

124 pts.

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are three methods used by scientists to conduct investigations?
- How does science help people?
- What are five jobs available to people who want to be scientists?



California Science Standards

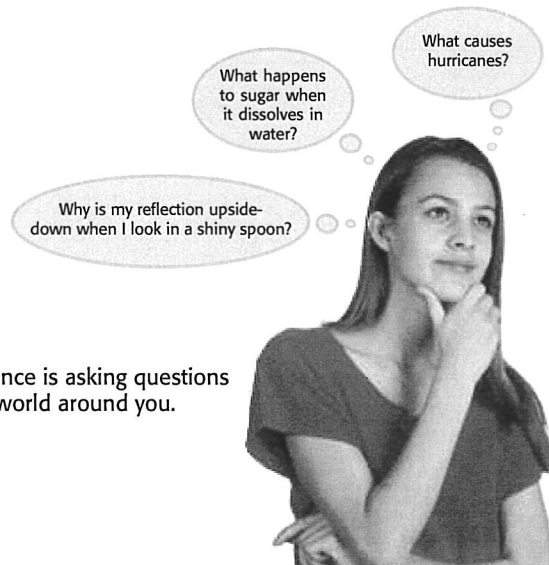
8.9.a

What Is Science?

Science is knowledge of the natural world. You gain this knowledge by observing and investigating the world around you. Science helps you discover facts and predict how things in the world will behave.

QUESTIONS

Asking a question is the first step in the process of gaining knowledge. The student pictured below is curious. She has thought up three questions about the world. ✓



Part of science is asking questions about the world around you.

You may have questions about different environments, such as deserts or the sea. You may wonder about the moon, the sun, and the whole universe. You may wonder how the food you eat keeps you healthy. These are all science questions.

STUDY TIP

Summarize As you read, keep a list of the different traits of good scientists. When you finish reading, write a paragraph telling why each trait is a good one for a scientist to have.

1 point

READING CHECK

1. Identify What is the first step in the process of gaining knowledge?

2 points

Critical Thinking

2. Describe What are two things the girl in the figure can do to answer her questions?

1. _____
2. _____

SECTION 1 Science and Scientists *continued*

CALIFORNIA STANDARDS CHECK

8.9.a Plan and conduct a scientific investigation to test a hypothesis.

Word Help: conduct to carry out

3. Explain What are three methods scientists use to answer questions?

1. _____

2. _____

3. _____

3 points

2 points

Critical Thinking

4. Explain How could you test your explanation that storms come from the west?

How Do Scientists Search for Answers?

Scientists conduct careful investigations to find answers to questions about the natural world. As a scientist, you can use several methods to begin an investigation.

RESEARCH

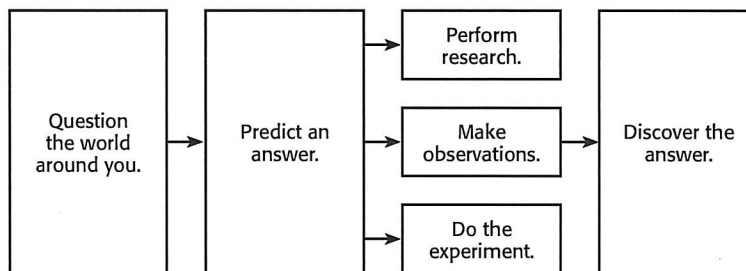
You can look up information in books, in scientific journals, and on the Internet. You can also ask experts. It is important to think about the value of the information you get from the Web page you check or the person you ask. Are they information sources you can trust?

OBSERVATION

You can find answers to some questions on your own, by observing what is going on around you. *Observing* means using your senses to study what is happening. For example, you may notice that before a storm, there are big, dark clouds in the sky. You also may notice that the wind is blowing from the west. These observations could lead you to research whether these two things are related.

EXPERIMENTATION

You can answer some of your questions by doing experiments. An *experiment* is a test of an idea. Before experimenting, you must come up with a prediction or a likely answer to your question. For example, you could suggest that the wind blows big, dark clouds from the west. Your prediction could be that storms come from the west. Then, you could make a plan to test your prediction.



Research, observation, and experimentation are scientists' tools for searching for answers. Research and observation help scientists plan experiments. You can use these tools, too. A well-planned experiment may tell you the answer. It may even cause you to ask more questions.

SECTION 1 Science and Scientists *continued***How Do the Answers Affect Us?**

Although scientists cannot answer every question, they do find many interesting and helpful facts. Some of the answers help save people's lives, save Earth's resources, and protect our environment.

SAVING LIVES

Because scientists study moving objects, they have been able to answer the question, "How can passengers be protected during automobile accidents?" Scientists performed tests. As a result, airbags are now installed in cars. Drivers and passengers are required to wear seat belts. Motorcyclists are encouraged to wear helmets. ✓

CONSERVING RESOURCES

Science has also helped answer the question, "How can Earth's resources be made to last longer?" Recycling is one answer. Examples of used things that can be recycled are paper, aluminum, steel, glass, batteries, and tires.

Recycling rates have increased over the past 40 years. The table below shows how recycling of waste material has risen in the United States.

Year	Percentage of waste recycled
1960	6.4
1970	6.6
1980	9.6
1990	16.2
2000	30.0

PROTECTING THE ENVIRONMENT

Through the study of Earth's atmosphere, scientists found a serious problem. They discovered that the ozone layer, which protects the Earth from harmful rays from the sun, was getting thinner. They asked, "How can we protect the ozone layer?" Scientists researched, observed, and experimented. They found that chemicals used widely in spray cans destroyed the ozone when they rose up into the atmosphere. Today, different chemicals are used in spray cans. In addition, many things that used to be sold in spray cans are packaged differently.

1 point

READING CHECK

5. List What are two results of scientists' study of moving objects?

2 points

Math Focus

6. Analyze Data Between which two years did recycling increase the most? About how much did it increase?

1. _____

2. _____

Section 1 Review

8.9.a 

SECTION VOCABULARY

science the knowledge obtained by observing natural events and conditions in order to discover facts and formulate laws or principles that can be verified or tested	
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1. Identify What are three methods that scientists use for investigation? 1 point

1. _____ 2. _____ 3. _____

2. Describe What are three sources of information scientists use when they do research? 1 point

1. _____ 2. _____
3. _____

3. Match Draw an arrow from the definition of the job to the type of scientist.

Studies volcanic eruptions	Science illustrator	look it up !! 5 points
Measures wind speed of hurricanes	Volcanologist	
Draws diagrams of body parts	Geochemist	
Knows how plants and animals affect one another	Meteorologist	
Knows how to remove oil from the ground	Ecologist	

4. Explain Tell two ways that scientists can help people. 1 point

1. _____
2. _____

5. Apply Concepts Your friend wants to know how much salt is added to the fries at her favorite burger restaurant. What would you suggest that she do to find out? 2 points

6. Use Data A scientist knows that a slow flow of lava travels at a rate of 3 m per day. Show how the scientist would determine how far the lava could travel in 30 days. 3 points

CHAPTER 1 The Nature of Physical Science
SECTION 2 **Scientific Methods**

134 points

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are the steps in the scientific method?
- How do scientists form a hypothesis?
- What do scientists do before telling others about their experimental results?



California Science Standards

8.9.a, 8.9.b, 8.9.c

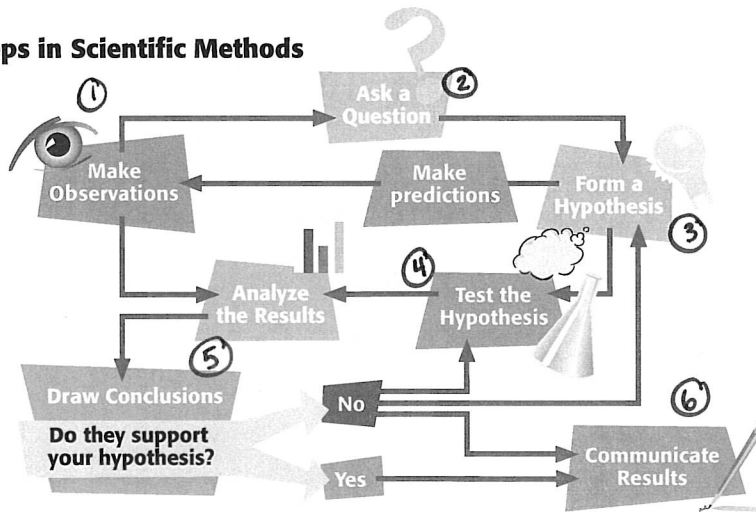
What Are Scientific Methods?

Two scientists wanted to find a better way to move ships through the water. They thought that studying the way penguins swim might give them some ideas about how to improve ships. In this section, you will learn how these scientists used scientific methods to answer their questions.

Scientific methods are the ways in which scientists answer questions and solve problems. As scientists look for answers, they often use the same steps. However, there is more than one way to use the steps. Look at the figure below. ✓

This figure shows six steps that are part of most scientific methods. Scientists may use all of the steps or just a few steps during an investigation. They may repeat some of the steps or do the steps in a different order.

Steps in Scientific Methods



There are many steps in scientific methods. Notice that there are many ways to move through the different steps.

STUDY TIP

Outline As you read this section, make a chart showing how two scientists used the steps in scientific methods to improve ships.

1 point

READING CHECK

1. Describe What are scientific methods?

1 point

TAKE A LOOK

2. Identify What is the usual next step after analyzing the results?

SECTION 2 Scientific Methods *continued*

Why Do Scientists Ask Questions?

Asking questions helps scientists focus on the reason for an investigation. Questions arise after **observation**, which is collecting information by using the senses. A good example is the story of the two scientists who wanted to improve the way ships move through the water. This type of scientist is called an engineer. *Engineers* are scientists who build things based on scientific knowledge. ✓

1 point

✓ **READING CHECK**

3. Describe Who are engineers?

REAL-WORLD EXAMPLE

Two engineers were studying how the propellers on ships work. They found that ships used a lot of fuel to push themselves through the water. Their job was to find a way to make ships move faster while using less fuel.

The engineers looked to nature to find a method to improve the efficiency of ships. A ship that is *efficient* does not use as much fuel as other ships to travel a certain distance. They observed sea animals in order to investigate what made them swim fast. The engineers noticed that penguins are master swimmers. Penguins have stiff bodies just like ships. However, they are able to push themselves through the water with ease.

Now the scientists were ready to ask their question. They wanted to know, “How can a ship’s propellers be built to push the ship through the water with ease?”

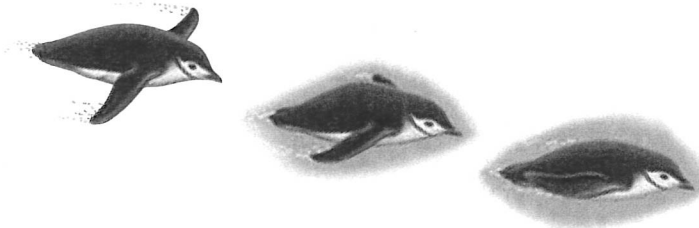
 **Say It**

Investigate Find out how the propeller of a ship works. Present your findings to your class or a small group.

2 points

TAKE A LOOK

4. Identify How do penguins use their wings?



Penguins use their wings as flippers to “fly” underwater. As their wings are pulled inward, they push against the water. This movement pushes the penguins forward.

SECTION 2 Scientific Methods *continued*

How Do Scientists Form a Hypothesis?

Once a scientist has made observations and asked a question, he or she is ready to predict an answer. This is called forming a hypothesis. A **hypothesis** is a possible explanation or guess at an answer to a question. ✓

You must be able to test a hypothesis. A scientist tests a hypothesis by gathering more information or doing an experiment.

1 point

✓ **READING CHECK**

5. Describe What is a hypothesis?

POSSIBLE ANSWER FROM NATURE

The ship engineers had observed the slow movements of ships and the fast swimming of penguins. Their observations led them to make a hypothesis about how to propel a ship through water. They guessed, “A propulsion system that imitates the way a penguin swims works better than one that uses propellers.”

ANOTHER WAY TO WORD PREDICTIONS

Before scientists test a hypothesis, they may say what they think will happen in an *if-then statement*. An if-then statement makes the results easier to measure. The engineers’ prediction might have been: “If two flippers are attached to a boat, then the boat will be more efficient than a boat powered by propellers.”

The following table gives some examples of if-then statements.

If car A uses less gasoline than car B while taking the same trip,	then Car A is more efficient than Car B.
If it takes more force to stop an object with a large mass,	then it will take _____ force to stop a compact car than a large truck.
If a grape and an orange fall at the same rate,	then they will hit the ground at the _____ time when they are dropped from the same height.

2 points

Critical Thinking

6. Infer In the table, complete the “then” statements that have a missing word. Write each missing word on the line provided.

Why Does a Scientist Test a Hypothesis?

After you form a hypothesis, you must test it. You must find out if it answers your question correctly. Testing helps you find out if your hypothesis is pointing you in the right direction. You test a hypothesis by doing experiments.

SECTION 2 Scientific Methods *continued*

1 point

CALIFORNIA STANDARDS CHECK

8.9.c Distinguish between variable and controlled parameters in a test.

7. Identify Which of the parameters are both groups in an experiment exposed to?

CONTROLLED EXPERIMENTS

When scientists working for drug companies invent a medicine, they have to find out if the medicine will work. They usually test the drug on a large group of animals. Often, they work with special laboratory mice. All of the mice in the experiment have the same disease.

They divide the large group of mice into two smaller groups. One is called the *control group*. The other is the *experimental group*. The results from the experimental group are compared with those of the control group. In this way, scientists see if the drug had the expected effect.

Both groups should be about the same size and age. Size and age are called *factors* or *parameters*. These factors are characteristics of the mice. All of the factors for each group must be the same. These factors are called the *controlled parameters* of the experiment.

There is one factor that is different for each group. The control group will be given something called a *placebo*. It will not contain the drug being tested. The experimental group will be given the real drug. This difference is called the *variable parameter* of the experiment. ✓

The scientists watch carefully to see if the animals get better. It is important that the animals be treated exactly the same. The only difference is that the experimental group is given medicine.

1 point

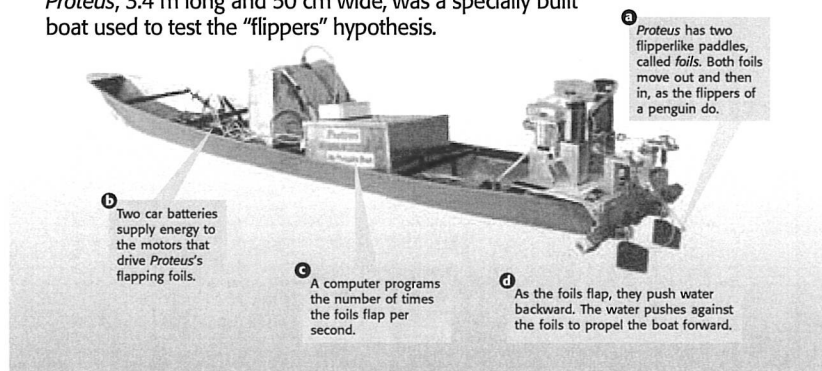
READING CHECK

8. Describe When a new drug is being tested, what does the control group take instead of the real drug?

BUILDING A TEST BOAT

The engineers who were trying to design an efficient boat thought they should test their hypothesis by building one. They built *Proteus*, the penguin boat. It had flippers like a penguin so that the scientists could test their hypothesis about propulsion through the water.

Proteus, 3.4 m long and 50 cm wide, was a specially built boat used to test the “flippers” hypothesis.



1 point

TAKE A LOOK

9. Identify Instead of a propeller, what is used by *Proteus* to move the boat through the water?

SECTION 2 Scientific Methods *continued*

How Did the Scientists Test *Proteus*?

Another way to have a controlled experiment is to repeat the test several times, changing one condition each time. That's what the engineers did with *Proteus*.

The engineers took *Proteus* to the Charles River in Boston. After putting the boat in the water, they were ready to collect data. **Data** are pieces of information collected from experiments. For each test, they paddled the boat across the river for the same distance with the same weather. ✓



Proteus, the "penguin boat," was tested in the Charles River in Boston.

The engineers collected data on the speed of the boat and the amount of energy used to move the foils. The data recorded for the first trip were compared with the data from all of the other trips. The factor that was changed for each trip was the flapping rate of the foils. ✓

The experimental part of the test began with the second trip. The engineers increased the flapping rate, which was the variable parameter. Then they recorded the energy used and the speed. The engineers made several more experimental voyages. Each time, they set a different flapping rate and collected data on the energy used and the speed.

To find if the new design was efficient, they compared the amounts of energy used by the motors with the speeds of the boat on each trip. This step is called *analyzing* results.

2 points

✓ **READING CHECK**

10. Identify What two conditions stayed the same when *Proteus* sailed across the river?

1. _____
2. _____

10.5 What did the engineers measure after each trip?

1 point

1 point

✓ **READING CHECK**

11. Identify What factor was changed for each trip?

- _____
- _____

* this is what is being tested.

AKA: Independent Variable
or
Manipulated Variable

SECTION 2 Scientific Methods *continued*

How Do Scientists Analyze Results?

After you collect your data, you must analyze it. To *analyze* data means to interpret what the data mean. One way to analyze data is to organize them into tables and graphs. Tables and graphs make the relationships of the numbers easier to see. ✓

It's always a good idea to perform your experiment several times. Repeated tests tell you whether your data are accurate. If you get similar results every time and they support your hypothesis, then you know you are close to proving that your hypothesis is correct. Similar results on a number of tests show that your experimental data are *reproducible*. Reproducible data show other scientists that you designed a good experiment.

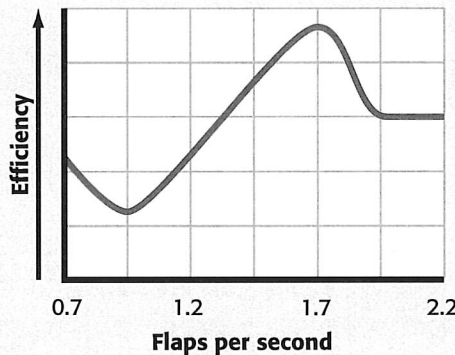
1 point

READING CHECK

12. Describe What does it mean to analyze data?

ANALYZING PROTEUS

The engineers calculated the data for energy used and the speed. They used the data to calculate *Proteus*' efficiency. Then they made the line graph below.



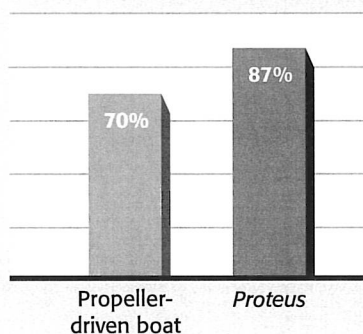
This graph shows the efficiency of *Proteus* when the flippers are moving at different rates.

2 points

Math Focus

13. Analyze When did *Proteus* show the highest efficiency?

They also used the data to compare *Proteus*' efficiency with the average efficiency of a propeller-driven boat. You can see the analysis of the results in the bar graph below.



This graph shows the efficiency of *Proteus* compared with the efficiency of propeller-driven boats.

2 points

Math Focus

14. Compare Which boat was the more efficient?

How much more efficient was it?

SECTION 2 Scientific Methods *continued*

Was Your Hypothesis Correct?

At the end of the investigation, you must draw a conclusion. You do this by looking at your analysis. The results tell you if your hypothesis was correct. This is the same as saying that your results support your hypothesis.

It's also possible that you will come to a different conclusion. You may decide that your results do not support your hypothesis. If so, you can change the procedure, gather more information, or ask new questions. Whether your hypothesis is supported or not, the results are always important.

PROTEUS CONCLUSION

The engineers found that penguin propulsion was more efficient than propeller propulsion. They concluded that the results supported their hypothesis. ✓

The scientists were able to reach this conclusion because they did many tests. They were careful to have controlled parameters with only one variable parameter. They measured everything accurately. This proved that their results were not accidental. Their data showed the same relationship many times. Therefore, their results were reproducible.

Drawing a conclusion to support your hypothesis usually leads to more questions. More questions lead to more investigations. This is how scientific progress continues.

How Do You Tell Others About Your Results?

Other scientists will want to conduct their own tests based on your results. There are three ways to communicate the results of your investigation to them. You can use any or all of them. ✓

Ways to communicate the results of an investigation	Audience
Write a paper for a scientific journal.	scientists and others who read the journal
Give a talk.	scientists and others who are interested in the work
Create a Web site.	anyone interested in the work

Sharing your results allows other scientists to continue your work. Sharing also makes it possible for others to do your experiments and prove you were right.

1 point

✓ **READING CHECK**

15. Explain Why did the engineers feel that their hypothesis was correct?

3 points

✓ **READING CHECK**

16. Identify What are three ways scientists communicate the results of their investigations?

1. _____

2. _____

3. _____

Section 2 Review

8.9.a, 8.9.b, 8.9.c



SECTION VOCABULARY

<p>data any pieces of information acquired through observation or experimentation</p> <p>hypothesis a testable idea or explanation that leads to scientific investigation</p> <p>Wordwise The prefix <i>hypo-</i> means "under." The root <i>thesis</i> means "proposition." Other examples are <i>hypodermic</i> and <i>hypodallergenic</i>.</p>	<p>observation the process of obtaining information by using the senses</p> <p>scientific methods a series of steps used to solve problems</p>
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1. **Complete** What are the steps that most scientific methods use? 3 points

Steps in Scientific Methods
1.
2.
3.
4.
5.
6.

2. **Describe** Why do scientists use scientific methods? 1 point

3. **Explain** A synonym is a word that has the same meaning as another word. What are two synonyms for *hypothesis*? 2 points

1. _____ 2. _____

4. **Explain** Why must an experiment have a control group? 1 point

5. **Explain** What is a variable parameter? 1 point

6. **List** What was the variable parameter in the laboratory mice experiment? In the *Proteus* experiment?

