Designing Experiments

Grades 6-10
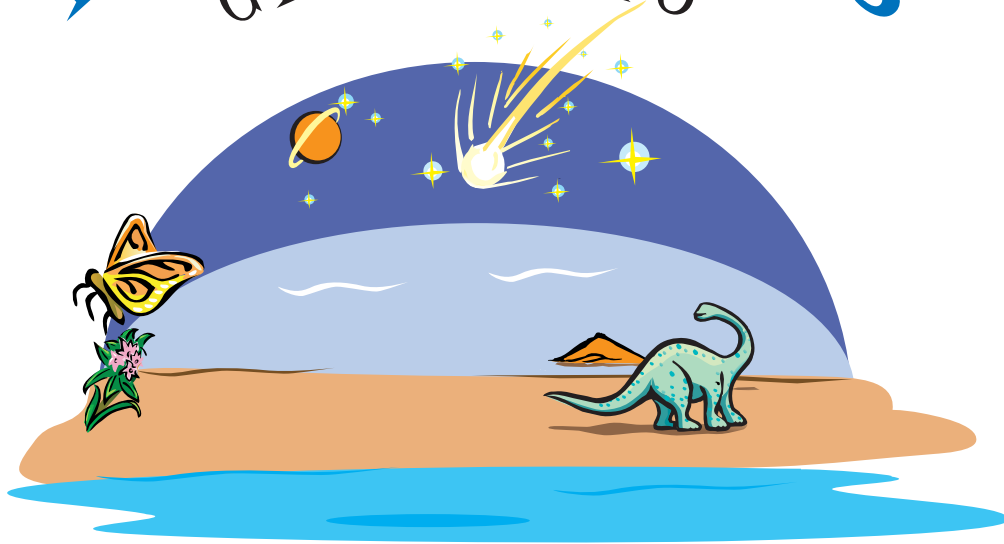
Brought to you by the editors of teachervision.com

Contents

SKILLS INTRODUCTION

Designing an Experiment

Have you ever timed two different routes to school or compared two kinds of shampoo? If you have, you have performed a simple experiment. You probably did not plan your experiment on paper before you carried it out. Scientists, however, design experiments carefully before actually performing them. **Designing an experiment** is making an organized plan to test a hypothesis. An experimental design usually follows a definite pattern. When you design experiments according to this pattern, you will use many individual science skills. Some of these skills are described briefly below.

Pose a Question

Scientists design experiments to answer questions or solve problems. For example, suppose you've heard people say that adding sugar to the water in a vase of flowers keeps the flowers fresh. You wonder whether that statement is true. To find out, you will perform an experiment. You write the topic to be investigated in the form of a scientific question: "Does adding sugar to water keep flowers fresh?"

Develop a Hypothesis

A hypothesis is a prediction about the outcome of an experiment. A properly worded hypothesis is in the form of an *If . . . then . . .* statement. The hypothesis you decide to test in your experiment is *"If I add sugar to the water in a vase, then the flowers will stay fresh longer."*

Plan the Procedure

The procedure describes what you plan to do and identifies the data you plan to collect. Begin by identifying the manipulated variable—the factor you will purposely change—and the responding variable—the factor you predict will change as a result of the manipulated variable. Here, the manipulated variable is the presence or absence of sugar in the water. The responding variable is the length of time that the flowers remain fresh. The procedure is a step-by-step description of how you will change the manipulated variable and observe the effects upon the responding variable. Preparing a data table for recording your observations is a key part of planning the procedure.

Before you begin carrying out the procedure, you must also identify the materials you will need. Write a list of those materials and then continue making your plan. When your plan is complete, revise the materials list, if necessary.

Designing an Experiment *(continued)*

Controlling Variables To be sure that your results are caused only by changes in the manipulated variable, you need to control all other variables that might affect your experiment. Controlling variables means keeping conditions the same. For example, you would keep all the flowers at the same temperature. Other variables you would control include the type and size of the containers, the number of flowers in each container, and the amount of light they receive.

Writing Operational Definitions To enable anyone to repeat and test your experiment, you must write an operational definition for any key term that does not have a single, clear meaning. For example, you could define "remaining fresh" as "flowers keeping their petals." That definition tells anyone how to measure the responding variable.

Interpret the Data

During the experiment, you record all your observations. These observations are your data. Interpreting the data means explaining that data. You may make simple comparisons or look for trends or patterns. For example, if flowers in both groups kept the same number of petals, both groups of flowers stayed fresh the same length of time.

Draw Conclusions

After you interpret the data, you need to compare that interpretation with your hypothesis and decide whether the hypothesis was true or false. This step is called drawing a conclusion. This step may conclude a scientist's investigation, or it may lead the scientist to raise new questions and design new experiments.

☑ *Checkpoint* Designing an experiment properly can be a challenging task. Why do scientists take the time to plan all the details carefully before beginning work on an experiment?

SKILLS PRACTICE

Designing an Experiment

Choose a question from the list below as a topic for an experiment. Alternatively, pose a scientific question of your own and obtain your teacher's approval to use that question.

Remember, as one of the first steps in planning your investigation, you may need to narrow your original question. Then write a hypothesis and design an experiment to answer the question. Be sure to include all the necessary parts of an experiment, such as naming the manipulated and responding variables and identifying the variables you will control. Write any operational definitions that are needed. Include a data table you could use for recording your observations. Use the back of this sheet or a separate sheet of paper for your work.

1. How is heart rate affected by exercise?

2. How are bean seedlings affected by water that has been polluted by detergent?

3. What effect does acid rain have on marble statues?

4. Does sand in the wheels of my in-line skates affect how fast they roll?

5. Will a wet sheet become dry when hung outdoors on a freezing day?

6. Is a family's health affected by using a dishwasher?

7. How is gas mileage affected by the type of gasoline used?

8. Does the presence of plants growing on a hillside change the amount of soil erosion?

9. Does cold water freeze faster than hot water?

10. Does the type of shampoo I use have an effect on how long my hair stays clean?

11. Think About It Review the experiment you just designed. What are some practical problems you might encounter if you carried out the experiment? What could you do to solve one of those problems?

SKILLS INTRODUCTION

Posing Questions

Why isn't my radio working? What's the most popular radio program? How does a radio work? What's the best kind of music? These are different kinds of questions you might ask. Some of them concern physical objects. Others are based on values or opinions—what people believe is right or wrong, or beautiful or ugly.

Questions are an essential part of science. But scientific questions are limited to the natural world—to material objects and energy changes you can observe directly or with scientific tools. The objects may be either living or nonliving things. The energy changes may be easy to observe, such as the sound of thunder overhead, or more difficult, such as the light coming from a distant star. What makes a question scientific is that it can be answered by observations, or evidence.

Scientists may start with a broad question such as "Why do people get colds?" Next, they break the question down into smaller questions: Can you catch a cold from someone else? Is there a relationship between getting chills and catching a cold? They state the final question in a way that can be answered by investigation or experiment. A good scientific question is "Does getting chilled cause colds?"

Narrowing down a question often helps researchers plan an investigation and gather evidence to answer the question. For example, to determine whether chills cause colds, a scientist could ask volunteers to undergo low temperatures that produce chills. If few or no volunteers catch colds, the scientist has obtained evidence to answer the question.

▶ Tips for Posing Questions

1. Begin by listing several questions on a topic about the natural world.
2. Try to eliminate questions that cannot be answered by gathering evidence.
3. Break broad questions into questions that can be investigated one at a time.
4. Word questions in a way that allows them to be answered by an investigation or experiment. Here are some good ways to begin scientific questions: "What is the relationship between . . ." "What factors cause . . ." "What is the effect of . . ." Be sure that the question identifies a relationship or factor you can investigate.

☑ *Checkpoint* Choose the one topic below that can be answered scientifically, and word it in the form of a scientific question.

◆ Which flowers are prettier, daisies or roses?

◆ Can you get warts from handling toads?

◆ Do cats make better pets than dogs?

SKILLS PRACTICE

Posing Questions

Examine the statements below. For each of Questions 1–10, write yes *if the topic can be investigated scientifically. Write* no *if it cannot be investigated scientifically. Then, for each item to which you answered yes, rewrite the topic in the form of a scientific question. Answer Question 11 on the back of this sheet.*

1. Some people work better in the morning, and other people work better in the afternoon.

_____

2. Taking something that belongs to another person is wrong.

_____

3. Snakes travel in pairs.

_____

4. Animals behave in strange ways before an earthquake.

_____

5. People who don't recycle should have to pay fines.

_____

6. Basketball is a better sport than soccer.

_____

7. You will remember best whatever you read just before you fall asleep.

_____

8. Maria's kind of bike is faster than Rob's kind of bike.

_____

9. Each year when the weather gets cold, birds fly to warmer regions.

_____

10. Trucks use more gasoline than cars.

_____

11. Think About It Choose one of the scientific questions you developed and tell what kind of evidence you would need to answer the question. How do you think a researcher could collect that evidence?

SKILLS INTRODUCTION

Developing a Hypothesis

Suppose you and your neighbor are growing tomatoes. One day you notice that your neighbor's plants are much bigger than yours. What's causing the difference? How can you get your plants to grow as big as your neighbor's?

The question you asked about the tomato plants could lead you to develop a hypothesis. A **hypothesis** (plural: *hypotheses*) is a prediction about the outcome of a scientific investigation. Like all predictions, hypotheses are based on a person's observations and previous knowledge or experience.

In science, hypotheses must be testable. That means that researchers should be able to carry out an investigation and obtain evidence that shows whether the hypothesis is true or false. The way a hypothesis is written can outline a way to test it. Try to word each of your hypotheses in the form of an *If . . . then . . .* statement.

Read the following three examples. Notice which of these predictions are testable. Notice which are properly worded hypotheses.

Example 1: If I give my plants fertilizer, then they will grow as big as my neighbor's plants. (testable and properly worded)

Example 2: If I get lucky, then my plants will grow bigger. (not testable, because you can't control "getting lucky")

Example 3: My plants aren't growing bigger because I don't water them enough. (not worded properly)

▶ Tips for Developing Hypotheses

◆ Ideas for hypotheses often result from problems that have been identified or questions that have been raised. To help develop ideas for a hypothesis, write down several questions about the topic. Try to narrow the questions to one that can be investigated scientifically. Then write the hypothesis.

◆ Make sure the hypothesis is a prediction.

◆ Make sure the hypothesis can be tested through an investigation.

◆ Check the way you worded the hypothesis. A properly worded hypothesis should take the form of an *If . . . then . . .* statement.
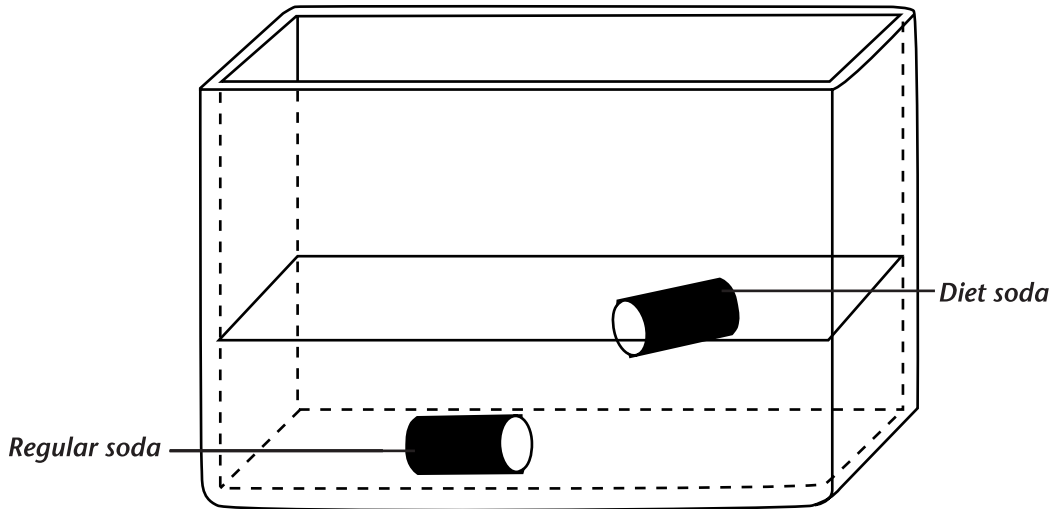
☑ *Checkpoint* Write a properly worded hypothesis based on this question: "Will empty trucks use the same amount of gas as heavily loaded trucks?"

SKILLS PRACTICE

Developing a Hypothesis

The day after a picnic, you look into the cooler. All of yesterday's ice has turned to water. Only two beverages are left. A can of diet soda is floating at the surface. A can of regular soda is resting at the bottom.

Diet soda

Regular soda

You pick up the two cans. You see that both drinks are made by the same company. Then you read the labels.

Regular Soda

CARBONATED WATER
SUCROSE
CARAMEL COLORING
NATURAL FLAVORS

Diet Soda

CARBONATED WATER
ASPARTAME
CARAMEL COLORING
NATURAL FLAVORS

Developing a Hypothesis *(continued)*

Answer the following questions. Use the back of this sheet if you need more space.

1. You think that something about the regular drink must have made it sink, while something about the diet drink made it float. Write down at least two possible explanations for the events.

_____

_____

2. Suppose that the type of drink did *not* affect which can floated or sank. Maybe the cans themselves were different in some way. Maybe something besides soda got into one of the cans by mistake. Write down at least two possible explanations for the events.

_____

_____

3. Write down any other possible explanations you can think of. Could the cooler have had any affect? Could something in the water be responsible? Could there be an object in the water that you can't see?

_____

_____

4. Review your answers to Question 1. Use one of your ideas to write a hypothesis explaining why one can floated and the other sank. (*Hint:* Make sure you use the words *If. . . , then. . . .*)

_____

_____

5. Review your answers to Questions 2 and 3. Choose one of your statements describing something besides the type of drink that caused the floating or sinking. Write a hypothesis based on that idea.

_____

_____

6. Are both of your hypotheses testable? Write a brief description of how you could test each one. Mention any equipment you would need. (*Hint:* You can open the cans and pour out the drinks as part of your tests.)

_____

_____

7. **Think About It** Review your work. Use it to help you write a short summary of how to develop a hypothesis about an event.

www.TeacherVision.com

SKILLS INTRODUCTION

Controlling Variables

Suppose that you are planning to try out for the track team. To make the team, you need to increase your speed. You wonder whether to eat a new cereal being advertised for athletes. You could eat the cereal every morning for a month, then run a timed race. If your new time was faster than your previous time, would the cereal be the cause? Based on your test, there'd be no way to know! Too many factors could explain your improved speed. The only way to be sure whether a particular variable causes a specific result is to conduct a controlled experiment.

Every experiment involves several variables, or factors that can change. For example, consider this question: Will houseplants grow faster if you make the room warmer? To answer this question, you decide to grow plants at different temperatures. The variable that you purposely change and test—the temperature of the room—is called the **manipulated variable.** The factor that may change as a result of the manipulated variable—how fast the plants grow—is called the **responding variable.**

An experimental plan is not complete unless the experimenter controls all other variables. **Controlling variables** means keeping all conditions the same except for the manipulated variable. In an experiment on temperature and plant growth, for example, you have to control any other variables that might affect the growth rate. Such variables include the size of the container, the type of soil, the amount of water, the amount of light, and the use of fertilizer. In addition, you would need to use identical plants in the experiment.

*Control Group
20°C*

*Experimental Group
25°C*
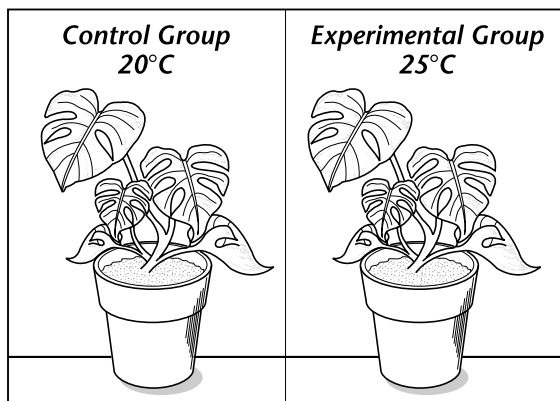
*Same kinds of plants
Identical containers
Same type and amount of soil
Same type and amount of fertilizer
Same amount of water
Same lighting*

When all these variables are controlled, you can logically conclude that the differences in your results are due to changes in the manipulated variable.

www.TeacherVision.com

Controlling Variables *(continued)*

How to Identify the Control Group In a controlled experiment, scientists usually study groups of living or nonliving things instead of comparing just two individual things. The groups that are being studied are called the experimental group and the control group. The experimental group is the group whose conditions are being changed. In the example on the previous page, the plants being grown at the warmer temperature of 25°C make up the experimental group. The control group, or the control, is the group whose conditions are *not* being changed. In the example, the plants grown at the usual temperature of 20°C make up the control group.

The purpose of the control group is to serve as a standard of comparison. For example, if the plants in the control group grew an average of 1 centimeter after 3 weeks, you could compare whether the plants in the experimental group grew the same amount, or grew more than or less than 1 centimeter.

▶ Tips for Controlling Variables

◆ Start by describing the question or process being investigated. Then identify the manipulated variable and the responding variable in the investigation. Predict the kinds of results you might observe in the responding variable.

◆ Create a list of all of the other variables that might affect the responding variable.

◆ Consider whether you have forgotten any of the most common types of variables: time, temperature, length, width, height, mass, volume, number, and the kinds of substances being used in the experiment.

◆ Determine whether or not one of the objects or groups of objects will serve as the control.

☑ *Checkpoint* Why must variables in an experiment be controlled?

SKILLS PRACTICE

Controlling Variables

Answer the following questions in the space provided. Use the back of this sheet if you need more space.

1. You are planning an experiment to find out whether the rate at which water freezes depends on the shape of its container. Identify the manipulated variable and the responding variable. List the other variables you would control.

_____

_____

_____

2. Researchers want to determine the best temperature for storing batteries. Describe a possible experiment and list the variables to be controlled in that experiment. Be sure to identify the manipulated and the responding variables.

_____

_____

_____

3. Your friend has to plan an experiment for a science fair. He asks for your help. His topic is "The Strongest Cloth for Backpacks." What variables must his experiment include? What variables must be controlled?

_____

_____

_____

4. Suppose you wanted to compare two different stain removers to learn which one was better at removing food stains from clothing. In your test, what variables would you need to control?

_____

_____

_____

5. Think About It Some classmates conducted an experiment to find out which brand of paper towels is the strongest. You find out that they didn't try to control any variables. Write a few sentences explaining why they cannot draw any useful conclusions from their experiment.

_____

_____

_____

SKILLS INTRODUCTION

Forming Operational Definitions

Suppose that your class and another class work together on an experiment. You're trying to determine what kinds of balls roll the fastest. When the experiment is finished, you all want to compare your data, so you must all perform the experiment in the same way. That means that each time a team of students repeats the experiment, they have to use the same materials and procedure as every other team. They must also make their measurements in an identical manner.

Scientists also repeat investigations—their own and those of other researchers—to be sure that specific data are reliable. To make such repetition possible, scientists use operational definitions. An **operational definition** is a statement that describes how a particular variable is to be measured, or how an object or condition is to be recognized. Operational definitions tell you what to do or what to observe. (The word "operational" means "describing what to do.") Operational definitions need to be clear and precise so that a reader knows exactly what to observe or measure.

In the experiment described above, the two classes could agree on a common procedure: Set up a ramp exactly 10 centimeters high and 2 meters long, and use tape to make a "finish line" at the bottom of the ramp. Make a series of tests by letting two different balls to roll down the ramp at the same time. By using the following definition, the classes would eventually determine which ball rolls the fastest.

Example 1: Operational definition: The fastest ball is the one that crosses the finish line before all the other balls.

When you read or write an operational definition, ask yourself, "Does this definition describe what to do or what to observe?" In the example just given, the student teams would be able to use the procedure and the definition to compare their results. Here are some other examples of operational definitions.

Example 2: Lemon juice, vinegar, and certain other substances are acids. To find out whether a substance is an acid, place a drop of the substance on blue litmus paper. Operational definition: Substances that cause the litmus paper to turn pink are acids.

Example 3: To measure a person's pulse, place your index and middle fingers lightly on the inside of the person's wrist and find the beating artery. Operational definition: The pulse is the the number of beats counted in 1 minute.

Example 4: You have to classify vertebrates as fish, amphibians, reptiles, birds, or mammals. Operational definition: A bird is an animal that has two feet, a pair of wings, and feathers.

Example 5: You have to determine the relative ages of layers of sedimentary rock. Operational definition: In sedimentary rock that has not been disturbed, the oldest rock is the bottom layer area, and the youngest rock is the top layer.

Often, it is possible to write more than one operational definition for a variable. For example, the speed of a moving object can be measured in many ways, including with instruments such as timed photographs, speedometers, and radar guns. When you write an operational definition, choose a procedure that makes sense for the investigation you're carrying out. Ask yourself: "Will the measurements I obtain with this definition give me data that help me test my hypothesis or answer my question?" If the answer is no, you need to rethink and revise your definition.

▶ Tips for Writing Operational Definitions

◆ Look over the written plan for carrying out an investigation, or write up a plan.

◆ Identify and list any variables or terms that do not have a single, clear, obvious meaning.

◆ If there are several reasonable ways to make an observation or to perform an action, choose one that suits the purpose of the investigation.

◆ Write a clear, complete definition of what the researcher should do or measure. Check your definition by asking yourself, Will this definition tell another person what to observe or how to measure? If necessary, revise your definition before starting your investigation.

☑ *Checkpoint* Why are operational definitions important in science?

SKILLS PRACTICE

Forming Operational Definitions

Write an operational definition for each underlined idea in the space provided.

1. <u>On a cold day,</u> let the water in the pan freeze outdoors.

_____

_____

_____

2. You will test these two fertilizers to determine which one helps <u>plants grow faster.</u>

_____

_____

_____

3. Rearrange the list of zoo animals in order of their size, <u>with the biggest ones first.</u>

_____

_____

_____

4. People who take a driver's education course are probably <u>better drivers</u> than drivers who do not.

_____

_____

_____

5. When you finish working on an experiment, <u>wash your hands thoroughly.</u>

_____

_____

_____

6. Think About It A good operational definition tells a person clearly how to perform an observation or take a measurement. Choose one of your definitions and explain whether you think other people would be able to follow the directions you provided.

_____

_____

INTRODUCING THE SKILL

Interpreting Data

Suppose your class is planning a party. You don't have lots of money to spend, so you're looking for bargains as you buy the food, drinks, and decorations. For example, you can buy soft drinks in separate cans, in packs of six cans, or in one-liter bottles. Some stores are having sales, and you also have a few money-saving coupons. To figure out the best price, you would first have to decide how many soft drinks you need, list all the price information you have, and then compare the various choices. That's similar to what you do when you analyze data in a science investigation.

During a science investigation, you make observations and take measurements that are called **data.** For example, you might observe color changes in a liquid or measure the temperature of objects left out in a sunny spot. After you collect your data, you need to interpret—or find meaning in—the data by looking for patterns or trends.

Suppose that scientists recorded the temperature at a specific location on Earth's surface. After that, they drilled below the surface to collect temperatures at different depths. The results of their work are shown in the table below.

Depth (km)	Temperature (°C)
0	15
1	52
2	88
3	120
4	151
5	179
6	206
7	232
8	257

By looking at the table, you can see that the deeper the location of the measurement, the higher the temperature. But it's hard to find any more details about that trend by just examining the table. So you decide to graph the data.

Interpreting Data *(continued)*

You could use the data to create a graph like this one. You could then interpret the graph and make inferences like the ones that follow.

Example 1: The deeper the location of the temperature reading beneath Earth's surface, the hotter the temperature is.

Example 2: For every additional kilometer of depth, the temperature increases about 30 Celsius degrees.

Example 3: The temperature at a depth of 3.5 km would be about 135°C.

To determine whether your interpretation of the data is logical, you compare it with what you already know. You know that lava from inside Earth sometimes erupts from volcanoes, and that lava is extremely hot. You decide your interpretation of the data makes sense.
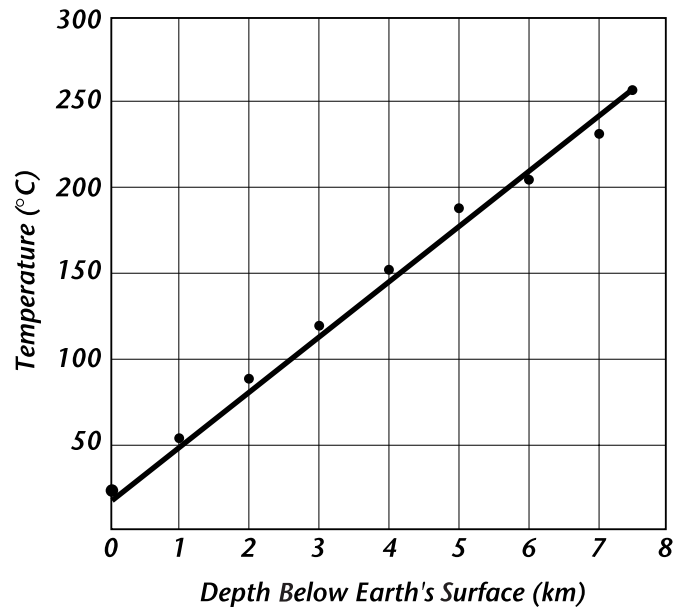
▶ **Tips for Interpreting Data**

◆ Organize the data into a table or arrange the data in a specific order, such as largest to smallest. If applicable, make calculations such as adding, subtracting, or finding averages.

◆ Make a graph of the data.

◆ Look for trends or patterns in the data or graph.

◆ Make one or more inferences from the data. Then compare the inferences with what you already know about the topic.

◆ If your inferences seem to contradict what you know, review your work to see whether you made any errors or need to examine the data again.

☑ *Checkpoint* Could you use the data about temperatures beneath Earth's surface to predict the temperature at 9 km beneath Earth's surface? Explain your reasoning.
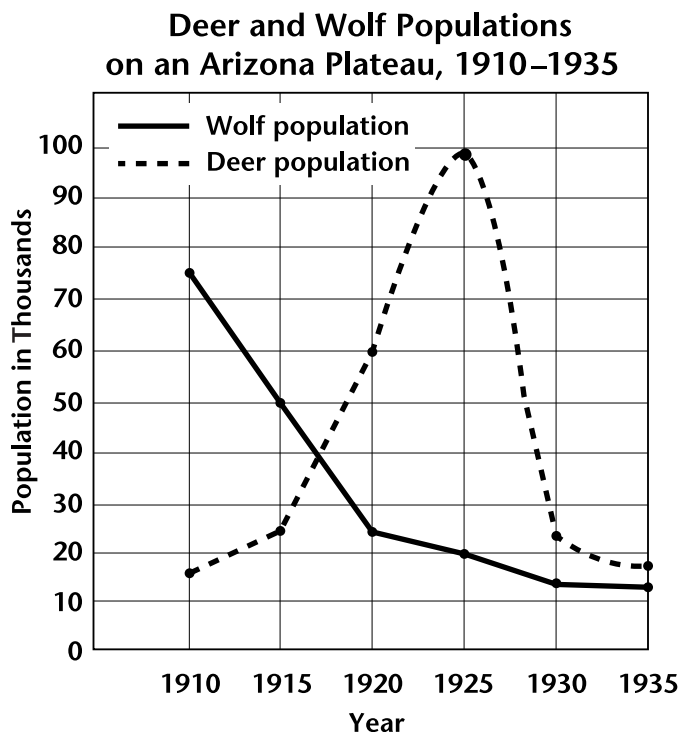
www.TeacherVision.com

SKILLS PRACTICE

Interpreting Data

Answer the following questions on the back of this page or on a separate sheet of paper.

Deer and Wolf Populations on an Arizona Plateau, 1910–1935

This graph presents data that were collected over a 25-year period in a region of Arizona.

1. Start by summarizing the data. Using the title and the axis labels as a guide, write a sentence describing what the data show.

2. Examine the wolf graph. How big was the wolf population in 1910? (*Hint:* Remember to multiply the numbers on the vertical axis by 1,000.)

3. What does the shape of the wolf graph tell you about the wolf population from 1910 to 1935?

4. Examine the deer graph. How big was the deer population in 1910?

5. What does the shape of the deer graph tell you about the deer population from 1910 to 1935?

6. List two other facts that you can learn from the graph.

7. How can the changes shown in this graph be explained?

8. Does your explanation in Question 7 fit in with what you know about deer and wolves? Explain.

9. **Think About It** Look back over your work. Make a list of the steps you took as you interpreted the data in the graph.

SKILLS INTRODUCTION

Drawing Conclusions

Suppose that you have a portable radio with headphones. One day you turn the radio on, but you don't hear your favorite station. You try other stations and still get no sound. You think that the batteries must be dead, so you put in new ones. Still there is no sound. You try replacing your headphones with ones from your sister's radio. Your favorite music is back! You draw the conclusion that there was something wrong with your headphones.

In everyday language, the word "conclusion" means an explanation or interpretation of an observation or a statement. In science, the word "conclusion" usually has a more limited meaning. **Drawing a conclusion** means making a statement summing up what you have learned from an experiment.

The conclusion of an experiment is usually related to the hypothesis. You may recall that a hypothesis is an *If . . . then . . .* prediction made about the outcome of an experiment. After you have carried out the procedure, made and recorded observations, and interpreted the data, you can finally determine whether your experiment showed your hypothesis to be true or false.

Suppose that Leon and Jobelle each write a hypothesis about the summer temperatures where they live.

Example 1: Leon writes, *If I measure the temperature on sunny summer days in this location, then the warmest air temperatures will occur between 11 A.M. and 1 P.M.*

Example 2: Jobelle writes, *If the day is sunny, then the hottest time of the day will be about 3 o'clock in the afternoon.*

They then test their hypotheses by measuring the outdoor temperature several times a day for the month of July. Then they average their data and graph the data as shown at the right.

Average Daily Temperatures for July
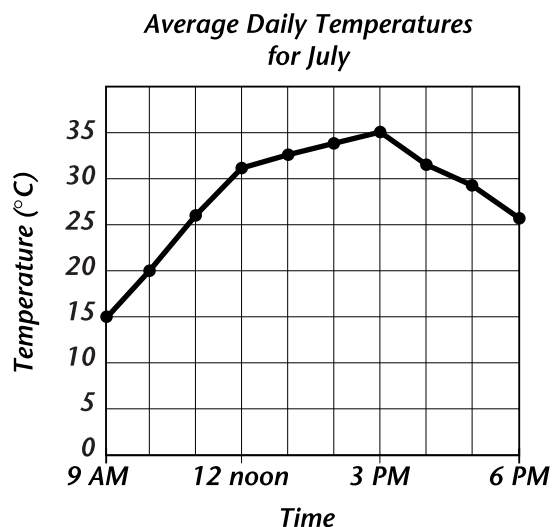
Drawing Conclusions *(continued)*

From the graph, Leon can see that the results of the investigation do not support his hypothesis. He draws this conclusion: *Based on a study of temperatures between 9 A.M. and 6 P.M. on sunny days, the warmest temperatures do not occur between 11 A.M. and 1 P.M. but happen sometime later in the afternoon.*

The results do support Jobelle's hypothesis, however. She draws the following conclusion: *On sunny days in July, the warmest temperatures occur about 3 P.M.*

Before scientists become confident of their conclusions, they often repeat their experiments many times and compare their work with that of others. Additional experiments may provide further support for a particular hypothesis. Alternatively, they may cause a researcher to revise or replace the hypothesis.

▶ ## Tips for Drawing Conclusions

- ◆ Refer to the hypothesis for your experiment.
- ◆ Review the observations in your experiment. Analyze the data, completing whatever calculations or graphs will help you identify trends or patterns in your results.
- ◆ Determine whether your data support your hypothesis or suggest that it is false. Write a statement summing up what your results show.
- ◆ Consider whether you might plan other experiments to support your conclusion or compare your work with that done by other researchers.

☑ ***Checkpoint*** Do you think Jobelle can use the data to draw a conclusion about daily temperature changes that occur at other times of the year? Explain.
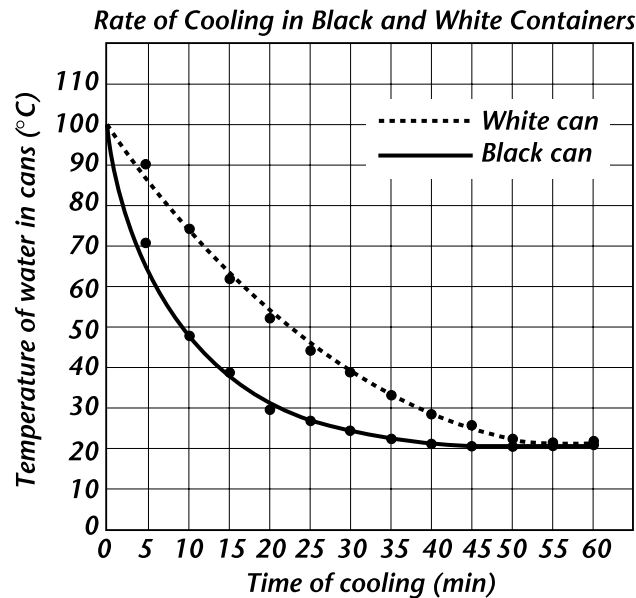
SKILLS PRACTICE

Drawing Conclusions

Answer the questions below on the back of this page or on a separate sheet of paper.

Olena and Bruce are studying whether the color of a container affects how fast the container cools down. Olena wrote this hypothesis: *If you put hot water in white and black cans, the cans will cool down at the same rate.* Bruce wrote this hypothesis: *If hot water is put in black and white cans, the black can will cool down faster than the white can.* They then tested their hypotheses. Here is their graph.

Rate of Cooling in Black and White Containers

Temperature of water in cans (°C)

- **White can** (dotted line)
- **Black can** (solid line)

Time of cooling (min)

1. Examine the data presented in the graph. Notice the temperatures of the black and white cans at the times the measurements were taken. What does this data tell you about the way the two cans cooled down?

2. Compare the evidence in the graph with Olena's hypothesis. What conclusion should Olena draw?

3. Compare the evidence in the graph with Bruce's hypothesis. What conclusion should Bruce draw?

4. Neither Bruce or Olena included anything about the cans' final temperatures in their hypotheses. Rewrite one of their conclusions to include information about the final temperatures of the cans.

5. **Think About It** Who do you think learned more about temperature changes: Bruce or Olena? Does it make any difference if one person's hypothesis was shown to be false? Explain.

SKILLS INTRODUCTION

Creating Data Tables

Suppose that your class decides to sponsor a Scrabble® competition to raise money. You'll ask people to pay $1.00 each to play. The money will go to a charity that your class has chosen. To keep track of the results, all players will have official score cards that show the number of games they play, their wins and losses, their game scores, and their average score. The easiest way to show all that information would be in a data table.

A **data table** is an organized arrangement of information in labeled rows and columns. Data tables are helpful in many kinds of situations. In science, they are particularly useful when you record observations during an investigation. Making data tables may also help you interpret information that someone else has collected.

Planning a data table is an important part of designing an experiment. A data table provides an orderly way for you to record observations. It can help you keep complete records by reminding you of everything you need to observe. Also, data tables can provide spaces for the results of calculations you plan to do as you interpret the data.

When you create a data table, start by identifying the manipulated and responding variables. For example, suppose you are comparing two types of fertilizer to see whether one of them makes plants grow taller. Your manipulated variable is the type of fertilizer. Your responding variable is the height of the plants. You decide you will measure the height of the plants once a day for a period of three weeks. You also decide to include a control, a plant that receives no fertilizer. You might make a table like the one below.

Effects of Fertilizer on Plant Growth			
Time (days)	Height of Plant (cm)		
	Control Plant (no fertilizer)	Fertilizer A	Fertilizer B
Day 1			
Day 2			
Day 3			

Creating Data Tables *(continued)*

Check your plan to be sure that your data table has a column for each kind of information you will observe and a row for each occasion when you'll make an observation. Be sure to label the columns and rows accurately and identify the units of measurement you are using. And be sure to give the data table a title.

Review the draft of your table to be sure it has places for all the data you plan to collect. For example, in an experiment on the effects of plant fertilizer, you might want to insert columns to record the daily temperature or additional changes in the plants, such as the number of leaves that develop. When your review is complete, create the final data table in your notebook.

▶ Tips for Creating Data Tables

- ◆ Consider the manipulated and responding variables to determine what observations you will be making.

- ◆ If you plan to make observations according to a regular pattern, such as once a day, once an hour, or once every five minutes, plan to show those times in the data table.

- ◆ Make a draft of your table. Show all the columns and rows you'll need and what labels they will have. Be sure to write a title for your table.

- ◆ Insert units into the column labels where they are needed.

- ◆ Compare the draft of the data table to the plan for your experiment to be sure you have a place to record all observations you expect to make.

- ◆ Revise the draft of your data table and draw the final table in your notebook.

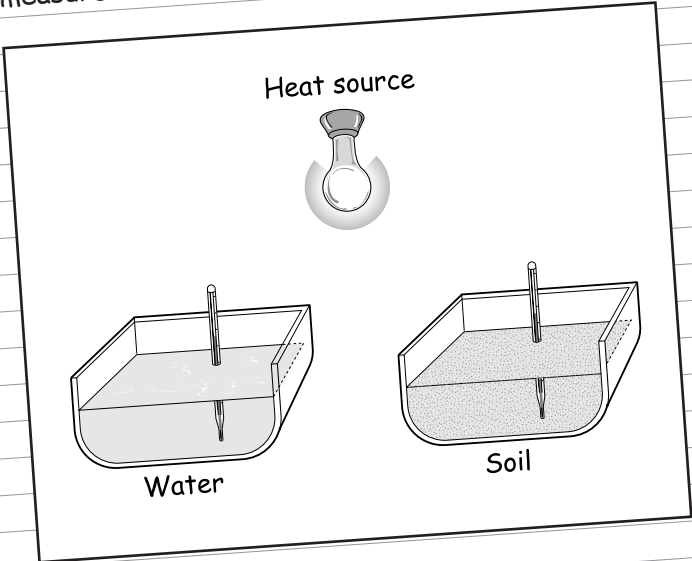☑ *Checkpoint* How can a well-organized data table help you keep complete records during an experiment?

SKILLS PRACTICE

Creating Data Tables

Read over the notebook page shown below. Then answer the questions that follow in the spaces provided or on a separate sheet of paper.

Maria did not make a data table before she began her science investigation, but she wrote these notes.

To find out whether water or land gets hotter or cooler in the sun, I will set up a pan of water and a pan of soil. I will put a light bulb halfway between the two pans, and each pan will have a thermometer in it. I will leave the light on for ten minutes and measure the temperature in each pan once every minute.

Heat source

Water

Soil

Here are the results I got. The soil temperatures measured in °C were 20.0, 21.0, 22.0, 23.0, 24.0, 26.0, 27.0, 28.5, 30.0, 31.0, 32.0. Then I turned the light off, and the temperatures were 32.0, 31.0, 30.5, 29.5, 28.0, 27.0, 26.0, 25.0, 23.5, 22.0.

The water temperatures were 20.0, 20.5, 21.0, 21.5, 22.0, 22.0, 22.5, 22.5, 23.0, 23.0. After I turned off the light, the temperatures were 23.0, 22.5, 22.5, 22.0, 22.0, 22.0, 21.5, 21.0, 21.0, 20.5.

Creating Data Tables *(continued)*

1. Think about Maria's plan. What does the light bulb represent? What do the pans of soil and water represent?

_____

_____

_____

2. What is the manipulated variable in Maria's experiment? What is the responding variable?

_____

_____

_____

3. Would Maria need to consider any other variable(s) as she created a data table for this lab? Explain.

_____

_____

_____

4. Draft a plan for a data table for Maria's experiment. Review your plan and then create the data table. Fill in the table with the data Maria obtained.

_____

_____

_____

5. Think About It Examine the data table you made. Is it a complete record of Maria's investigation? Explain.

_____

_____

_____

_____

_____

SKILLS INTRODUCTION

Creating Bar Graphs

Each day, some students are absent from school because of illness or other factors. Suppose you are given a list of the number of students absent in Grades 6 through 9 today. You are asked to graph the data so that the principal can easily compare the absences across the grades. Which type of graph should you use: bar, circle, or line?

Today's Absences	
Grade	**Number**
6	7
7	9
8	12
9	4

The type of graph you should make depends on your data. Here, the absences in each grade are distinct, or separate, categories. For example, the number of 9th grade absences is distinct from the number of 8th grade absences. You should make a bar graph.

Today's Absences
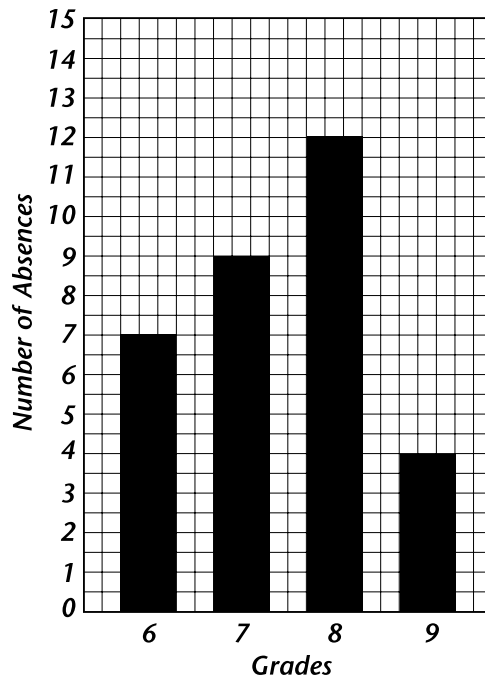
A bar graph is a diagram in which data about separate but related items are represented by rectangular shapes called bars. You usually place the categories being studied on the horizontal axis. Place the measurements or amounts on the vertical axis. The measurement for each category is represented by a separate bar. The length of the bar indicates the amount of the measurement.

Constructing Bar Graphs *(continued)*

In science, bar graphs usually have simple rectangular shapes to indicate the measurements. Sometimes in newspaper and magazines, bar graphs use drawings that represent the measurements. For example, each absent student could be represented by the drawing of a person. For larger numbers, a drawing could stand for 10 students. But regardless of the way the measurement is represented, bar graphs make it easy to read and compare the separate but related data.

▶ ### Tips for Constructing Bar Graphs

1. Organize your data in a table. A table makes it easier for you to construct a graph.

2. Draw horizontal and vertical axes on a sheet of graph paper.

3. Place the category being studied, or the manipulated variable, on the horizontal axis. Place the measurements that have been made, or the responding variable, on the vertical axis. Label both axes.

4. Determine the scale for the measurements to be shown on the vertical axis. Choose a scale that lets you represent all the values in your data table. Each square on the graph paper will represent a certain amount. All squares have the same value. In the example on the previous page, each square represents one absent student.

5. On the horizontal axis, show a bar for each category being represented. Use an equal number of squares for the width of each bar and leave a space of at least one square between the bars. In this example, three squares are used for each bar. A space of two squares has been left between the bars.

6. Using your data, draw in the bars. Remember, all the bars must have the same width.

7. Write a title for your bar graph.

☑ ***Checkpoint*** Which of the following examples would you show in a bar graph?

(1) the average weight of a dog during each year of its life

(2) the numbers of dogs, cats, birds, fish, and other pets people cared for during the previous year

Explain your answer.

SKILLS PRACTICE

Creating Bar Graphs

Answer the questions below on the back of this page. Use a sheet of graph paper to make the graph.

The table below shows the relative diameters of the planets in our solar system in Earth units. That means that Earth is represented as having a diameter of 1 Earth unit. The planet Uranus, which has a diameter that is four times the size of Earth's diameter, is represented by 4 Earth units. The planets are listed in order of their distance from the sun. Mercury is the closest, and Pluto is the farthest away.

Diameters of the Planets in Earth Units	
Planet	**Diameter in Earth Units**
Mercury	0.40
Venus	0.95
Earth	1.00
Mars	0.50
Jupiter	11.20
Saturn	9.50
Uranus	4.00
Neptune	3.90
Pluto	0.20

1. On which axis will you place the names of the planets? (*Hint:* The planets are similar to a category being studied, or a manipulated variable. List the planets in the same order as in the table, starting with Mercury.)

2. Notice that the measurements you need to represent include some numbers between 0 and 1, with the largest number between 11 and 12. What scale will you use to represent the planet diameters? (*Hint:* You may need to estimate the height of certain bars.)

3. On a sheet of graph paper, make a bar graph that displays the data in the table.

4. **Think About It** Suppose you made a bar graph showing the planets' distances from the sun, and you listed them in the same order as in this graph. How would the new graph be similar to the graph you just made? How would it be different?

Creating Line Graphs

A science class studying frogs counted the number of times the frogs croaked at different temperatures. The results are shown in the data table on the right. To help interpret that data, the class then created a line graph. A **line graph** is used to display data that show how one variable (the responding variable) changes in response to another variable (the manipulated variable). You should use a line graph when your manipulated variable is continuous, that is, when there are other measurements possible between the ones you tested. For example, in this experiment, temperature is a continuous variable since 27°C is between 26° and 28°, and 22.5°C is between 22° and 23°. Temperature, time, mass, and velocity are just a few examples of continuous variables.

Number of Croaks vs. Temperature	
Air Temperature in °C	**Frog Croaks per Minute**
22	12
23	14
24	15
26	16
28	17
31	21
32	26

Number of Frog Croaks at Different Temperatures
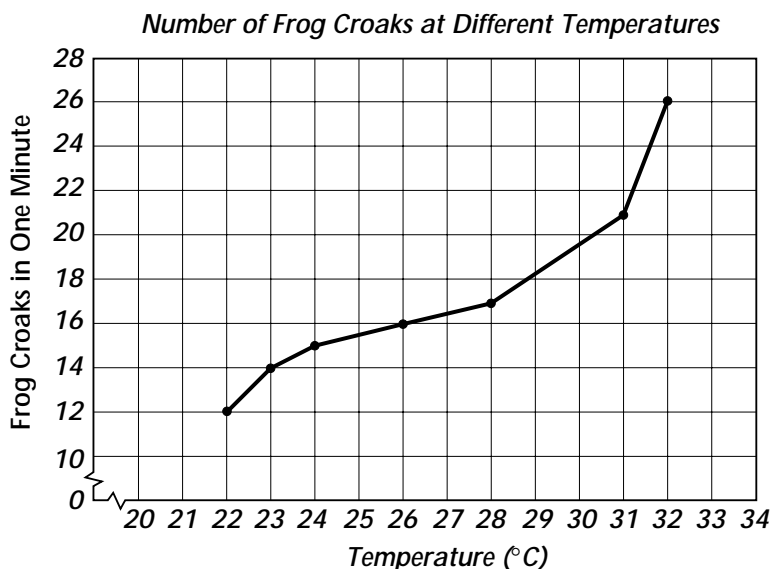
A line graph is a powerful tool because it shows a relationship between two variables. Here, the line graph shows how the number of frog croaks per minute changes as temperature changes. Line graphs also allow you to identify trends and relationships in the data, and thus infer values you did not actually measure. For example, you can infer that at 30°C, the frogs might make 20 croaks per minute. At 20°C, they might make about 10 croaks per minute. (To find out whether these inferences were true, you would have to do additional research.)
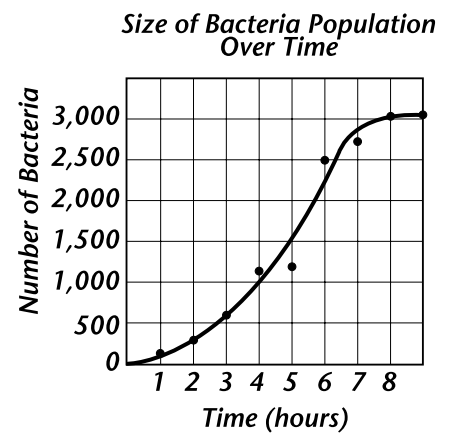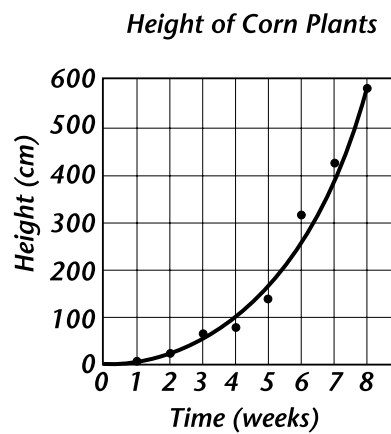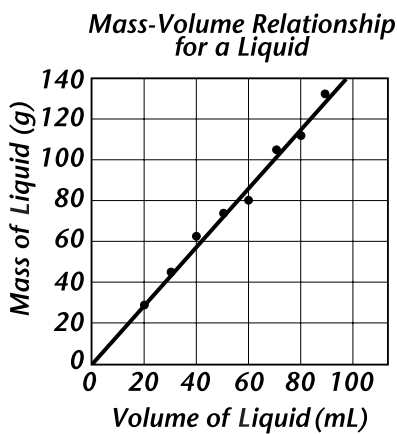
Creating Line Graphs *(continued)*

What Is a Best Fit Line Graph? Notice that unlike the graph on page 64, the lines on the graphs below were not drawn from point to point. Instead, the graphs are smooth and continuous. They flow through as many of the data points as possible but do not necessarily touch all the points. This kind of graph is called a "best fit graph." A best fit graph shows an average, a trend, or a pattern in the data.

You may wonder how scientists know when to use a best fit graph. As you continue to study science, you will see that certain kinds of graphs commonly result from scientific experiments. The graphs shown below are three examples.

The first graph shows a straight line. You can read that graph to see that as the volume of a liquid (the manipulated variable) increases, the mass of that liquid (the responding variable) also increases.

Mass-Volume Relationship for a Liquid   **Height of Corn Plants**   **Size of Bacteria Population Over Time**

The center graph shows a curve that continues to rise. You can read that graph to see that over time (the manipulated variable), a corn plant's height (the responding variable) continues to increase.

The graph on the right shows a curve that rises and then flattens out. Here, as time (the manipulated variable) passes, the size of the bacteria population (the responding variable) increases steadily until it reaches a certain size. Then, the size of the population becomes constant.

Look for these and other patterns as you examine additional graphs. Recognizing the pattern of a graph will help you to understand the actual events it represents.

Creating Line Graphs *(continued)*

▶ **Tips for Creating Line Graphs**

1. On graph paper, draw a horizontal, or *x-,* axis and a vertical, or *y-,* axis.

2. Label the horizontal axis with the name of the manipulated variable. Label the vertical axis with the name of the responding variable. Include the units of measure.

3. Create a scale on each axis by marking off equally-spaced numbers along the axis. Begin with zero or a number slightly less than the smallest number to be graphed. Be sure that each scale covers the entire range of data collected for that variable. Label the units on each scale.

4. Plot each point where the variables intersect. You can do this by following an imaginary line up from the measurement on the *x*-axis. Then follow a second imaginary line across from the corresponding measurement on the *y*-axis. Place a dot where the two lines intersect.

5 Consider whether you will plot from point to point or make a best fit graph. If you plot from point to point, each segment connecting two adjacent points should be straight. If you make a best fit graph, the connecting line should be smooth.

6. Give your graph a title that identifies the variables or the relationship between the variables in the graph. On page 64, "Number of Frog Croaks at Different Temperatures" is a complete title that clearly describes this graph.

☑ *Checkpoint* How could you use a line graph to help you make predictions about data that were not actually measured? Use one of the graphs on page 64 or 65 to help you answer this question.

www.TeacherVision.com

SKILLS PRACTICE

Creating Line Graphs

Use a sheet of graph paper to make a graph of the data given below. Then answer the questions that follow on the back of this page or on a separate sheet of paper.

Time vs. Temperature for Unknown Substance		
Time (min)	Temperature (°C)	Solid, Liquid or Gas
0	–20	Solid
5	0	Solid (melting)
10	0	Solid (melting)
15	52	Liquid
20	100	Liquid (boiling)
25	100	Liquid (boiling)
30	100	Liquid (boiling)
35	100	Liquid (boiling)
40	100	Liquid (boiling)
45	100	Liquid (boiling)
50	100	Liquid (boiling)
55	100	Liquid (boiling)
60	100	Liquid (boiling)
65	100	Liquid (boiling)
70	100	Liquid (boiling)
75	110	Gas
80	120	Gas

A group of researchers were investigating the properties of an unknown substance. They decided to heat the material to study its melting and boiling behavior. They heated a 1-kg sample of the solid material at a steady rate. They measured and recorded the temperature of the sample every 5 minutes.

1. On a sheet of graph paper, make a line graph of the data the group collected.

2. What does the graph tell you about the temperature of the substance at different times during the investigation?

3. Think About It Use the information from the third column of the data table to explain what is happening during the various sections of your graph.

www.TeacherVision.com

SKILLS INTRODUCTION

Creating Circle Graphs

Suppose that you order an eight-slice pizza for yourself and two friends. The illustration below shows how many pieces each person eats.

Charlotte

Natalia

Juan

Natalia

Juan

Natalia

Juan

Natalia
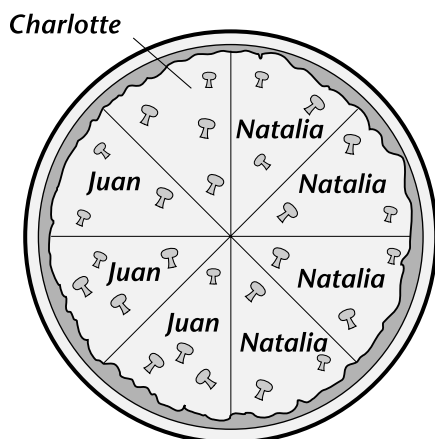
You can change this illustration into a circle graph. A **circle graph** shows data as parts of a whole. The circle represents the whole, or total. The wedges, or segments, represent the parts. Because it resembles a pie cut into slices, a circle graph is sometimes called a pie graph or pie chart.

If you change the pizza illustration into a circle graph, the whole circle will represent the complete pizza. The segments of the graph will show the part of the pizza that each person ate. Look at the data table to see how the number of pieces can be changed into percentages. In a circle graph, all of the parts add up to the total, or 100%.

Amount of Pizza Eaten		
Person	**Number of Pieces**	**Percent of Pizza**
Natalia	4	50%
Juan	3	37.5%
Charlotte	1	12.5%

Charlotte 12.5%

Juan 37.5%

Natalia 50%
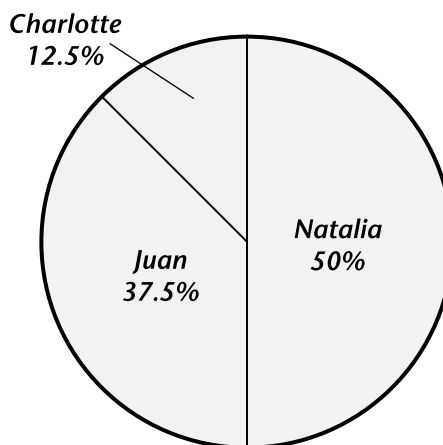
Portion of Pizza Eaten

Like bar graphs, circle graphs can be used to display data in a number of separate categories. Unlike bar graphs, however, circle graphs can be used only when you have data for all the categories that make up the whole.

Creating Circle Graphs *(continued)*

▶ **Tips for Making Circle Graphs**

Kinds of Ads on Children's TV Shows	
Type of Product	**Number of Ads**
Toys	70
Breakfast foods	50
Fast food and drinks	50
Other products	30

1. Organize your data into a table or list. For example, the data table on the right shows information about 200 ads shown on children's TV shows.

2. To find the size of the wedge for each type of product, set up a proportion. Let x equal the number of degrees in that wedge. Then cross-multiply and solve for x. Since there are 360 degrees in a circle, each proportion will read as shown on the right:

$$\frac{\text{Number of ads for product type}}{\text{Total number of ads}} = \frac{x}{360°}$$

For toys: $\quad \dfrac{70}{200} = \dfrac{x}{360°}$

$$70 \times 360° = x \times 200$$

$$\frac{70 \times 360°}{200} = x$$

$$126° = x$$

Number of Ads	70	50	50	30
Size of Wedge	126°	90°	90°	54°

3. Use a compass to draw a circle. Mark the center of the circle. Then use a straightedge to draw a line from the center point to the top of the circle.

4. Use a protractor to measure the angle of the first wedge, using the line you just drew as the 0° line. For example, the wedge for Toys is 126°. Draw a line from the center of the circle to the edge for the angle you measured.

5. Write a label on the wedge to show what it represents. If there is not enough space in the wedge, write the label outside the circle and draw a line to the wedge.

6. Continue around the circle, drawing in and labeling the other wedges. For each new wedge, use the edge of the last wedge as your 0° line.

7. Determine the percentage that each wedge represents by dividing the number of degrees in the wedge by 360°.
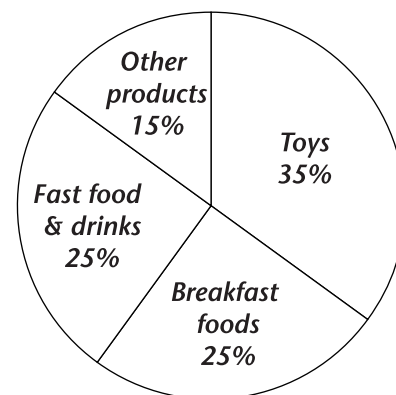
For toys: $\quad \dfrac{126°}{360°} \times 100\% = 35\%$

Kinds of Ads on
Children's TV Shows

☑ *Checkpoint* If you add up the number of degrees in all the wedges of a circle graph, what is the total? If you add up all the percentages, what is the total?

S K I L L S   P R A C T I C E

Creating Circle Graphs

To complete this activity, you will need a compass and a protractor. Use those tools to answer Question 1 on the back of this page or on a separate sheet of paper. Answer the remaining questions in the spaces below.

A middle school class surveyed 500 families who own pets. The data table below shows what kinds of pets the families own. Create a circle graph to display the data.

Kinds of Pets Owned by Families	
Pet	**Number of Families**
Dogs	180
Cats	160
Birds	25
Fish	25
*Other	110

* Includes gerbils, hamsters, rabbits, guinea pigs, and ferrets

1. Make a circle graph to display the data in this table. (*Hint:* You can round off numbers if you wish.)

2. What are some facts you can learn by examining the graph?

_____

_____

_____

3. Think About It Think about the process of creating a circle graph. Why might circle graphs be a less exact way of displaying data than bar graphs?

_____

_____

_____

_____

_____

_____

ANSWER KEY

Designing Experiments

Introduction

Checkpoint: Sample—Scientists want to test a specific variable and control other variables. If the design is right, they can be confident of the results they obtain.

Posing Questions

Introduction

Checkpoint: The second question is scientific. Sample revision: Does handling toads cause warts?

Practice

Note: Student revisions of scientific questions will vary.

1. Yes; Sample—Will some people be able to perform a specific task, such as adding pairs of numbers, more accurately in the morning, while others perform more accurately in the afternoon?
2. no
3. yes
4. yes
5. no
6. no
7. yes
8. yes
9. yes
10. yes
11. Answers will vary. Sample for Question 1: Give people addition quizzes in the morning and afternoon for several days, and compare the two groups of scores.

Developing a Hypothesis

Introduction

Checkpoint: Sample—If a truck carries a load that is equal to 25% of its own weight, it will use more gas than an identical empty truck.

Practice

Note: The story in this activity is based on the fact that the density of drinks with sugar is usually much greater (because there's so much more sugar in the drink) than the density of the same drinks with aspartame.

1. Samples: Maybe the drink has more syrup. Maybe sucrose is heavier than aspartame. Maybe the company puts more bubbles in the diet drink to make it taste better.
2. Samples: Maybe the can that sank is a little larger, or maybe it contains more drink or less air. Maybe one can was damaged.

3. Sample: Maybe the can at the bottom is caught on something.

4. Sample: If you weigh equal volumes of each drink, then the diet drink will weigh less than the regular drink.

5. Sample: If you find the volumes of drink in each can, then there will be less drink in the can that floated.

6. Sample tests: Check the volume of the cans. Weigh the unopened cans, the drinks, or the empty cans. Pour the drinks into graduated cylinders to check their volumes.

7. Sample: List as many different ideas as I can, choose the most sensible one, and then write an "if-then" prediction.

Controlling Variables

Introduction

Checkpoint: You can be sure that the manipulated variable is causing the changes in the responding variable only when you control other variables that might affect the outcome.

Practice

All answers are samples.

1. MV: shape of container; RV: time for water to freeze; CV: amount of water, material of containers, initial temperature of water

2. MV: storage temperature; RV: hours of use after storage; CV: use same kind of batteries, same moisture, same expiration date

3. MV: types of fabric; RV: how long fabric can carry heavy load without tearing; CV: initial condition of fabric, size of fabric tested, load used

4. MV: different brands or types of stain remover; RV: how quickly the stain is removed; CV: same type and size of stain, same amount of stain remover applied, how long stain remover is allowed to work

5. If the lab group didn't control essential variables, they can't know what really caused the results of the strength tests. For example, if they used objects of different masses to test strength, maybe one paper towel tore because they used a more massive object.

Forming Operational Definitions

Introduction

Checkpoint: Sample—Operational definitions tell researchers how to measure specific variables so that they all do it the same way. If they didn't use the same procedures, they could not check each other's work.

Practice

1. Sample: Use a thermometer to be sure the outdoor temperature is 0°C or below.

2. Sample: Measure the height of each plant daily with a metric ruler. After 3 weeks, the tallest plant is the one that grew fastest.

3. Samples: Order by mass; order by length measured from head to tip of tail.

4. Sample: Better drivers are those who did not cause any accidents and or receive traffic tickets in the past year.

5. Sample: Wet both hands completely, lather all parts of the hands with soap, rinse completely, and repeat once more.

6. Sample: For Question 3, a person could easily arrange animals in a list, starting with animals having the most mass and ending with those with the least mass.

Interpreting Data

Introduction

Checkpoint: Yes. The graph shows that the temperature increases regularly with depth, so you could extend the line on the graph and then make the prediction.

Practice

1. The wolf population declined, while the deer population first increased and then dropped dramatically.

2. 75,000 wolves

3. The wolf population declined significantly.

4. about 15,000 deer

5. The deer population increased sharply to about 100,000 in 1925. Then it dropped to about 18,000 in 1935.

6. Answers will vary. Sample: In 1910, there were about five times as many wolves as deer. In 1917, the sizes of the two populations were about equal.

7. As the wolf population declined, the deer population was able to increase because fewer wolves were killing the deer. Then, there was not enough food for all the deer.

8. Answers will vary. The data are consistent with the idea that wolves are hunters that prey upon deer.

9. Answers will vary, but students should start by examining the title and axis labels before trying to interpret the graphed data.

Drawing Conclusions

Introduction

Checkpoint: Samples—No, because the sunlight is different at different times of the year. Yes, the pattern will be the same, but the temperatures will be lower during other seasons.

Practice

All answers are samples.

1. The black can cooled faster than the white can.

2. Olena's hypothesis was false. The color of the containers does have an effect on the rate at which the cans cool, with black cans cooling faster than white cans.

3. Bruce's hypothesis was supported. Black cans containing hot water cool faster than white cans.

4. Black cans containing hot water cool faster than white cans, but after a period of time, they reach the same temperature.

5. Answers will vary, but students should recognize that both researchers learn more about science either way.

Designing an Experiment

Practice

You may wish to arrange students in small groups to help each other improve on their experiment designs, and then discuss selected designs as a whole class.

1–10. Students should follow all the relevant guidelines in their experimental designs.

11. Answers will vary, but might focus on special equipment that would be needed, or long time periods that might be needed to test some hypotheses.

Creating Data Tables

Introduction

Checkpoint: Sample—If you make places in the data table for every observation you plan to make, an empty box is a reminder that you didn't yet record some data.

Practice

1. The light bulb represents the sun and the pans represent bodies of land and water.

2. MV: the different materials in the pans; RV: temperature of the materials

3. She should control any other variables that might affect her results. Example, the pans must start at the same temperature and be placed away from heaters.

4. The table should include the usual elements, including columns for Time, Light Off or On, Water Temperature, and Soil Temperature.

5. Answers may vary. Students should make sure they include a column indicating whether the light was on or off.

Creating Bar Graphs

Note: Bar graphs can be created with the bars running horizontally or vertically. However, many students have difficulty deciding which axis to use for each variable, so this book introduces only one approach. Once your students are adept at graphing, you may want to allow either type of bar graph.

Introduction

Checkpoint: The number of pets; to show separate but related categories

Practice

1. horizontal axis

2. vertical axis 0–12, with spaces large enough to plot points between whole numbers

3. Titles and labels can be taken from the table.

4. The bars for distance will get longer from left to right.

Creating Line Graphs

Introduction

Checkpoint: With some line graphs, you can infer values you did not measure, so you can make predictions about those values.

Practice

1. The graph should have a horizontal line from 20 minutes to 70 minutes.

2. The graph should show that sometimes the temperature increased and at other times it was constant.

3. The solid melts at 0°C, increases temperature until it boils at 100°C, then increases temperature again after it becomes a gas.

Creating Circle Graphs

Introduction

Checkpoint: In all circle graphs, the wedges should add up to 360° and the percentages should add up to 100%.

Practice

1. The circle graph should follow all the rules.

2. Answers will vary. Sample: About one third of the families surveyed own dogs.

3. Answers will vary. Sample: You may need to round numbers when calculating percents and degrees.

Test A: Basic Process Skills

1. O

2. I

3. O

4. O

5. b

6. a

7. a

8. b

9. b

10. b

11. Answers will vary, but the two groups must fit the definition accurately.

12. Answers will vary, but they must include two correct levels of classification.

13. two

14. scale

15. Yes. With two people sitting on the ends, each of the two people sitting at the corners don't have enough room for their dish, glass, and utensils.

16. Sample: The models helped Marcia make sure that she left enough space for every chair and table setting.

17. About 67 mL

18. 78 mL

19. d

20. a

21. g

22. f

23. b

24. e

25. c

Test B: Measuring and Calculating

1. 5.8 cm

2. 4.3 cm

3. 1.5 cm

4. 58 mm

5. 43 mm

6. 6.2 mL

7. 35 mL

8. 74 mL

9. 12 cm^2

10. 40 cm^3

11. 75 mL

12. 25 mL

13. 167.5 g

14. 153 g

15. 17°C

16. 63°C

17. 6°C

18. 36.9°C

19. -3°C

20. 4°C

21. 11°C

22. 34,000 g

23. 3,000 cm

24. 0.25 L

25. 4.5 km

Test C: Designing Experiments

1. e

2. a

3. i

4. g

5. c

6. j

7. b

8. h

9. l

10. f

11. L

12. H

13. E

14. C, K

15. G

16. A, J

17. I

18. F

19. B, D

20. M

21. c

22. d

23. c

24. c

25. a

Test D: Data Tables and Graphs

1. bar graph

2. line graph

3. circle graph

4. data table

5. line graph

6–7. Creating Data Tables Tables for organizing the data should resemble the ones that follow. (*Note:* Data on p. 83 are presented in an inconsistent manner typical of student notes.)

Weather Conditions for September 4 – September 9			
Date	High (°C)	Low (°C)	Conditions
9/4	28	18	Partly cloudy
9/5	27	20	Sunny
9/6	26	20	Sunny
9/7	23	19	Partly cloudy
9/8	29	21	Thunder-storms
9/9	28	23	Sunny

| Heart Rate vs. Exercise			
	Heart Rates (beats per minute)		
Person	Sitting	Walking	Jumping Jacks
Carla			
Mike			
Una			

Partial credit could be given as follows:

(6 points) Using the manipulated and responding variables for column and/or row heads.

(2 points) Using appropriate units in heads.

(2 points) Giving the table an appropriate title.

8. Creating Circle Graphs The completed circle graph should resemble the one below.

Energy Sources in Pleasantville
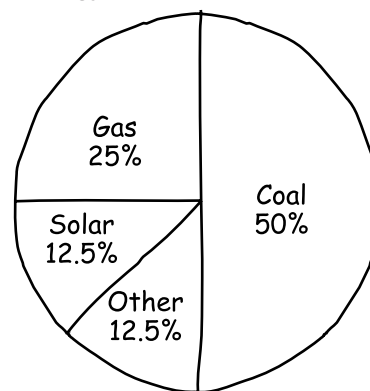
Partial credit could be given as follows:

(6 points) Calculating the correct number of degrees in each wedge.

(6 points) Estimating and drawing the wedges on the circle template.

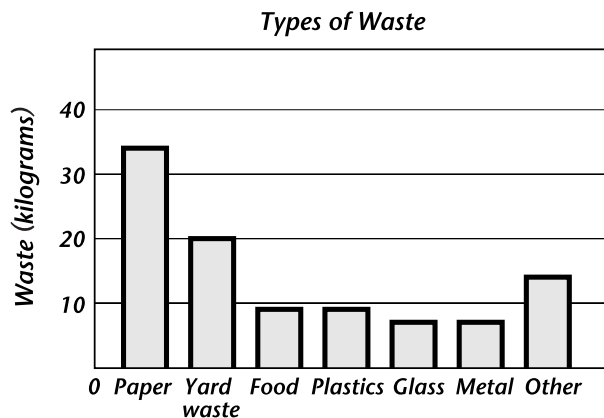**(6 points)** Converting numbers into correct percents.

(1 point) Label each wedge with the correct category.

(1 point) Using an appropriate title.

ANSWER KEY

9. **Creating Bar Graphs** The completed bar graph should resemble the one below.

Types of Waste

Partial credit could be given as follows:

(4 points) Drawing horizontal and vertical axes.

(5 points) Choosing and labeling categories for each axis.

(5 points) Determining an appropriate, uniform scale, such that all values can be represented on the graph and that each square has the same value.

(5 points) Labeling the amount scale at regular intervals along one axis.

(1 point) Writing a title for the graph.

10. **Creating Line Graphs** The completed line graph should resemble the one at the bottom of the page.

Partial credit could be given as follows:

(2 points) Drawing horizontal and vertical axes.

(3 points) Labeling the horizontal, or *x*, axis with the name of the manipulated variable and labeling the vertical, or *y*, axis with the name of the responding variable.

(3 points) Creating scales for the graph such that the scales cover the entire range of the data collected for each variable.

(2 points) Marking off equally spaced intervals along each axis.

(2 points) Labeling each scale such that each begins with 0 or a number that is slightly less than the smallest number to be graphed.

(3 points) Correctly plotting each point.

(1 point) Connecting the plotted points.

(1 point) Giving the graph an appropriate title.

(3 points) Extrapolating from the graph that the lava will reach the neighborhood in about 8 minutes.

Lava Flow vs. Time