

How Are Canals & the Paleozoic Era Connected?

Before the invention of the locomotive, canals, such as the one at upper right, were an important means of transportation. In the 1790s, an engineer traveled around England to study new canals. The engineer noticed something odd: All across the country, certain types of rocks seemed to lie in predictable layers, or strata. And the same strata always had the same kinds of fossils in them. Since each layer of sedimentary rock typically forms on top of the previous one, scientists realized that the strata recorded the history of life on Earth. By the mid-1800s, the known rock strata had been organized into a system that we now know as the geologic time scale. In this system, Earth's history is divided into units called eras, which in turn are divided into periods. Many of the rock layers in the Grand Canyon (background) date from the Paleozoic, or "ancient life," Era.



unit projects

Visit green.mssscience.com/unit_project to find project ideas and resources.
Projects include:

- **History** Discover some of Earth's inhabitants of different time periods using the fossil record. Create a drawing of a scene in Earth's history.
- **Technology** Choose an extinct animal to investigate. How has technology allowed paleontologists to learn about how it lived?
- **Model** As a group, design a wall mural or diorama depicting the layers of the geologic time scale, or a particular scene of interest from an era.




Use online resources to form your own opinion concerning plate tectonics. Investigate the *Fossils of Antarctica* and what they could tell us about its ancient climate and location.



The Nature of Science

chapter preview

sections

- 1 How Science Works
- 2 Scientific Problem Solving
 - Lab** Advertising Inferences
 - Lab** Model an Archaeological Dig
 -  **Virtual Lab** What strategies are involved in solving a scientific problem?

How did they live?


Digging in a cave in Southern France, these researchers are unearthing ancient human relics—some dating back to about 200,000 years before present. Notice the string grid layout on the cave floor.

Science Journal Write about any human artifact you know of that was discovered in an area near your home, or that was unearthed in another region.

Start-Up Activities



Model an Excavation

Excavations to unearth tools or other clues of past human life often are slow processes. Care must be taken so the remains are not broken or destroyed as they are removed from the soil. Try to excavate a cookie without destroying the treasures within. 

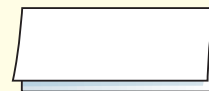
WARNING: *Never eat or drink in the science lab, and never use lab glassware as a food or drink container.*

1. Obtain an oatmeal cookie with raisins and walnuts from your teacher.
2. Place the cookie on a large paper towel.
3. Use a biology probe to remove the raisins and walnuts from the cookie without damaging either one.
4. Give all pieces of the excavated cookie to your teacher for disposal.
5. Wash your hands with soap and water when you have finished.
6. **Think Critically** In your Science Journal, write a paragraph that explains how probing the cookie might be similar to removing bones, tools, or other evidence of ancient life from Earth's crust.

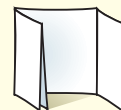
FOLDABLES™ Study Organizer

Science and Technology Make the following Foldable to compare and contrast science and technology.

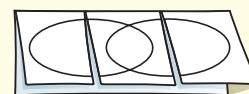
- STEP 1** Fold one sheet of paper lengthwise.



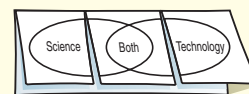
- STEP 2** Fold into thirds.



- STEP 3** Unfold and draw overlapping ovals. Cut the top sheet along the folds.



- STEP 4** Label the ovals as shown.



Construct a Venn Diagram As you read the chapter, list the aspects unique to science under the left tab, those unique to technology under the right tab, and those characteristics common to both under the middle tab.



Preview this chapter's content and activities at green.msscience.com



How Science Works

as you read

What You'll Learn

- **Explain** the science of archaeology.
- **Compare and contrast** science and technology.

Why It's Important

Science and technology are important parts of your everyday world.



Review Vocabulary

artifact: object of historical interest produced by humans, such as a tool or weapon

New Vocabulary

- science
- technology

Groundbreaking News

It was Friday morning, and the students in Ms. Garcia's science lab were waiting eagerly for class to start. Unlike most days in science class at York Middle School, this meeting would be a field trip to the north end of the school. Students were eager to observe work that would result in the long-awaited, new gymnasium. The students in group 4—Ben, Emily, Maria, and Juan—peered out the windows. They saw construction equipment, including bulldozers and trucks much like the ones shown in **Figure 1**, pull up to the school. With pencils and notebooks in hand, the interested students hiked out to the site. They watched as massive shovels moved hundreds of kilograms of dirt from one spot to another.

Buried treasure? All of a sudden, the power-shovel operator stopped the giant scoop in midair. He looked curiously into the hole he was making, and then he climbed from his seat high above the ground. He called some of the other workers over. They all stared into the pit. One of the workers motioned for Ms. Garcia and her students to come a little closer. Everyone was surprised at what they saw. A piece of broken pottery was sticking out from the loosened soil.

Figure 1 Construction efforts sometimes unearth prehistoric sites.





Figure 2 Much can be learned about ancient cultures from materials they left behind.

Archaeologists study pottery and other items to learn more about ancient humans.



Archaeologists work in the field to gather data.



Science in Action One worker suggested that the pottery might be only one of thousands of pieces of trash that were buried long before the school was built. Another worker, however, wasn't so sure. He thought that the pottery could perhaps be an ancient piece of art, such as the one shown in **Figure 2**. Nonetheless, a decision was made to stop the excavation, at least for the moment.

Back in the classroom, the students talked excitedly about the find. This, they all agreed, was real science. **Science**, they knew, is the process of trying to understand the world.

Calling in the Experts Although the discovery was exciting, Ms. Garcia reminded the students that the piece of pottery might be something that was thrown out only decades ago. To be sure, however, the school's principal called an archaeologist at the local college. Archaeologists, such as the two shown in **Figure 2**, are scientists who study the cultural remains of ancient humans. Cultural remains, known as artifacts, might be tools, weapons, rock drawings, buildings, or pottery, such as that found at the school. Dr. Lum, the students were told, would be at the school on Monday to examine the pottery.

Ms. Garcia suggested that her students research more about the history of their area. This would help the students evaluate how this pottery might have originated from ancient cultures that once lived in the area. Ben and the others in his group quickly began their research. Maria thought that it would be a good idea to take notes on their findings. That way, they could compare what they found with what Dr. Lum told them on Monday. The others in the group agreed and put their science notebooks into their backpacks before heading to the library.

Scienceonline

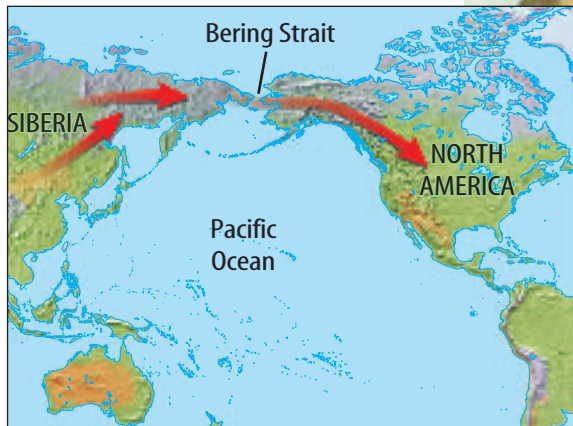
Topic: Artifacts and Human History

Visit green.msscience.com for Web links to information about how artifacts provide clues about human behavior and history.

Activity Select a human artifact, such as a tool, art piece, or waste material. List three specific examples of this type of artifact, and include the location where each was found. Summarize the knowledge gained about the humans who produced the artifacts.



Figure 3 Archaeologists study artifacts of ancient people like those from ancient Egypt or like those who came to North America about 12,000 years ago.



One branch of archaeology studies the cultural remains of people who lived before history was written.



Researching the Past

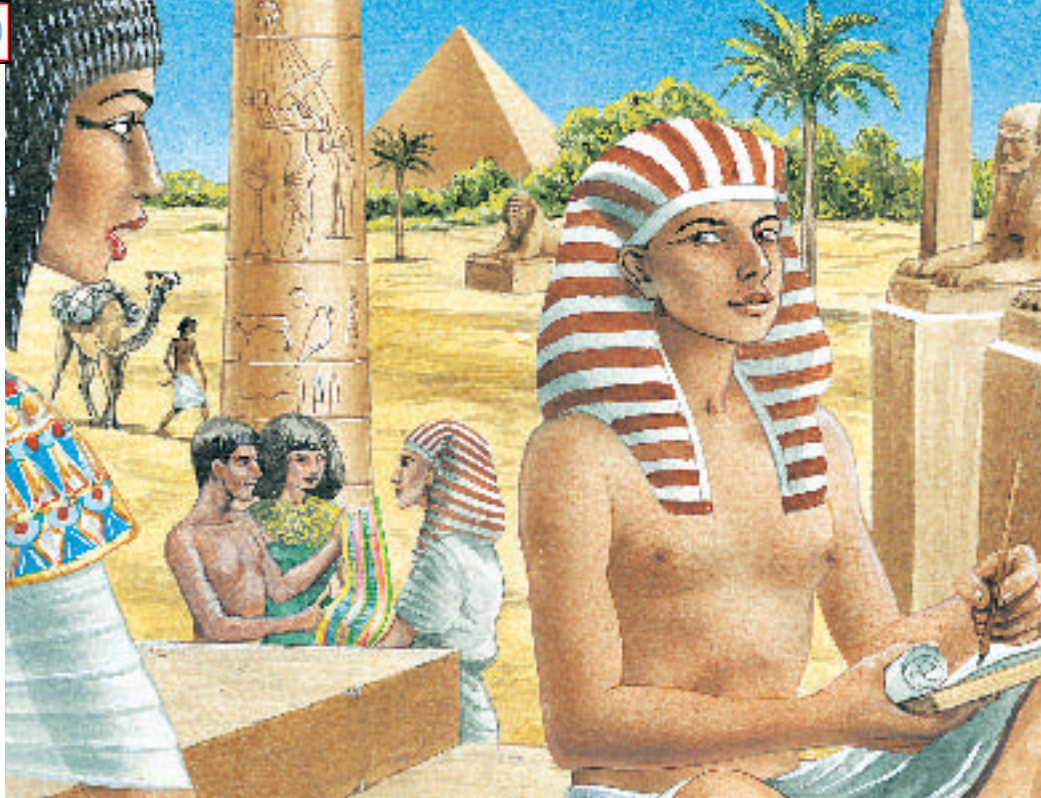
At the library, Juan used an encyclopedia to begin his research. He found out that archaeology is a branch of science that studies the tools and other cultural remains of humans. There are two major branches of archaeology, as shown in **Figure 3**. One focuses on groups of people who lived before history was written. The other studies civilizations that developed since people began writing things down. To his surprise, Juan also discovered that archaeology covers a time span of more than 3 million years. About 3.5 million years ago, he read, the first ancestors of humans are thought to have appeared on Earth.



Reading Check

What are the two major branches of archaeology?

The other students took turns finding out about the history of their area. Ben found that many scientists hypothesize that the first people came to North America from Asia about 12,000 years ago. Over thousands of years, these people migrated to different parts of the continent. Emily and Maria discovered that the area around their city was settled about 2,000 years ago. After locating a few more sources of information, the students took notes on all the information they had gathered. Emily suggested that they also write any questions they had about the pottery or the science of archaeology. Juan, Ben, and Maria agreed, and each wrote a few questions. The group left the library eager to hear how its findings would compare with what Dr. Lum would tell them on Monday.



Another branch of archaeology studies civilizations that have developed since written history began.

Think Critically How would you define written history when distinguishing rock drawings from hieroglyphics?

Dr. Lum's Visit Dr. Lum arrived before nine o'clock. When the bell rang, Emily's hand shot up. She was hoping to be the first to ask about the pottery. However, before calling on her, Dr. Lum said she wanted to give the students some background information and then she would answer their questions.

Dr. Lum explained how important it is to preserve prehistoric sites for present and future generations. She also said that many archaeological sites, like the possible one on the school grounds, are found by accident. More scientific work would have to be done before construction on the site could continue.

Technology Several kinds of technology would be used to study the area, such as computers and cameras. **Technology** is the use of knowledge gained through science to make new products or tools people can use. **Figure 4** shows some common types of technology. Dr. Lum told the students that a radar survey would be conducted to help study the find at the school. This type of technology, Dr. Lum explained, helps scientists "see" what's beneath the ground without disturbing the site. Experts from other fields of science probably would be called upon to help evaluate the site. For instance, geologists, scientists who study Earth processes, might be contacted to help with soil studies.

Figure 4 Computers and radar are two examples of technology used in archaeological research.

List at least three other forms of technology.





Relative Ages Archaeologists and geologists determine the relative ages of layers of sediment and artifacts by examining where they lie in comparison to other layers. For example, in undisturbed sediment, the bottom layer is the oldest and the layer on top is the youngest. Model this concept with a stack of books.

Working Together Dr. Lum ended her talk by suggesting that the students go back to the site with her. There, she would examine what had been found. She also would try to answer any questions the students might have about the find.

Maria and Emily led the group of curious students toward the north end of the school yard. Dr. Lum used her hand lens to observe the piece of pottery carefully. After examining the piece for awhile, she announced that she thought the pottery was old and that an archaeological dig, or excavation of the site, was in order. The students asked if they could participate in the dig. Dr. Lum said she would welcome all the help they could give.

Digging In

Weeks passed before the radar surveys were complete. The students in Ms. Garcia's class spent most of their time learning about how an archaeological excavation is done. Maria reported to the class that the holes and ditches that were being dug around the site would help determine its size. She also added that it was important that the site be disturbed as little as possible. By keeping the site intact, much of its history could be retold.

Finally, the day came when the students could participate in the dig. Each was given a small hand shovel, a soft paintbrush, and a pair of gardening gloves. Each student was paired with an amateur archaeologist. All of those involved were instructed to work slowly and carefully to excavate this important piece of their city's past. **Figure 5** shows a piece of pottery recovered from a similar archaeological dig site.

Artifacts are carefully mapped before they are excavated.



Figure 5 This paint brush, along with other tools, such as dental probes and toothbrushes, are commonly used to remove artifacts.

Explain why ancient sites must be excavated carefully.



Clues to the Past Many pieces of pottery, along with some tools, were found at the school site. Before the artifacts were removed from the soil, college students working with Dr. Lum took pictures or made drawings of each piece. These were used to make maps showing the exact location of each artifact before it was removed. The maps also would be used to show vertical and horizontal differences in the site.

Lab Work Each artifact was given a number and its location and orientation in the soil was recorded. After the artifacts were cataloged, they were removed from the site. Dr. Lum told the students that she would take the finds back to her lab. There, they would be cleaned, studied, and stored for future analysis, as shown in **Figure 6**.

Chemical analyses of certain artifacts would be used to determine their approximate age. Based on her knowledge of the area, Dr. Lum thought that the site was at least several thousand years old.



Figure 6 After artifacts are mapped and excavated, they're taken to a laboratory where they are cleaned and tagged for further study.

section 1 review

Summary

Groundbreaking News

- Science is the process of trying to understand the world.
- Important discoveries in science sometimes happen by accident.
- Discoveries must be subject to scientific testing in order to be validated.

Researching the Past

- Background research is an important part of any scientific study.
- Technology applies knowledge that is gained from doing science.

Digging In

- Both field and lab methods are used during scientific studies.

Self Check

1. **Explain** what archaeology is.
2. **Describe** several common forms of technology used in science.
3. **Explain** why scientists conduct radar surveys of archaeological sites.
4. **List** some examples of cultural remains studied by archaeologists.
5. **Think Critically** Why are maps of prehistoric sites often made before removing the artifacts?

Applying Skills

6. **Compare and contrast** science and technology. Include a discussion of how progress in science can lead to progress in technology, and vice versa.



Scientific Problem Solving

as you read

What You'll Learn

- **Explain** the steps taken in scientific methods.
- **Compare and contrast** scientific variables and constants.
- **Explain** how a control is used during an experiment.

Why It's Important

Scientific methods can help you solve many types of problems.



Review Vocabulary

analyze: to separate and study something as parts or basic principles in order to understand it as a whole

New Vocabulary

- scientific methods
- observation
- inference
- hypothesis
- independent variable
- dependent variable
- constant
- control

Scientific Methods

Several steps were taken to learn about the pottery found at York Middle School. When the pottery was found, a decision was made to stop construction at the site. One adult guessed that the pottery was old. An expert was called to verify the guess made about the pottery. Based on prior knowledge and further testing, it was concluded that the pottery was from a prehistoric culture.

Think about the last time you had a problem that took several steps or actions to solve. Step-by-step procedures of scientific problem solving are called **scientific methods**. Solving any problem scientifically involves several steps. The basic steps in a commonly used scientific approach are shown in **Figure 7**. The steps used can vary from situation to situation and aren't always done in the same order. But for now, take a look at each step in turn.



Reading Check

What are scientific methods used for?

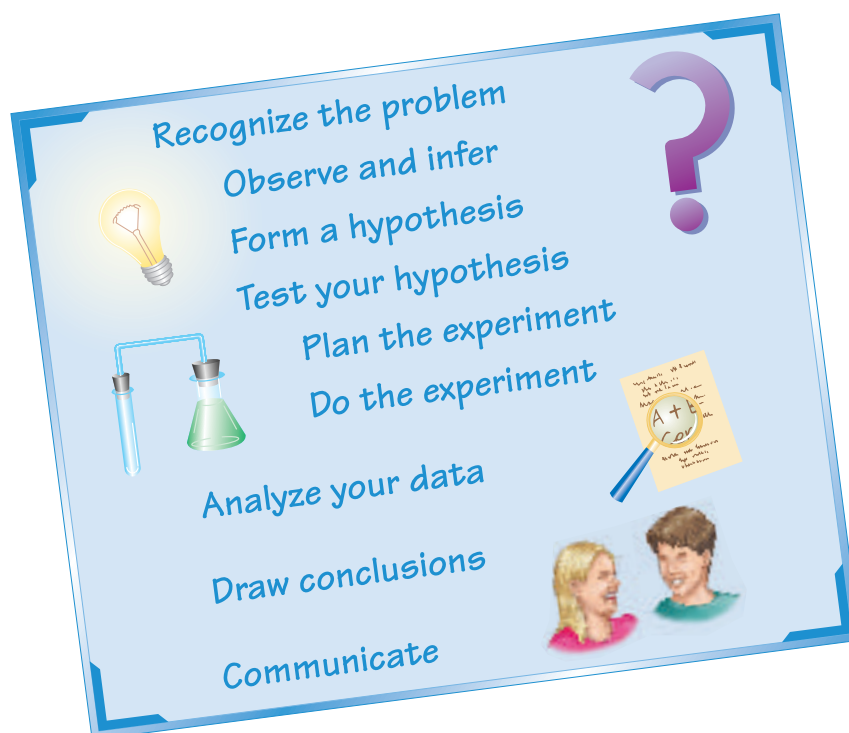


Figure 7 This illustration shows one way to solve a problem or find an answer to a question.



Recognize the Problem

Ben thought about all the science he had learned over the past few months. He was eager to find out more about the world around him. As he looked around his bedroom, he wondered what he could explore. It was then that Ben noticed that the plant on his windowsill was droopy. He quickly watered the wilting plant. Later in the day, Ben observed that the droopy plant had perked up. He concluded that he should water the plant on a regular basis. Every day after school, he watered the plant in his room.

After a few weeks, Ben noticed that the leaves on his plant had turned yellow and brown. He knew from science class that plants need water, so why was this plant not doing well? He talked to his teacher about the plant. She suggested that Ben use what he learned in science class to solve his problem. She pointed out that this problem might make a good project for the upcoming science fair.

Ben already has completed the first step in using a scientific approach to solving a problem—he recognizes a problem. A scientific problem is a question that can be answered using scientific methods. To solve his problem, Ben must do research about his plant. Using sources of information such as those shown in **Figure 8**, Ben identified his plant as a fig. In his Science Journal, he drew a picture of the plant and listed some facts about it.

Figure 8 Gathering information in the library or on the Internet can make your problem-solving tasks easier.

List Besides books and computers, what other resources can you use to gather information?



Reading Check

What is the first step in any scientific approach to solving a problem?



Mini LAB

Observing and Inferring

Procedure



1. Look at the **illustration** above. It is a part of a larger illustration.
2. Record in your Science Journal everything you observe about the illustration.

Analysis

1. Infer what might be happening in the illustration.
2. Compare your inferences with the illustration on the left-hand page of the Chapter Review. How close were your inferences to the actual illustration?



Observe In order for Ben to be able to answer the question about why his plant was not thriving, he needed to plan and carry out an experiment. First, he made and recorded careful observations about his plant. **Observations** can be bits of information you gather with your senses. Most scientific observations are made with your eyes and ears. You also can observe with your senses of touch, taste, and smell. Ben observed that many of the leaves had fallen off his plant. The stem, in places, was peeling. Ben also noticed that some white, powdery, smelly stuff was covering the soil in the pot. He stuck his finger into the soil. It was wet.

Infer Observations like Ben's often lead to inferences. An **inference** is a conclusion about an observation. Ben inferred that perhaps he was watering his plant too often. Can you make any other inferences about why Ben's plant wasn't thriving? To learn more about observing and inferring, do the Try At Home MiniLab on this page.

Form a Hypothesis

After a problem is identified, a scientist might make a hypothesis. A **hypothesis** (hi PAH tuh sus) is a statement that can be tested. **Figure 9** illustrates how hypotheses are based on observations, research, and prior knowledge of a problem. Sometimes more than one hypothesis can be developed.

Table 1 compares and contrasts hypotheses with two other scientific statements—scientific theories and scientific laws. Ben decided to use his inference about watering too often as his hypothesis. His hypothesis was the following: Fig plants grow best when they are watered only once a week.

Table 1 Scientific Statements

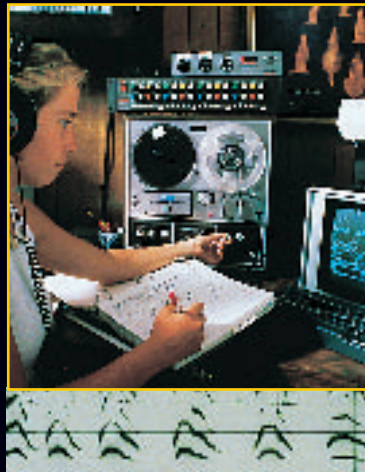
Hypothesis	A hypothesis is a statement that is tested with experiments. Hypotheses supported by repeated tests are used to form theories.
Theory	A theory is an explanation supported by results of many experiments. Theories attempt to explain why something happens.
Law	A scientific law describes the behavior of something in nature. Generally, laws predict or describe what will happen in a given situation, but they don't always explain why it happens.



Figure 9

Many hypotheses begin when people notice something interesting. A chance observation led Dr. Katharine Payne to form and test a hypothesis after watching elephant behavior in a zoo. While observing the animals, Payne felt a throbbing sensation in the air. She hypothesized that elephants use sounds that are below the range of human hearing to communicate over long distances.

A To test her hypothesis, Payne recorded the zoo elephants with special audio equipment, like that used by the researcher at right. Electronic printouts of the recordings revealed that the elephants were indeed making very low frequency sounds.



B Dr. Payne and her research team traveled to Africa to further test the hypothesis. They made audio recordings of infrasonic vibrations emitted by elephants in the wild.

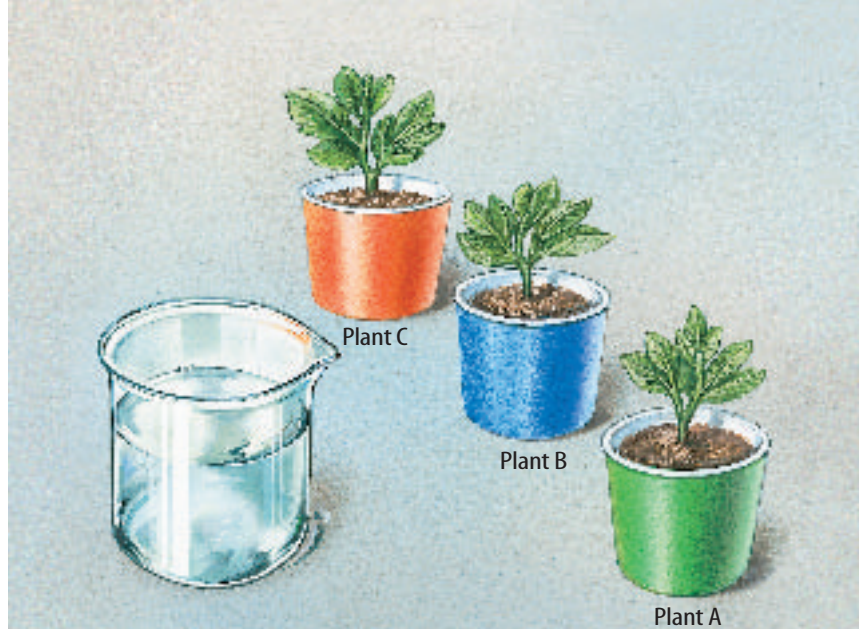
C From a distance of two miles, Payne played the recordings to a herd of elephants. With raised ears, they stood motionless to locate the source of the sound. Payne used a second group of elephants as a control group. This group was not exposed to the recorded sounds and displayed no unusual behavior. The results supported Payne's hypothesis that elephants use infrasound to communicate.





Figure 10 The number of times each plant is watered in one month is the independent variable in this experiment.

Throughout the experiment, similar-sized fig plants received the same amount of sunlight. They were planted in similar containers with the same type and amount of soil.



Test Your Hypothesis

To test his hypothesis, Ben will carry out an experiment using three plants. An experimental investigation is a series of carefully planned steps used to test a hypothesis. In any experiment, it's important to carefully consider what resources you will use and how to conserve them. It's also important to keep everything the same except for the item or variable you are testing so that you'll know which variable caused the results. The one factor that you change in an experiment is called the **independent variable**.

In Ben's proposed experiment, the independent variable is the number of times he waters each plant in a week. He then will observe how well each plant grows based on how frequently it receives water. The growth of the plants is the dependent variable in Ben's experiment. A **dependent variable** is the factor, or outcome, that will be measured in an experiment. **Figure 10** shows an experiment that tests the effects of water on plants.



Reading Check

What is a dependent variable in an experiment?

Plan the Experiment In order to test only one variable at a time, scientists often use constants. **Constants** are factors in an experiment that stay the same. In his experiment, Ben will use the same species and size of plants, which will be potted with the same kinds and amounts of soil in identical containers. Another constant will be the amount of light each plant will get.

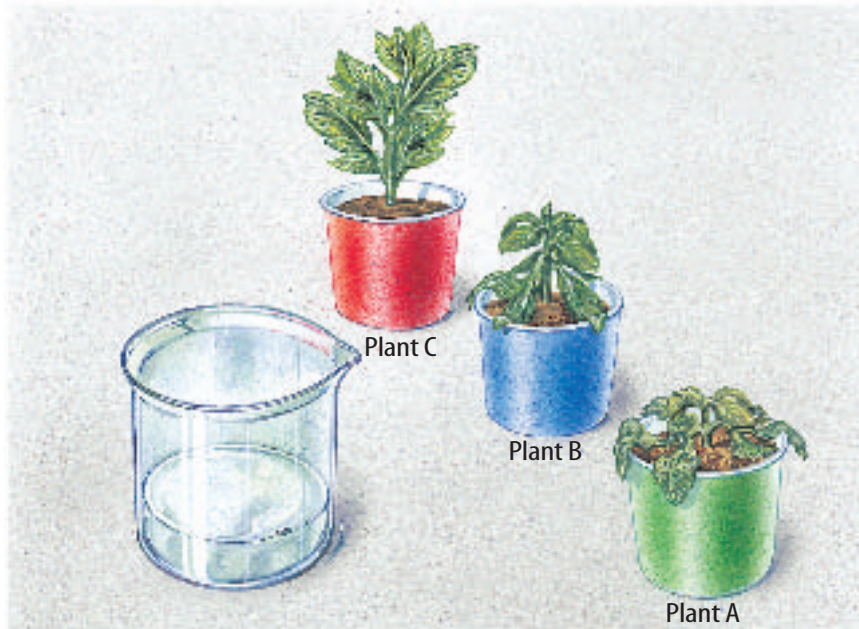
Some experimental investigations also have a control. A **control** is a standard used for comparison. For example, suppose a scientist wished to study the chemical makeup of a soil sample. A control soil—one of known chemistry—could be analyzed first. That way, data from the sample of interest could be directly compared to data from the control soil.



Topic: Scientific Methods

Visit green.msscience.com for Web links to information about how scientific research projects are carried out.

Activity Select three science projects that interest you. Make an outline of the steps used in each of the three scientific methods carried out in the projects. Compare and contrast the methods used in the three studies.



One month later, by keeping other factors constant and changing only one variable—the results of the experiment show the effect of watering frequency on the growth of fig plants.

Do the Experiment Ben gathered all the materials he would need to test his hypothesis. Before he started, Ben knew from Ms. Garcia's labs that he must write down a plan to follow. In his Science Journal, he wrote that he would use three fig plants. Plant A would only be watered once, at the beginning of the experiment. A second fig plant, Plant B, would get watered every day. The third fig plant, Plant C, would get watered once each week. His experiment would last one month.

Ben then made a table for recording his observations. He listed each plant and the number of times it was to be watered. Ben made room in the table for his measurements. He also made a plan to record his observations, which would include the height of each plant, the color of its leaves, and the number of leaves it dropped, if any.

Analyze Your Data

Data are collected during any scientific study. Some data are numeric values such as the length of an object or the temperature of a liquid. Other data you collect may include observations that use adjectives and phrases such as *faster*, *smaller*, *not as well as*, and *greener*. An experimenter must record and study the data collected, as shown in **Figure 11**, before he or she can draw conclusions about an experiment.

By the end of the month, Ben observed that the leaves still left on the plant that was watered only once were brown and shriveled. It had lost most of its leaves. The plant that was watered every day had a few leaves left on its branches, but these leaves didn't look too healthy. A white, smelly substance covered the soil. Ben noticed that the plant that was watered once each week had grown the tallest. Many healthy green-and-white leaves extended from its branches.

Figure 11 Observations and other data taken during an experiment must be logged carefully so that they are analyzed and properly interpreted later.





Figure 12 When results of experiments are communicated, it helps other researchers decide what to do next to help solve a problem.

These students are preparing for their school's science fair.



Draw Conclusions and Communicate

After studying his data, Ben was ready to draw some conclusions. A conclusion is a statement based on what is observed. Ben concluded that not watering a plant enough causes the leaves to dry out and die. Watering a plant too much also causes the leaves to die. Watering the plant once a week seems to be the best schedule, of those tested, for a fig plant.

Ben told his teacher about his results. She reminded him that in order to make sure his conclusions were valid, he should repeat his experiment. Ben agreed and did the same experiment again. Based on the results of his second experiment, Ben was able to conclude confidently that watering a fig plant once a week made it grow well in the conditions he used. His hypothesis was supported. An important step in the scientific process is to communicate the results of an investigation. Ben entered his project in his school's science fair, much like the students shown in **Figure 12**.

Plant Heights (cm)			
Week	Plant A	Plant B	Plant C
1	10.5	10.3	10.8
2	10.7	11.2	12.6
3	9.2	12.0	14.6
4	5.1	12.4	15.5

This table shows the results of an experiment similar to Ben's.

section 2 review

Summary

Scientific Methods

- Step-by-step procedures used during scientific investigations are called scientific methods.

Recognize the Problem

- Defining a problem usually is the first step.

Form and Test a Hypothesis

- A hypothesis is a statement that can be tested.
- Hypotheses are tested by controlling, manipulating, and measuring variables.

Analyze Your Data and Draw Conclusions

- Data analysis includes calculations and graphs.
- After data analysis, an investigator draws conclusions and communicates results.

Self Check

1. **List** the steps followed in a typical scientific method.
2. **Explain** how observations are different from inferences.
3. **Evaluate** why experiments should be repeated.
4. **Compare and contrast** a control and a constant.
5. **Think Critically** Isaac Newton once said, "If I have seen further, it is by standing on the shoulders of giants." What do you think Newton meant by this statement?

Applying Skills

6. **Use Variables and Controls** Describe another independent variable that might influence the growth of Ben's figs. How could Ben set up an experiment to test the effect of this different variable?

Advertising Inferences

Imagine you're reading a magazine and you see an ad for a pest control service. The ad states that 8 out of 10 homes have a problem with carpenter ants. Would you infer that your home might have ants? In this lab, you'll use advertisements to practice the science skills of observing and inferring. How do service providers get their data? Are the data correct?

Real-World Question

What observations and inferences can you make from advertisements?

Goals

- **Make** inferences based on observations.
- **Recognize** the limits of observations.

Materials

magazine advertisements
paper (1 sheet)
colored pencils or markers

Procedure

1. Select three magazine advertisements from those supplied by your teacher. In your Science Journal, make a table like the one shown.

Ad Data		
Type of Ad	Observation	Inference
Ad 1	Do not write in this book.	
Ad 2		
Ad 3		

2. For each magazine advertisement, list your observations. For example, you might observe that large, ferocious looking insects are pictured in a pest control ad.
3. What inferences does the magazine advertiser want you to make? Make inferences that relate your observations to the service or product being provided. The pest control advertisement, for example, might lead you to infer that if you don't want to be invaded by insects, you should hire their service.
4. Share your magazine advertisements and inferences with others in your class.

Conclude and Apply

1. **Compare and contrast** your classmates' inferences about the advertisements with your own. Are there other explanations for the things you observed in the advertisements?
2. **Create** your own magazine advertisement to sell a product. Think about what people will observe in the ad and what you want them to infer from it.
3. **Infer** Have a classmate make inferences about your magazine advertisement. What did your classmate infer about the magazine advertisement you created? Is this what you wanted the classmate to infer? Explain.

Communicating Your Data

Describe a new product or service to your class. As a group, brainstorm ideas for an ad to sell your product. **For more help, refer to the Science Skill Handbook.**

Model an Archaeological Dig

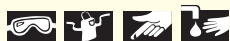
Goals

- In this lab you will use the skills, patience, and tools of a scientist while modeling and uncovering your example of a prehistoric site.

Possible Materials

craft sticks
toothpicks
plastic shovels
small paintbrushes
small stones
bits of black tissue paper
sand
interlocking building blocks
clear-plastic storage box
ruler, pencil, and paper

Safety Precautions



Real-World Question

Scientists often use models to study objects that are too large or too small to observe directly. In this lab, your group will construct a model of a prehistoric site. After you cover the site with sand, you'll exchange it with another group for them to unearth. Using materials provided by your teacher, you will create a miniature archaeological dig. What can be learned from an archaeological excavation? How do models help us learn about science?

Procedure

- Obtain a storage box in which to build your site.
- Using the materials provided by your teacher, begin by planning what remains your site will contain and where they will be placed.



Using Scientific Methods

3. While designing your site, keep in mind that this is an area where people once lived. Artifacts you might want to include are a hearth used for cooking, a trash pit, some sort of shelter, a protective wall, a burial site, a water source, and tools.
4. Now that you've placed your artifacts, create a map of your site. Draw your map to scale.
5. Cover your site with sand so that another group from your class can excavate the artifacts.
6. Exchange your model with one made by another group. Keep the map of your site for now.
7. Using the paintbrushes and shovels given to you, begin by slowly excavating the site your group received.
8. As you excavate, be sure to accurately record the locations of all of your discoveries. Draw a map as you excavate. Be sure to use the measurements you made as you unearthed the site.

Conclude and Apply

1. **Compare and Contrast** How was this experience similar to a real archaeological dig? Did any of the excavating tools damage or disturb the site? How do archaeologists avoid damaging the site?
2. **Infer** How do you think archaeologists recognize findings that aren't familiar to them? What clues do they use?
3. **Explain** Why did you make maps of your site and the site you excavated? How would maps help scientists after they have excavated a site?
4. **Compare and contrast** your map of the site you excavated to the map of the student who made it. How are your maps similar? How are they different? Do the same with the map you made for your own model of your archaeological dig.
5. **Identify** what other things do scientists study using models? Think of a scientific concept you've learned already this year, either small or large, that scientists study by using models.

Communicating Your Data

Make an enlarged version of the map you created while uncovering your findings. Display your maps on a poster like a scientist would. **For more help, refer to the Science Skill Handbook.**

Mama Solves a Murder

a mystery novel

by Nora DeLoach

My mama's name is Grace. Everybody calls her "Candi," like candied sweet potatoes, because of her skin, a golden brown color with yellow undertones that looks as smooth as silk.

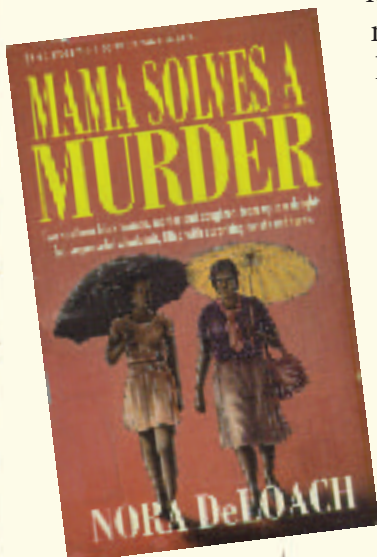
... Mama can be shrewd and cunning. She has uncanny perception and self control. Her mind is formidable¹, her beauty is enticing, but I've seen her use either to get in and out of places.

Mama is fifty-three and she works as a social worker in the small town of Hampton, South Carolina. While most of the things that arouse the mind don't excite Mama, I've seen her absolutely euphoric when her mind is deducing. She's a self-styled private investigator who sees herself as the romantic loner. Mama enjoys the tedious jobs of digging up bits and pieces until she's solved a mystery. Long ago, I don't remember when, Mama decided that if she could get at the truth of a problem, she would have made a contribution to humankind.

Who am I? My name is Simone, I'm Mama's one and only daughter....

...To be perfectly honest, Mama is my Sherlock Holmes and I'm her Dr. Watson.

¹ admirable or awe inspiring



Understanding Literature

Characterization An author's method of developing the personality of a character is called characterization. Simone, who is the narrator, talks directly to the reader about her mother. Her own observations help the reader understand the character of Mama. The author also uses an allusion—a reference to a well-known character, place, or situation—to describe her relationship to her mother. Can you find it?

Respond to the Reading

1. Based on this passage, how does Simone feel about her mother?
2. How is Mama like a scientist?
3. **Linking Science and Writing** Create an idea for a protagonist who is a scientist who solves a mystery involving a clue of soil particles on the victim's clothing.



In a mystery novel, readers are entertained by a protagonist, or main character, who employs a scientific method to solve a mystery. In *Mama Solves a Murder*, Mama and Simone create a scientific method as they gather information, make inferences, propose a hypothesis, and then test their hypothesis. Mystery novels usually include descriptions of technology and other resources used to solve the mystery.

Reviewing Main Ideas

Section 1 How Science Works

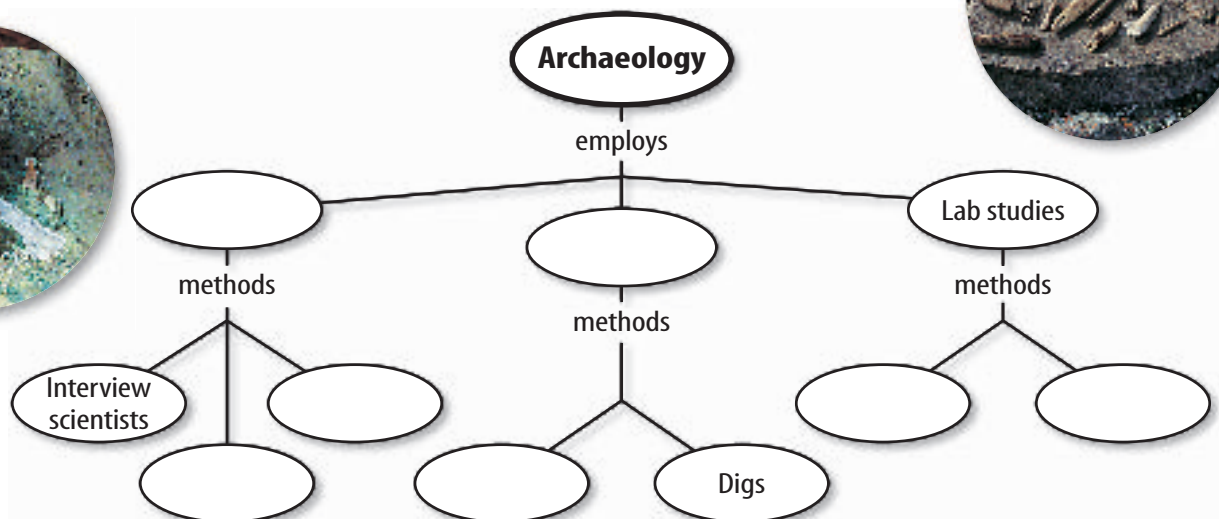
1. Science is a process of understanding the world around you. Technology is the use of knowledge gained through scientific thinking and problem solving. Archaeologists use science and technology to study the artifacts of ancient people.
2. Many archaeological sites and the artifacts they contain are found by accident. The excavation of an archaeological site is done slowly and carefully so the artifacts and the site itself are not damaged or destroyed.
3. Some artifacts, such as bones and charcoal, can be dated using chemical analyses.

Section 2 Scientific Problem Solving

1. Many scientific experiments involve variables, or factors that can change. An independent variable is a factor that the experimenter changes. The dependent variable is the factor that changes as a result of the independent variable. Independent variables should be changed one at a time, so the experimenter can determine what influenced the dependent variable's change.
2. Constants are factors in an experiment that don't change. A control, when one is included, is a standard used for comparison.
3. Scientific methods are step-by-step approaches to solving problems. These can include identifying the problem, forming and testing a hypothesis, analyzing the results of the test, and drawing conclusions.

Visualizing Main Ideas

Copy and complete the following concept map on methods used in an archaeological study. Use the following words and phrases: library, field studies, cleaning and storing, research, Internet, radar, and chemical analysis.



Using Vocabulary

constant p.16	inference p.14
control p.16	observation p.14
dependent variable p.16	science p.7
hypothesis p.14	scientific methods p.12
independent variable p.16	technology p.9

Each phrase below describes a science term from the list. Write the term that matches the phrase describing it.

1. variable changed by the experimenter
2. a statement that can be tested
3. step-by-step approach to solving problems
4. the process of understanding the world
5. a factor that remains the same phases of an experiment
6. new products or tools made because of knowledge gained through science
7. variable measured during an experiment
8. standard used for comparison

Checking Concepts

Choose the word or phrase that best answers the question.

9. What should an experimenter do after analyzing data?
 - A) carry out the experiment
 - B) draw conclusions
 - C) observe and infer
 - D) identify the problem
10. Why do scientists make maps of archaeological sites?
 - A) to photograph artifacts
 - B) to calculate the exact age of artifacts
 - C) to record where the artifacts were found
 - D) to discover artifacts

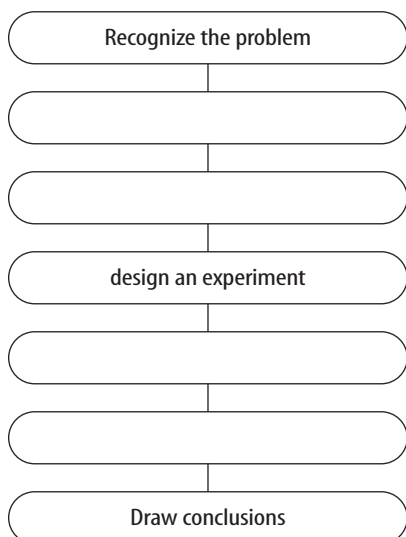
Use the illustration below to answer question 11.



11. What is a conclusion that is based on an observation?
 - A) a control
 - B) a hypothesis
 - C) an inference
 - D) a variable
12. A scientist publishes the results of an experiment. Which science skill is this?
 - A) observing
 - B) inferring
 - C) communicating
 - D) hypothesizing
13. What is a series of carefully planned steps used to test a hypothesis?
 - A) a constant
 - B) an observation
 - C) an experiment
 - D) a conclusion
14. Why should an experiment be repeated?
 - A) to form a hypothesis
 - B) to reduce the chance of error
 - C) to change controls
 - D) to identify the problem
15. What technology can help an archaeologist “see” a buried site before he or she begins to excavate it?
 - A) computer
 - B) mapmaker
 - C) radar
 - D) camera
16. What is the first step in a commonly used scientific method?
 - A) digging for artifacts
 - B) drawing conclusions
 - C) controlling variables
 - D) recognizing a problem

Thinking Critically

17. **Draw Conclusions** An archaeologist finds a site that contains many different layers of artifacts. What might he or she conclude about the people who lived at the site?
18. **Explain** why the following statement is incorrect: Scientists do all of their work in laboratories.
19. **Identify and Manipulate Variables and Controls** Identify all variables in Ben's fig experiment. Give an example of how Ben kept some variables constant.
20. **Explain** whether every scientific problem is solved using the same steps.
21. **Evaluate** Why is it important to keep good records during a scientific investigation?
22. **Concept Map** Copy the concept map shown on this page in your Science Journal. Then, use the following terms to complete the concept map of a commonly used scientific method: *perform the experiment, analyze data, form a hypothesis, and observe and infer.*



Performance Activities

23. **Design an Experiment** Describe how you might test which laundry soap cleans the best. Be sure to include variables, constants, and a control.
24. **Oral Presentation** Research how technology has been used to study ancient human artifacts in your area. Present your findings in a speech to your class.

Applying Math

25. **Soil Sample** A geologist collected a 2.5-kg soil sample for analysis. If she only needs 20 grams of sample to perform the analysis, what percentage of the soil sample will be tested?

Use the table below to answer questions 26–28.

Roman Units of Measure (Volume)

Unit	Conversion	Volume (L)
1 congius	= 6 sextarii	3.281
1 modius	= 16 sextarii	8.751
1 amphora	= 3 modii	26.261

26. **Classical Units** In the Classical Period, an amphora was a container used to transport liquids such as wine and olive oil. The amphora also was the name of a unit of volume used during this period. According to the table, about how many sextarii are in one amphora?
27. **Soda Serving** Suppose you were serving your friends a soft drink using the units in the table. Which of the units represents the likeliest single serving of soda? One sextarius is equivalent to how many liters?
28. **Modius Conversion** According to the table, one modius is equivalent to how many liters? How many congii make one modius?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. What predicts or describes the behavior of something in nature?
- A. hypothesis C. law
B. inference D. theory

Use the photos below to answer question 2.



2. What step of a scientific method is illustrated in the photos?
- A. observation
B. hypothesis
C. conclusion
D. data collection and analysis
3. Hearing, sight, taste, and smell all are used for which aspects of science?
- A. hypotheses C. observations
B. laws D. theories
4. Which of the following is a process of trying to understand things about the world?
- A. science C. bias
B. technology D. conclusion
5. Which of the following would not be considered an artifact?
- A. tool C. drawing
B. weapon D. soil
6. Which is used as a background research tool?
- A. Reciting a law
B. Inventing a microchip
C. Forming a hypothesis
D. Studying a periodical

Use the figure below to answer question 7.



7. According to this map, what best describes a path of ancient people entering North America?
- A. from Asia to North America
B. from Australia to North America
C. from the Bering Strait to the Atlantic
D. from South America to North America
8. What are computers and microscopes examples of?
- A. hypotheses
B. variables
C. technology
D. constants
9. Select a tool that could be used to collect data during an archaeological dig.
- A. law
B. radar
C. periodical
D. artifact
10. Which of the following can be used to test a hypothesis?
- A. experiment
B. theory
C. law
D. variable

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the photo below to answer question 11.



11. Complete the table by determining whether each statement about the plant is an observation, an inference or a hypothesis.

Statement	Observation, Inference or Hypothesis
The plant needs more water.	
The plant has big leaves.	
The plant does not have flowers. Something is eating the plant.	
If the plant is moved to a different location, then it will be healthier.	
The plant may need more sunlight.	
If an insecticide is used on the plant, then it will become healthier.	

12. How does a hypothesis become a theory?
13. What happens if data are not recorded properly?
14. What is the difference between an inference and a hypothesis?
15. Explain how independent and dependent variables are used in an experiment.
16. Why is it important to have constants in an experiment?

Part 3 Open Ended

Record your answers on a sheet of paper.

17. List several reasons why experiments with plants could be less problematic than those involving humans.
18. Suppose a scientist is studying a disease, such as cancer. Why is it important to communicate his or her findings? List several ways that the scientist could communicate his or her data.

Use the photo below to answer questions 19 and 20.



19. List several observations and inferences and formulate a hypothesis about changing the condition of this plant.
20. Design an experiment to test your hypothesis about the plant. What are your independent and dependent variables? What would you include as constants?
21. Explain how an archaeologist should approach a new site.