SC.5.N.1.1 … plan and carry out scientific investigations.… **SC.5.N.1.2** Explain the difference between an experiment and other types of scientific investigation. **SC.5.N.1.3** Recognize and explain the need for repeated experimental trials. **SC.5.N.1.4** Identify a control group and explain its importance.… **SC.5.N.1.5** … scientific investigation frequently does not parallel the steps of "the scientific method."

LESSON 3

ESSENTIAL **QUESTION**

What Are Some Types of Investigations?

Engage Your Brain

Find the answer to the following question in this lesson and record it here.

What did this scientist do prior to starting her experiment with plants?

_____

_____

_____

_____

ACTIVE **READING**

Lesson Vocabulary

List the terms. As you learn about each one, make notes in the Interactive Glossary.

_____

_____

_____

_____

Main Ideas

The main idea of a paragraph is the most important idea. The main idea may be stated in the first sentence, or it may be stated elsewhere. Active readers look for main ideas by asking themselves, What is this paragraph mostly about?

A Process for Science

Testing bridge models, mapping a storm's path, searching the sky for distant planets—each of these investigations uses scientific methods.

How does the shape of the room affect the sound of a voice?

ACTIVE READING As you read these two pages, draw a line under each main idea.

How does having a cold affect a person's singing?

Start with a Question

Scientists observe the world and then ask questions that are based on their observations. But not all questions are the same. A good scientific question is one that can be answered by investigation. A scientific investigation always begins with a question.

How high a note can a singer sing?

Can a human voice shatter glass?

Plan an Investigation

Once a scientist has a testable question, it is time to plan an investigation. **Scientific methods** are ways that scientists perform investigations. There are many ways that scientists investigate the world. But all scientific methods use logic and reasoning.

(br) ©GEORG HOCHMUTH/epa/Corbis

▶ **Suppose you've just heard an opera singer warm up her voice. Write your own science question about the sounds a singer makes.**

_____

_____

Experiments

In an experiment, scientists control all the conditions of the investigation. Scientists study what happens to a group of samples that are all the same except for one difference.

Repeated Observations

Scientists use repeated observation to study processes in nature that they can observe but can't control.

Using Models

Scientists use models when they cannot experiment on the real thing. Models help scientists investigate things that are large (like a planet), expensive (like a bridge), or uncontrollable (like the weather).

Investigations Differ

The method a scientist uses depends on the question he or she is investigating. An **experiment** is an investigation in which all of the conditions are controlled. Models are used to represent real objects or processes. Scientists make repeated observations to study processes in nature without disturbing them.

Drawing Conclusions

Whatever scientific methods are used, scientists will have results they can use to draw conclusions. The conclusions may answer the question they asked before they began. They may point to other questions and many more ideas for investigations.

▶ Write the type of investigation you should use to answer the following questions.

How do different bridge designs react to strong winds?

_____

How fast does the wind blow where a bridge will be built?

_____

Which type of paint works best to keep a bridge from rusting?

_____

Explosive Observations

How does a hurricane affect animals? Are coral reefs dying? How do whales raise their young? These are some science questions that can be answered with repeated observation.

ACTIVE READING As you read these two pages, place a star next to three examples of repeated observation.

Old Faithful

Some science questions can only be answered by making observations. This is because some things are just too big, too far away, or too uncontrollable for experiments. However, much can be learned from repeated observation.

In Yellowstone National Park, heated water and steam shoots out of holes in the ground. This is called a geyser. Old Faithful is a famous geyser that erupts about every hour. Observations of the geyser collected over many years can be used to predict when the next eruption will occur. A prediction is a statement, based on information, about a future event.

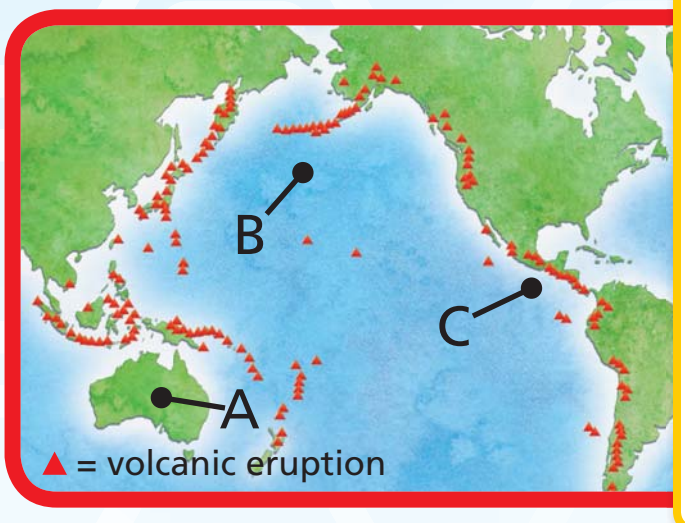
The time until Old Faithful's next eruption is affected by how long the previous eruption lasted. Suppose the last eruption was at 3:05 p.m. and lasted 3 minutes 15 seconds. Predict when it will erupt next.

How long an eruption lasts	1 min 30 sec	2 min	2 min 30 sec	3 min	3 min 30 sec	4 min	4 min 30 sec	5 min
Time until next eruption	50 min	57 min	65 min	71 min	76 min	82 min	89 min	95 min

The first observation of a whale is often its spout.

Scientists have many questions about whales—the largest mammals on Earth. How long do whales live? How do they communicate? How do they care for their young? How far can they travel in a year? These questions can be answered with repeated observation.

For example, the tail flukes of whales are different from one whale to another. Scientists take photos of the flukes and use them to identify individual whales. Once they know which whale is which, they can recognize them each time they are seen in the ocean.



Predict

Scientists have observed and recorded volcanic eruptions for hundreds of years. The map to the left shows that data. Which location—A, B, or C— is most likely to have a volcanic eruption? _____ Why do you think scientists call this region the "Ring of Fire"?

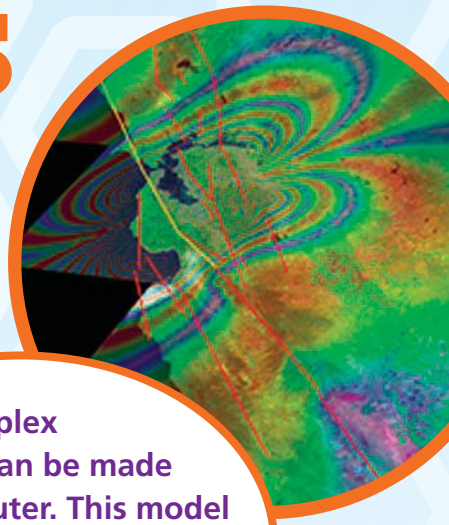
_____

_____

_____

Super Models

How does a bat fly? How might Saturn's rings look close up? How does a heart work? These are some science questions that can be answered with models.



Complex models can be made on a computer. This model shows where the most damage would occur if an earthquake were to strike.

ACTIVE READING Circle different types of models that are described on these two pages.

When Modeling Is Needed

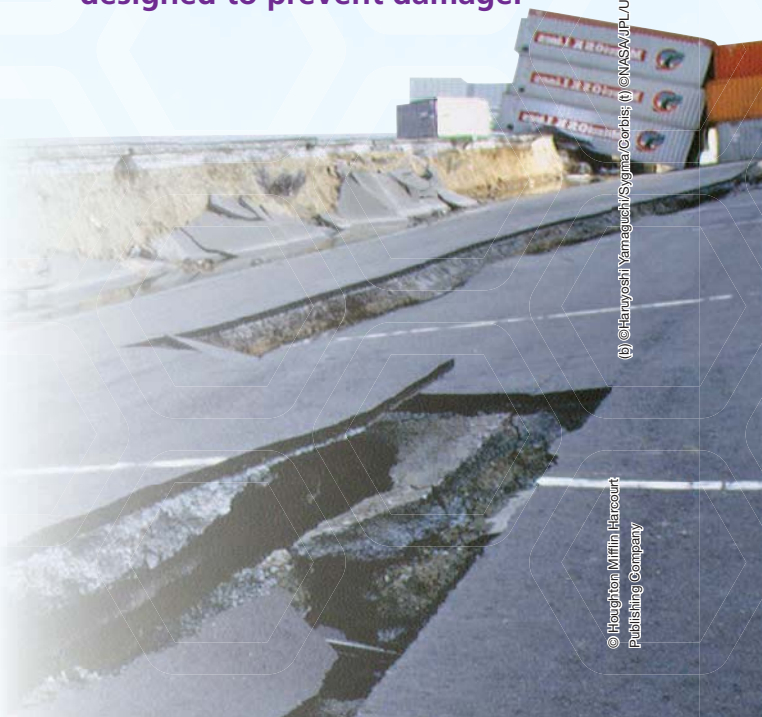
When scientists cannot experiment with the real thing, they can use models. Scientific models are needed to understand systems that have many hidden parts, such as an ant colony or the Internet. Scientists draw conclusions and make predictions by studying their models.

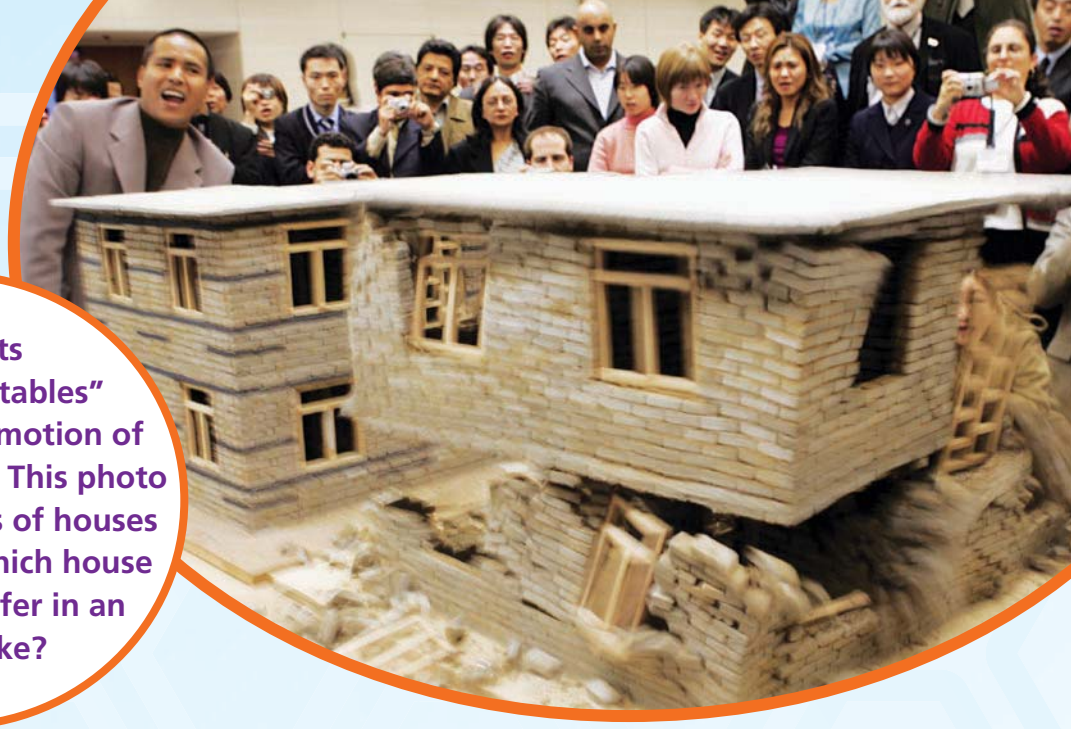
The closer the model represents the real thing, the more useful it is. So scientists change their models as they learn more.

Types of Models

Models are made in different ways. One way is to build a physical model. An earthquake shake table with model buildings on it is a physical model. Another way is to program computer simulation models. Scientists can speed up time in computer models so that they can see what might happen long in the future. Drawing diagrams and flow charts is a third way to make models. These two-dimensional models can be used to show how ideas are related.

Earthquakes are difficult to predict, and they can cause damage. New structures are designed to prevent damage.





Scientists build "shake tables" that model the motion of real earthquakes. This photo shows two types of houses being tested. Which house seems to be safer in an earthquake?

Use Models

How is an earthquake model made of gelatin like a real earthquake? How is it unlike a real earthquake?

Alike: _____

_____

Different: _____

_____

_____

You can model the effects of an earthquake, using gelatin for the ground and buildings made of blocks.

How to Excel *in* Experimentation

You're enjoying a frozen juice pop. The heat of your tongue melts the pop. As you slurp the liquid, you think about how different substances freeze.

ACTIVE READING As you read the next four pages, circle lesson vocabulary each time it is used.

Ask Questions

You know a freezer is cold enough to freeze water. You also know that juice is mostly water. You ask "Does adding substances to water affect its freezing point?"

Many science questions, including this one, can be answered by doing experiments. An **experiment** is a procedure used to test a *hypothesis*. It's a good idea to make some observations before stating a hypothesis. For example, you might put a small amount of orange juice in a freezer. Then you'd check it every few minutes to look for changes.

Hypothesize

A hypothesis is a statement that can be tested and will explain what can happen in an investigation. In the case of the freezing question, you think about what you already know. You can also talk to other people. And you can do research such as asking an expert.

You find out that the freezing point and melting point of a material should be the same temperature. An expert suggests that it is better to measure the melting point than the freezing point.

Design an Experiment

A well-designed experiment has two or more setups. This allows you to compare results among them. For the freezing/melting experiment, each setup will be a cup of liquid.

A **variable** is any condition in an experiment that can be changed. In most experiments, there are many, many variables to consider. The trick is to keep all variables the same in each setup, except one. That one variable is the one you will test.

Among the setups should be one called the control. The **control** is the setup to which you will compare all the others.

You've decided to dissolve different substances in water and freeze them. Then you plan to take them out of the freezer and use a thermometer to check their temperatures as they melt.

Hypothesize

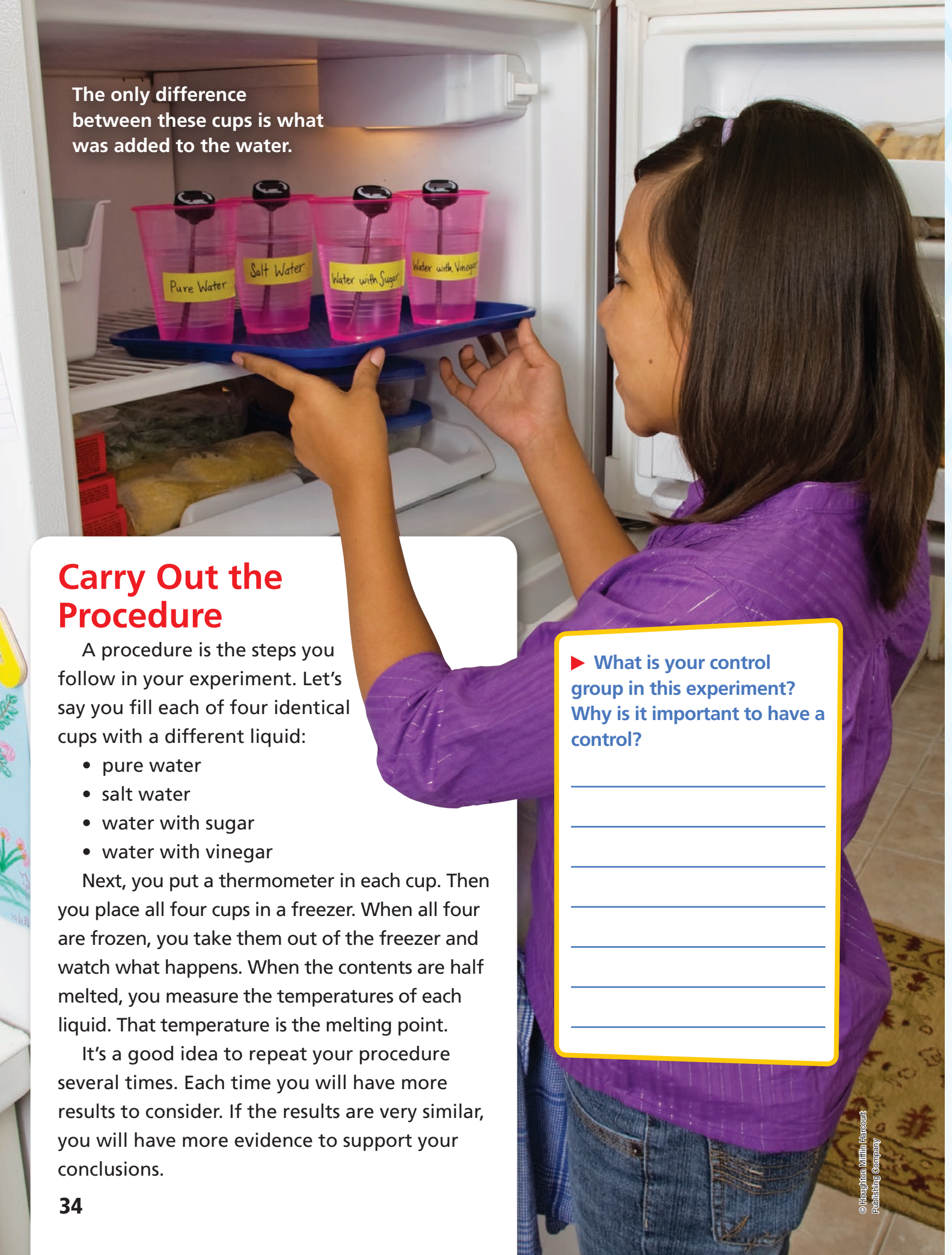
Fill in the blank in the hypothesis.

Any substance dissolved in water will _____ the temperature at which the mixture freezes and melts.

Identify and Control Variables

When you identify and control variables, you determine which conditions should stay the same and which one should be changed. Circle the variable that will be tested. Underline the variables that will remain the same.

- **the kinds of cups**
- **the amount of water**
- **the material that is dissolved in the water**
- **the temperature of the freezer**
- **the types of thermometers**
- **the amount of time you leave the cups in the freezer**



The only difference between these cups is what was added to the water.

Carry Out the Procedure

A procedure is the steps you follow in your experiment. Let's say you fill each of four identical cups with a different liquid:

- pure water
- salt water
- water with sugar
- water with vinegar

Next, you put a thermometer in each cup. Then you place all four cups in a freezer. When all four are frozen, you take them out of the freezer and watch what happens. When the contents are half melted, you measure the temperatures of each liquid. That temperature is the melting point.

It's a good idea to repeat your procedure several times. Each time you will have more results to consider. If the results are very similar, you will have more evidence to support your conclusions.

▶ **What is your control group in this experiment? Why is it important to have a control?**

Record and Analyze Data

You could write down your observations as sentences. Or you could make a table to fill in. No matter how you do it, make sure you record correctly. Check twice or have a team member check.

Once the experiment is completed and the data recorded, you can analyze your results. If your data is in the form of numbers, math skills will come in handy. For example, in the data table below, you'll need to know how to write, read, and compare decimals.

Melting Point Experiment

Substance	Melting Point (°C)
Pure water	0.0
Salt water	–3.7
Sugar water	–1.8
Vinegar water	–1.1

Draw Conclusions and Evaluate the Hypothesis

You draw conclusions based on your results. Remember that all conclusions must be supported with evidence. The more evidence you have, the stronger your conclusion.

Once you've reached a conclusion, look at your hypothesis. Decide if the hypothesis is supported or not. If not, try rethinking your hypothesis. Then design a new experiment to test it. That's what scientists do—build on what they learn.

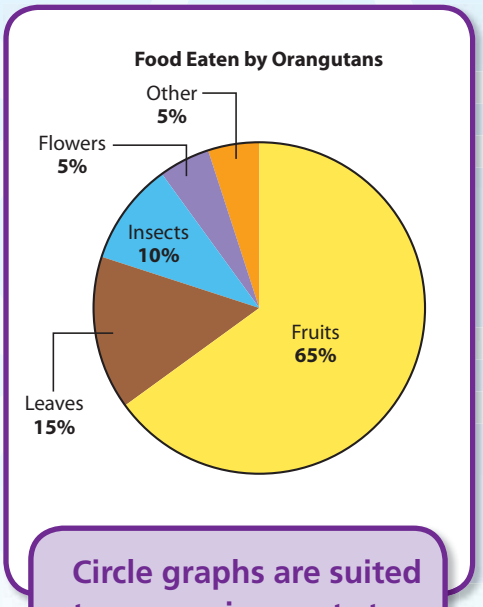
Draw Conclusions

What conclusion can you draw based on this experiment?

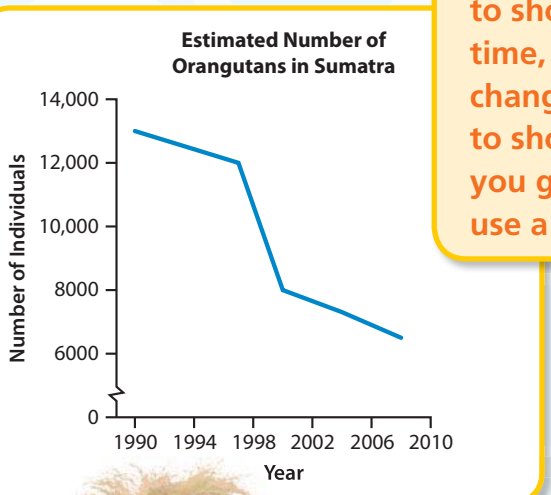
Special Delivery: Data Displays

Once you've completed a science investigation, you'll want to share it. What's the best way to communicate the data you collected?

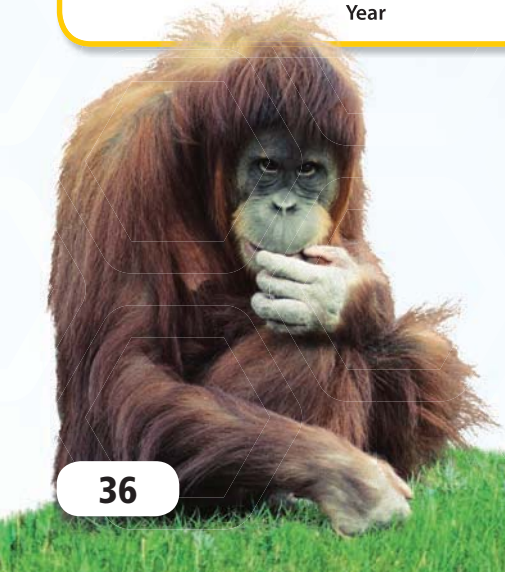
As part of their investigations, scientists collect, record, and interpret data. There is more than one way to display, or communicate, your data. Some kinds of displays are more suited to certain kinds of data than others.



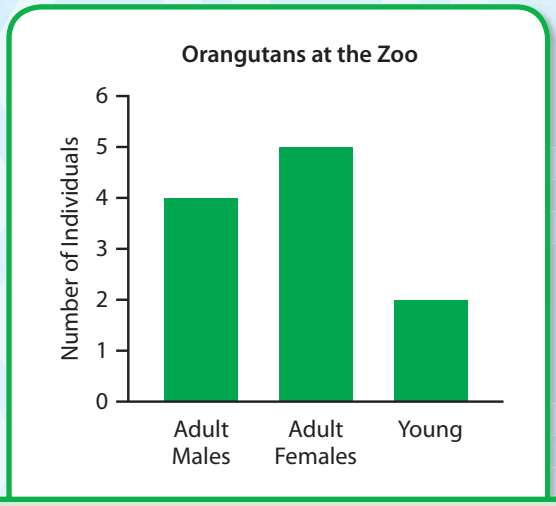
Circle graphs are suited to comparing parts to the whole. If you want to show fractions or percents, use a circle graph.



Line graphs are suited to show change over time, especially small changes. If you want to show how much you grow each year, use a line graph.



Diagrams are suited to show data that do not include numbers. This diagram shows how an orangutan uses a tool to eat seeds in fruit.



Bar graphs are suited to compare things or groups of things. When your data are in categories, use a bar graph.

DO THE MATH

Draw a Bar Graph

Draw a bar graph on this page. Use the data in the table below. Decide whether you want the bars to be vertical or horizontal. Carefully label the intervals on each axis. Draw the bars. Then title and label all the parts of your graph.

Number of Orangutans Counted

Day	Number
Monday	7
Tuesday	13
Wednesday	10
Thursday	2
Friday	6