen and pistils, it is a perfect flower. If either part is missing, the flower is imperfect.
- 3 Encourage students to be as detailed as possible with their diagrams. If students do not know the name of a part, encourage them to use references such as a visual dictionary or approved Internet sites to research the name of the part. Remind students to use all their senses except taste as they make and record their observations.

Teacher Notes

Lesson 3 Animal Life Cycles

Essential Question

How do animals grow, develop, and reproduce?

Objective

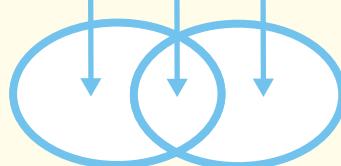
- Define complete and incomplete metamorphosis.
- Discuss fertilization and explain how the processes of external and internal fertilization work.

Reading Skill **Compare and Contrast**

Different Alike Different

1000

Different



You will need a compare-and-contrast graphic organizer.



FAST TRACK

Lesson Plan When time is short, follow the Fast Track and use the essential resources.

1 Introduce

Look and Wonder

2 Teach

Discuss the Main Idea

Develop Vocabulary

3 close

Think, Talk, and Write

Teacher Notes

Lesson 3 Animal Life Cycles

Objectives

- Define complete and incomplete metamorphosis.
- Discuss fertilization and explain how the ~~processes of external and internal fertilization~~ work.

1 Introduce

► Assess Prior Knowledge

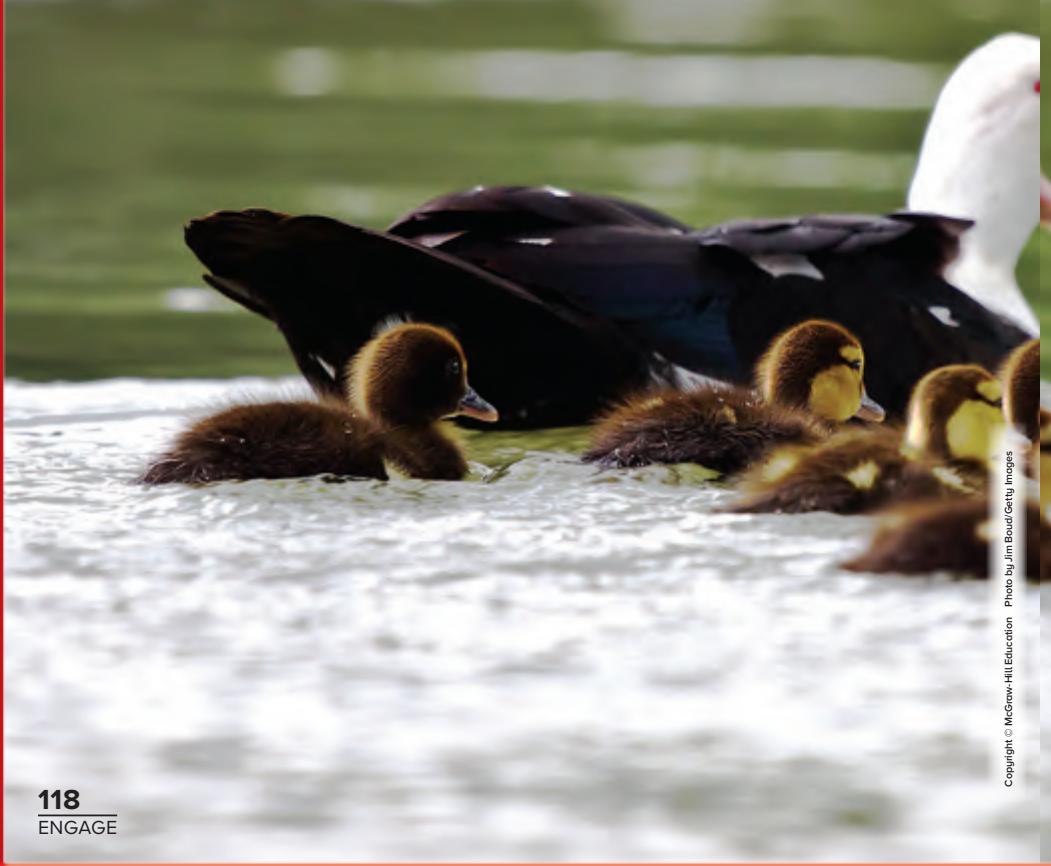
Ask students to describe how animals change during their lifetimes from their births to their deaths. Record student responses on the board.

Possible answers: They grow larger; their form changes; their behavior changes. Ask:

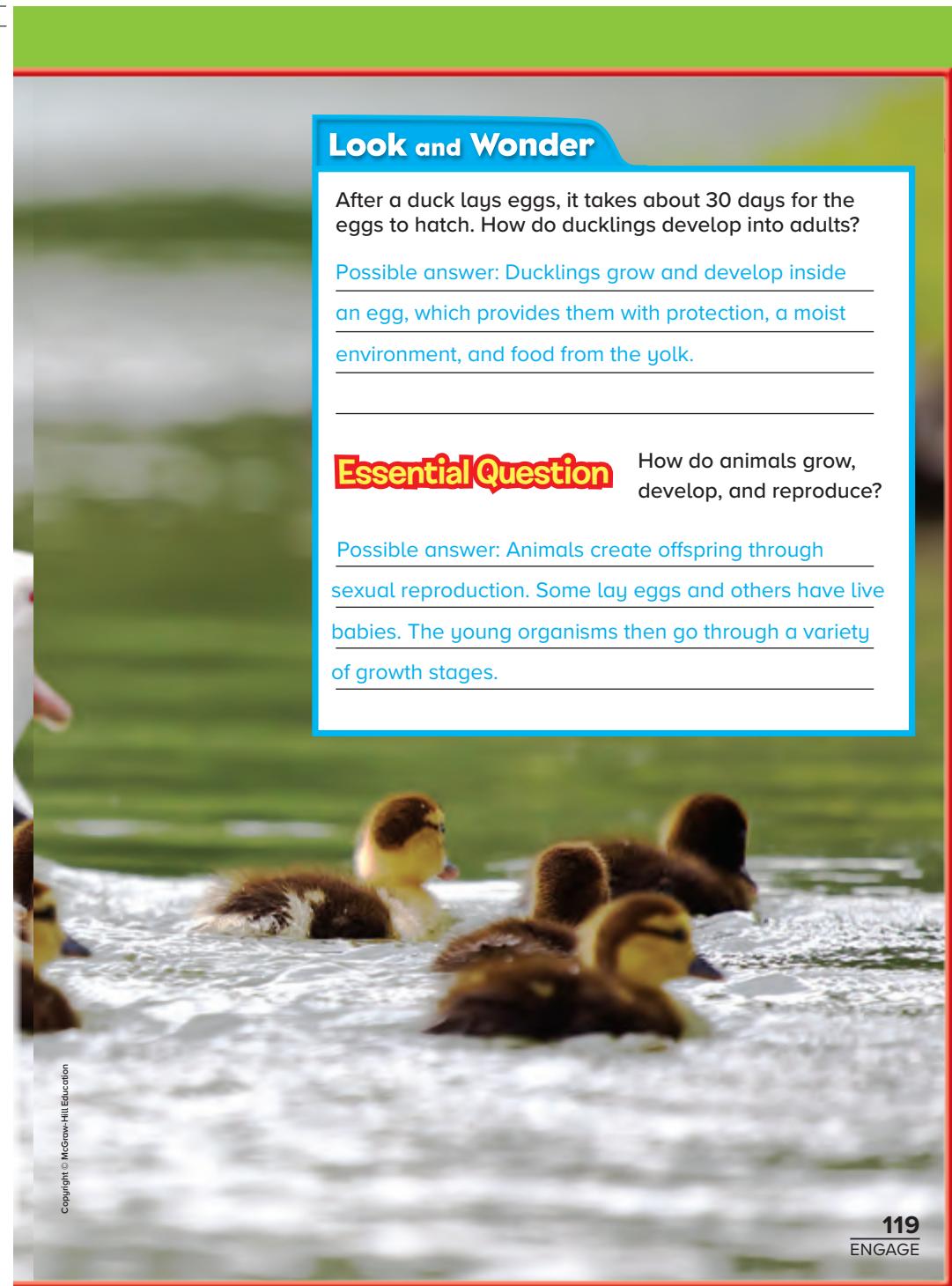
- In what ways do you think animals change during their lives? Animals grow in size and change physically as they develop over their life spans.**
- Do you think all animals change in the same way during their lifetimes? Not all animals experience the same changes during their lifetimes.**

Lesson 3

Animal Life Cycles



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Look and Wonder

After a duck lays eggs, it takes about 30 days for the eggs to hatch. How do ducklings develop into adults?

Possible answer: Ducklings grow and develop inside an egg, which provides them with protection, a moist environment, and food from the yolk.

Essential Question How do animals grow, develop, and reproduce?

Possible answer: Animals create offspring through sexual reproduction. Some lay eggs and others have live babies. The young organisms then go through a variety of growth stages.

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Look and Wonder

Invite students to share their responses to the Look and Wonder statement and question:

■ **How do ducklings develop into adults?**

Write ideas on the board and note any misconceptions that students may have. Address these misconceptions as you teach the lesson.

Essential Question

Have students read the Essential Question. Tell them to think about it as they read through the lesson. Advise students that they will return to this question at the end of the lesson.

Explore

pairs



20 minutes

Plan Ahead You may want to make enlargements of the stages of frog development and do the activity as an entire class.

Purpose In this activity students examine data that they have “collected” to determine how frogs change during their life spans.

Structured Inquiry

Purpose Have a discussion with students to point out the kinds of things to look for as they make their observations.

Explore**What are the stages in an animal's life cycle?****Purpose**

You are part of an expedition that is studying the life cycle of frogs. You have collected some data about the frogs you observed. Interpret your data and photos to determine how long each stage of a frog's life cycle lasts.

Procedure

- Observe** Take a look at the stages involved in frog development.
- In the chart below, record changes in the frog's body structure during each stage of development. *Answers will vary.*

Stage 1		
Stage 2		
Stage 3		
Stage 4		
Stage 5		

- Interpret Data** Use the photos to determine how long each stage lasts. Record the information in your chart.

Stage 1: Fertilized eggs
Date: April 1Stage 2: Tadpole
Date: April 5Stage 3: Tadpole
Date: June 23Stage 4: Froglet
Date: July 7Stage 5: Mature Frog
Date: July 21

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EXPLORE

Alternative Explore**How does a grasshopper develop?**

Materials encyclopedia, reference books, and magazines
Students use reference materials to find out how a grasshopper changes from the time it hatches from an egg until it is an adult. Students should draw and label the stages of grasshopper development.

Inquiry Activity

Draw Conclusions

4 What was the shortest stage in frog development? What was the longest stage?

The shortest stage is from single cell to tadpole and the longest is between stages 2 and 3.

5 Infer When did the organism seem to change the most?

Possible answer: between the egg and the tadpole stage

6 How is the organism in stage 2 different from the organism in stage 4?

Stage 2 is more like a fish with gills and a tail. In stage 4, the tail is much shorter and the tadpole has four legs and no gills.

Explore More

How does the fertilized frog egg develop into a tadpole? Research for photographs of the first four days of a tadpole's life. Describe the changes you see.

Answers will vary. Students should observe the fertilized egg dividing into more and more cells. The resulting embryo should be comma-shaped.

Open Inquiry

What does the tadpole look like as it gets older?

Answers will vary.

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EXPLORE

Teacher Notes

2 Teach

Read and Respond

Main Idea Have students preview the lesson by reading the headings and looking at the pictures. Encourage them to predict what they will learn in this lesson.

Vocabulary Give a definition for each new vocabulary term. Then have students find the term in the lesson that matches the definition.

Reading Skill Compare and Contrast

Graphic Organizer Have students fill in a Compare and Contrast graphic organizer as they read through the lesson. They can use the Quick Check questions to identify each comparison and contrast.



What are animal life cycles?

► Discuss the Main Idea

Have students read the student pages. Explain that the two types of metamorphosis are very different from one another. Ask:

- **How does complete metamorphosis differ from incomplete metamorphosis?** Complete metamorphosis has four distinct stages: egg, larva, pupa, and adult. Incomplete metamorphosis has three stages: egg, nymph, and adult.
- **What happens during the nymph stage of incomplete metamorphosis?** The organism gets bigger but keeps the same basic shape and form.
- **What happens during the pupa stage of complete metamorphosis?** The organism's body inside the hard cocoon completely changes, growing wings, different mouth parts, different muscles, and legs.

Read and Respond

What are animal life cycles?

Like plants, animals have life cycles. When most animals begin life, they resemble the adults they will become. For example, after a baby chameleon hatches, its body gradually increases in size until it is an adult. Other animals, such as amphibians and insects, go through metamorphosis (me-tuh-MOR-fuh-sus). **Metamorphosis** is a series of distinct growth stages that are different from one another.

Complete Metamorphosis

Some animals, including butterflies, moths, flies, and beetles, go through complete metamorphosis. In **complete metamorphosis** the animal goes through four distinct stages. The adult body form looks very different from the newly hatched animal. A butterfly, for example, emerges from the egg as a plump larva (LAR-vuh). A **larva** is an immature stage that does not resemble the adult. The wormlike butterfly larva, or caterpillar, has no wings. It often eats different food than the adult.

After hatching, caterpillars begin a period of nonstop feeding. As the caterpillar grows, its outer skin stretches. This stretching stimulates a release of hormones that brings on the next stage of the life cycle—the pupa (PYEW-puh). The **pupa** is a nonfeeding stage during which a hard, caselike cocoon surrounds the organism.

The pupa is often thought to be a resting stage. Although it seems quiet, the organism inside the cocoon is very active. The entire body is changing. Wings, different mouth parts, new muscles, and new legs appear. When the cocoon opens, an adult butterfly with a completely restructured body emerges.



adult chameleon

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EXPLAIN

hatching chameleon

LA Support

Reinforce Vocabulary Clarify the meaning of the word **metamorphosis**. Draw a time line on the board and label four increments for stage 1 through stage 4. Point to each increment as you name each stage of metamorphosis.

BEGINNING Student can point to the correct picture on the student page as you read the following terms aloud: *egg, nymph, larva, pupa, and adult*.

INTERMEDIATE Student can use phrases and short sentences to describe the stages of complete metamorphosis.

ADVANCED Student can describe complete metamorphosis and incomplete metamorphosis in full sentences.

Complete and Incomplete Metamorphosis

Complete Metamorphosis Butterfly



Incomplete Metamorphosis Grasshopper



Read a Diagram

Which metamorphosis stage is skipped in incomplete metamorphosis?

The nymph stage is the same as the larva stage in complete metamorphosis, and the pupa stage is skipped.

Incomplete Metamorphosis

Some insect species, including grasshoppers, termites, and bedbugs, go through incomplete metamorphosis. During **incomplete metamorphosis** the animal goes through three stages that occur gradually. Young grasshoppers, for example, take on the nymph body form after hatching from eggs. A **nymph** (NIMF) is similar to an adult form, but it is smaller and lacks wings and reproductive structures. There may be several different nymph stages before the animal becomes an adult.

Because it has a rigid exoskeleton, an insect cannot grow gradually like

a mammal. Instead, it sheds its hard skeleton all at once to make room for a larger body. Grasshoppers go through five shedding stages before they reach adulthood. During each stage, the wings emerge a little bit more. By the time the grasshopper reaches its final stage, the adult body form is complete.

Quick Check

1. Why can't grasshoppers grow gradually?

They must shed their outer skeletons to make room for a larger body size.

123
EXPLAIN

► Develop Vocabulary

metamorphosis **Word Origin** Tell students that the word *metamorphosis* comes from the Greek word *metamorphoun*, which means “transform” or “change shape.”

complete metamorphosis Review with students the four stages of complete metamorphosis: egg, larva, pupa, and adult.

larva Explain to students that they do not add an s to make the word *larva* plural. The plural of *larva* is *larvae*.

pupa **Word Origin** Tell students that the word *pupa* comes from a Latin word that means “doll.” Also tell students that the plural of *pupa* is formed the same way as *larva*. The plural is *pupae*.

incomplete metamorphosis, nymph Review with students the three stages of incomplete metamorphosis: egg, nymph, and adult. Tell students that during the nymph stage, the animal undergoes several subtle changes and increases in size.

Differentiated Instruction

Leveled Activities

EXTRA SUPPORT Have students draw a Venn diagram, labeling one circle *incomplete metamorphosis* and the other circle *complete metamorphosis*. Have them write words that describe each process in the corresponding circle. Then have them write words that describe both life cycles in the overlapping area.

ENRICHMENT Have students use encyclopedias, other reference books, or approved Internet sites to research how organisms not shown in the text undergo metamorphosis. Have them choose an organism that undergoes incomplete metamorphosis and draw and label how the organism changes. Then have them find an organism that undergoes complete metamorphosis and draw and label it. Encourage them to share their finished drawings with the class.

How does fertilization occur in animals?

► Discuss the Main Idea

Tell students that there are two main kinds of fertilization that occur in animals. Ask:

- **Where does external fertilization take place?**
Possible answers: outside the body; outside the female's body; in the environment
- **How are delicate sex cells protected during external fertilization?** Possible answers: They are kept wet. They are not allowed to dry out.
- **Why is internal fertilization important to an animal?**
Internal fertilization protects both the sex cells and the fertilized eggs from drying out, from dangers in the environment, and from other organisms.

► Develop Vocabulary

external fertilization Review with students that external fertilization takes place in the environment, outside the body of the female.

internal fertilization Explain to students how internal fertilization is different from external fertilization and that internal fertilization occurs inside the body of the female.

How does fertilization occur in animals?

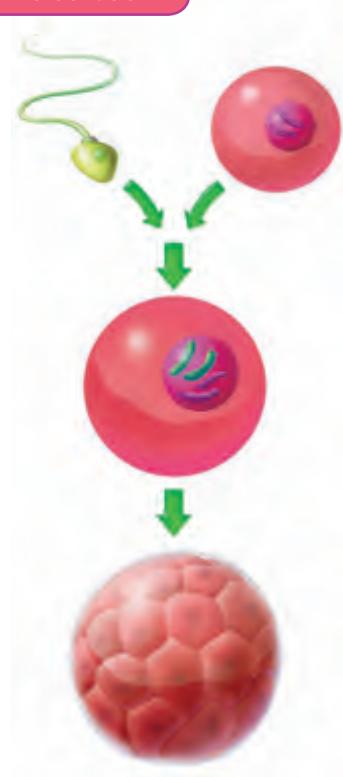
Sexual reproduction in animals starts with fertilization. When a sperm cell combines with an egg cell, the resulting fertilized egg starts growing. The problem that most animals face is that sex cells are delicate. They must be protected for fertilization to occur.

External Fertilization

Most amphibians and most fish solve this problem by releasing their sex cells into water. Male salmon, for example, prepare for fertilization by finding a section of gravel in a lake bed. The female digs a shallow nest in the gravel and releases her eggs. Once the eggs are in place, the male releases sperm over them in the water. This joining of egg and sperm outside the female's body is called **external fertilization**.

External fertilization is a high-risk process. Ponds, lakes, rivers, and oceans contain vast amounts of water. The chances of sperm cells finding and fertilizing the egg cells are decreased in large amounts of water. Many sex cells are lost, and some are eaten by other animals. The sex cells can also be exposed to extreme temperatures and pollution in the water.

Fertilization



This male salmon is spreading sperm cells onto egg cells that have been released into the water by the female.



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EXPLAIN

Science Background

Viviparous Fish

Viviparous fish bear their young live; they are not hatched from eggs. The scalloped hammerhead shark is one example of a viviparous fish. It does not have a placenta like humans, but it does have a uterus. The embryos are surrounded by a separate membrane. They are attached to a yolk sac, from which they get nutrients. When they are born, the pups can survive on their own, swimming and even hunting for food.

How do these animals manage to produce any offspring at all in these conditions? They ensure the production of offspring by releasing a great many sex cells at one time. The large numbers increase the chances that fertilization will occur. Typically, only one or two out of every thousand eggs laid survive to adulthood. For this reason, many fish and amphibians tend to produce a lot of eggs.

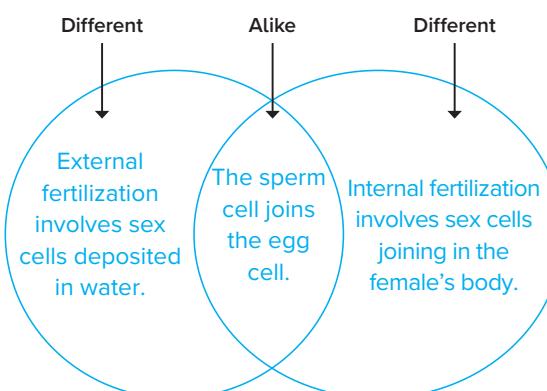
Internal Fertilization

How do the sex cells of land animals survive in the dry conditions on land? Reptiles, birds, and mammals solve this problem with internal fertilization. **Internal fertilization** is the joining of sperm and egg cells inside a female's body.

Internal fertilization increases the chances of fertilization and the offspring's survival. It protects sex cells and fertilized eggs from drying out. It also protects them from the dangers of harsh environments and other organisms. Since the chances of fertilization occurring are much greater with this method than through external fertilization, fewer eggs need to be produced.

Quick Check

2. How are external and internal fertilization similar? How are they different?

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EXPLAIN

Quick Lab

small groups

15 minutes

Model External Fertilization

See the Quick Labs in the Activity Lab Manual.

Objective Model the process of external fertilization.

Materials glass bowl, gravel, water, 15 blue marbles, 15 red marbles

- 1 Rather than provide materials for all students, consider doing this activity as a whole class demonstration. Place the glass bowl without the gravel on the platform of an overhead projector. Add water and then scatter the blue and red marbles.
- 4 The amount of "fertilized" marbles will vary, but the amount should be very few.
- 5 Students should conclude that external fertilization is not an accurate process.

Differentiated Instruction

Leveled Questions

EXTRA SUPPORT Which type of fertilization takes place outside the female's body? **external fertilization**

ENRICHMENT What can decrease the chances for completing external fertilization? **sperm cells released in water may not reach the egg cells; extreme water temperatures; water pollution**

What happens to a fertilized egg?

► Discuss the Main Idea

Ask students to describe any eggs that they have seen at home, in nature, or in a museum. Ask:

- **How does a bird's egg protect the embryo developing inside? The shell keeps the embryo from drying out. The yolk provides food for the developing embryo.**
- **How is a fish or amphibian egg protected? by a jelly-like layer that surrounds the egg**

► Develop Vocabulary

Have students review the meanings of *internal fertilization* and *external fertilization* before they begin discussing the material on this page.

What happens to a fertilized egg?

Successful fertilization produces an egg with a developing embryo inside it. Animals have different eggs depending on their structures and the environments in which they live.

Birds and some mammals lay eggs. So do most fish, amphibians, and reptiles. Fish and frogs lay their eggs in water. A jellylike layer around the eggs provides some protection for the embryos. The embryos get food from the yolks of the eggs.

Reptile and bird eggs have tough shells filled with a watery liquid. The liquid gives the embryo the wet environment it needs to develop and protects it from drying out. Because of this, reptiles and birds can lay their eggs on land. The yolk inside the egg provides the embryo with food.

Most mammals take the safety of the growing embryo a step further. Instead

of hatching outside the mother's body, the eggs of most mammals develop inside the mother. Because the eggs are protected inside the mother, most mammals do not produce as many eggs as other animals. Embryos are fed by their mothers' bodies as they develop.

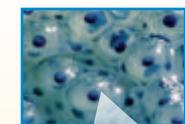
Monotremes are the only mammals that lay eggs. All other mammals give birth to live young.

Quick Check

3. Animals that lay more eggs, such as reptiles, tend to give less care to their offspring. Why might this be true?

Possible answer: Since reptiles invest less energy into caring for their young, they are forced to have more eggs to get a reasonable number of them to survive.

Comparing Eggs



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EXPLAIN



crocodile egg



chicken eggs

Read a Photo

Which egg provides the least protection for the developing embryo?

The frog egg provides the least protection because it is softer.

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Homework Activity

Which mammals lay eggs?

Have students use references such as an encyclopedia or approved Internet sites to research a mammal that lays eggs. Then have students write and illustrate a report that gives both the common and scientific names of the animal, tells where the animal lives, and describes how the animal grows and develops after it hatches from the egg.

3 Close

Lesson Review

► Discuss the Main Idea

Have students review their answers to the questions throughout the lesson. Address any remaining questions or misconceptions.

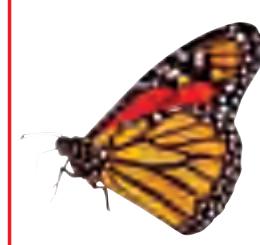
► Visual Summary

Have students summarize key points of the lesson in the Visual Summary. The titles in each box will help guide students to the topics they should summarize.

LESSON 3 Lesson Review

Visual Summary

Complete the lesson summary in your own words.



Metamorphosis Possible answer: Insects and amphibians develop in distinct growth stages as they go through the process of metamorphosis.



External and Internal Fertilization Possible answer: Eggs get fertilized outside of the body in the process of external fertilization. Some animals use internal fertilization to protect their eggs and developing offspring.



Eggs Possible answer: Animals have different types of eggs depending on their environments and life cycles.

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EVALUATE

Formative Assessment

Approaching Have students make a chart to show the steps of incomplete metamorphosis and complete metamorphosis.

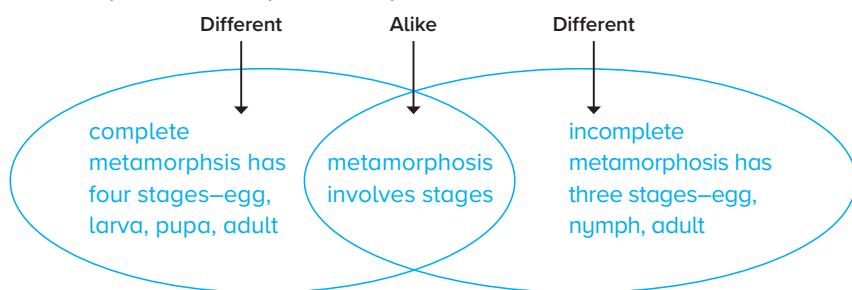
On-Level Have students use their own words to write two short paragraphs that compare and contrast internal and external fertilization.

Challenge Ask students to write a report about a dragonfly from its emergence from an egg until it becomes an adult. Have them describe what kinds of changes take place in the body, what kind of food the dragonfly eats, and how the dragonfly survives.

Think, Talk, and Write

1 Vocabulary A hard, caselike cocoon forms during the pupa stage.

2 Compare and Contrast How do complete metamorphosis and incomplete metamorphosis compare?



3 Critical Thinking Chicken eggs have a large food supply for the embryo. Why don't most mammal eggs have this? Explain.

Most mammal eggs grow inside the female's body and get the nutrition they need from the mother.

4 Test Prep Animals that carry out internal fertilization generally

- A produce many eggs.
- B produce only one egg their entire life.
- C produce thousands of offspring.
- D produce a small number of eggs.

5 Test Prep Which stage is a caterpillar?

- A egg
- B larva
- C pupa
- D adult

Essential Question How do animals grow, develop, and reproduce?

Answers will vary. Animals grow, develop, and reproduce in different ways.

Essential Question

Advise students to return to their original answer to the Essential Question. Ask:

How has your understanding of animal systems changed since the beginning of the lesson?

Student responses should demonstrate that they have developed their understanding of the lesson material.

CHAPTER 2 Review

► Visual Summary

Have students look at the pictures to review the main ideas of the chapter.

CHAPTER 2 Review

Visual Summary

Summarize each lesson in your own words.



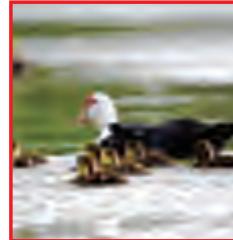
Reproduction

All living things come from other living things.



Plant Life Cycle

The life cycles of all plants involve different stages of development.



Animal Life Cycle

Animals use different strategies to reproduce and ensure the survival of their offspring.

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Chapter 2 • Review

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Teacher Notes

Vocabulary

Fill each blank with the best term from the list.

embryo

metamorphosis

fertilization

pollination

germination

pupa

1. The beginning of a new life form is called a(n) embryo.
2. The stage in which a caselike cocoon forms around the organism is called the pupa.
3. Pollen is transferred from the stamen to the pistil of a flower during pollination.
4. A sperm cell and an egg cell join into a single new unit during fertilization.
5. During its life cycle, a butterfly goes through a complete metamorphosis.
6. The development of a seed into a new plant is called germination.

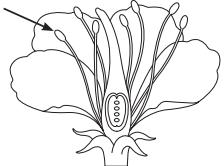
CHAPTER 2 Review

CHAPTER 2 Review

Skills and Concepts

Answer each of the following.

7. Which part of the flower below is the arrow pointing to?



A a sepal
 B a stamen
 C a pistil
 D a petal

8. **Observe** Look at a flower and draw it. Label any traits you notice. These may include the color of the flower's center and petals, the number of petals, and the length of the stem.



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Chapter 2 • Review



9. Compare and Contrast Compare wind-pollinated flowers and animal-pollinated flowers. Is this flower pollinated by animals or by the wind? Explain.

The flower is probably pollinated by



animals or insects. It is large and bright to

attract pollinators. Wind-pollinated flowers tend to be smaller and duller.

10. Explanatory Writing Explain the disadvantages of external fertilization.

The sperm cells may not be able to find and fertilize the egg cells. Sex cells
can be lost or eaten by other animals. Sex cells are exposed to pollution
and extreme temperature.

10. Advise students to return to their original answer to the Big Idea Question. Ask: How has your understanding of the topic changed since the beginning of the chapter? Student responses should demonstrate that they have developed their understanding of the chapter material.

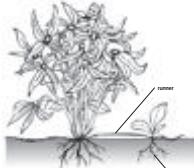
Test Preparation

1. **D: vegetative propagation.** Some types of vegetative propagation involve runners, or plant stems that lie on the ground and grow into new plants.
2. **C: spores.** Mosses and ferns are seedless plants that reproduce using spores. Angiosperms and gymnosperms are seed plants. Gymnosperms produce cones for reproduction. Plant roots absorb water and anchor the plant to the ground.
3. **C: goes through four distinct stages.** In complete metamorphosis, the adult body form looks different from the other stages. Incomplete metamorphosis involves three stages. One of the stages is the nymph stage.
4. **A: stamens and a pistil.** A perfect flower has both male and female structures. A flower is still perfect even if it is missing structures, such as petals and sepals.
5. **B: it contains food for the embryo.** The watery liquid in some eggs prevents the eggs from drying out. The shell provides some protection from other animals. Warmth must come from an incubating adult or the environment.
6. **D.** The pupa is the nonfeeding stage. Answer choice A is an adult. Answer choice B is an egg. Answer choice C is a larva.

Test Prep

Circle the best answer for each question.

1. Study this picture.



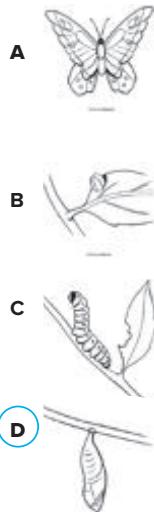
This plant is reproducing using

- A** seeds.
- B** budding.
- C** cones.
- D** vegetative propagation.

5. What is the purpose of the yolk in a bird's egg?

- A** It protects the embryo from drying out.
- B** It contains food for the embryo.
- C** It keeps the embryo safe from other animals.
- D** It keeps the embryo warm.

6. Which diagram shows the pupa stage of the butterfly's life cycle?



2. Mosses and ferns reproduce using

- A** seeds. **C** spores.
- B** cones. **D** roots.

3. When complete metamorphosis occurs, an animal

- A** has the same structures in its adult and immature forms.
- B** becomes a nymph.
- C** goes through four distinct stages.
- D** goes through three distinct stages.

4. A perfect flower must have

- A** stamens and a pistil.
- B** petals and stamens.
- C** petals and leaves.
- D** sepals and an ovary.

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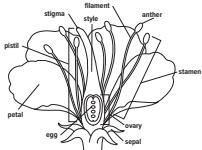
Chapter 2 • Test Prep

Teacher Notes

7. The flowers of some plants are bright and colorful to

- A entice people to cut them.
- B warn other organisms that they are dangerous.
- C capture light from the Sun.
- D** attract pollinators.

8. Study this diagram of a flower.



Identify the male and female parts of the flower. What is pollen and where it is produced? Explain how the egg is fertilized.

The male part of the flower is the

stamen. The female part is the

pistil. Pollen is a yellow powder that

contains sperm cells and is produced

in the anther on the stamen. The

pollen is carried to the stigma. From

there it passes down the style to the

ovary, where it fertilizes the egg.

7. D: attract pollinators. The colors of some flowers attract pollinators. Pollinators help the plant by transferring the flower's pollen to other flowers.

8. The male part of the flower is the stamen. It is made of the filament and the anther. The female part of the flower is the pistil. It is made of the stigma, the style, and the ovary. Pollen is a yellow powder that contains sperm cells. Pollen is produced in the anther on the stamen. The pollen is carried to the stigma. From there it passes down the style to the ovary, where it fertilizes the egg.

Depth of Knowledge

Level 1 Recall Level 1 requires memory of a fact, a definition, or a procedure. At this level, there is only one correct answer.

Level 2 Skill/Concept Level 2 requires an explanation or the ability to apply a skill. At this level, the answer reflects a deep understanding of the topic.

Level 3 Strategic Reasoning Level 3 requires the use of reasoning and analysis, including the use of evidence or supporting information. At this level, there may be more than one correct answer.

Level 4 Extended Reasoning Level 4 requires the completion of multiple steps and requires synthesis of information from multiple sources or disciplines. At this level, the answer demonstrates careful planning and complex reasoning.

Careers in Science

Objective

- Compare the duties of health care technicians.

Health Care Technician

Genre: Nonfiction Draw students' attention to the photo on the student page. Ask: **What clues does the photo give about the work people do in the career described?** **Possible answers:** their surroundings and their equipment

Talk About It

- Why would a health care technician need to like working with people? **Possible Answer:** because these technicians spend a lot of time working with patients who need health care

Learn About It

- Why must health care technicians know about the systems of the human body? **Possible answers:** to take X-rays of muscles and bones, to take blood samples or specimens

Write About It

Ask students to research how someone in the assigned career would apply the information learned in this chapter. Have them choose a specific job and research the training needed, then write a summary about what they learned.

Careers in Science

Health Care Technician

Doctors give patients checkups and medical treatment, but they do not work alone. They need the help of health care technicians. If you like working with people, then you might like this career. You would train while working in a doctor's office, clinic, hospital, or nursing home. You might schedule appointments and monitor the flow of patients. You might take X-rays of patients' muscles and bones and then develop the films. You might take blood samples for tests or treatment. You might collect lab specimens and perform tests. As you gained experience, you would take on more and more responsibility. Both doctors and their patients would depend on you doing a good job.



▲ Health care technicians prepare samples to be tested.



Write About It

Health care technicians have many duties. Write about a challenge a health care technician might face on the job.

Answers will vary. Accept reasonable responses.

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Integrate Writing

Career Journal

Have students write a journal entry about one day's work as a health care technician. Have students answer the following questions in their journal entries:

- What kinds of things would you see when you arrive at work?
- How many people would you typically see during the day?
- What kinds of things would be on your "to do" list?
- How would you describe what you do in a few words?

Teacher Notes