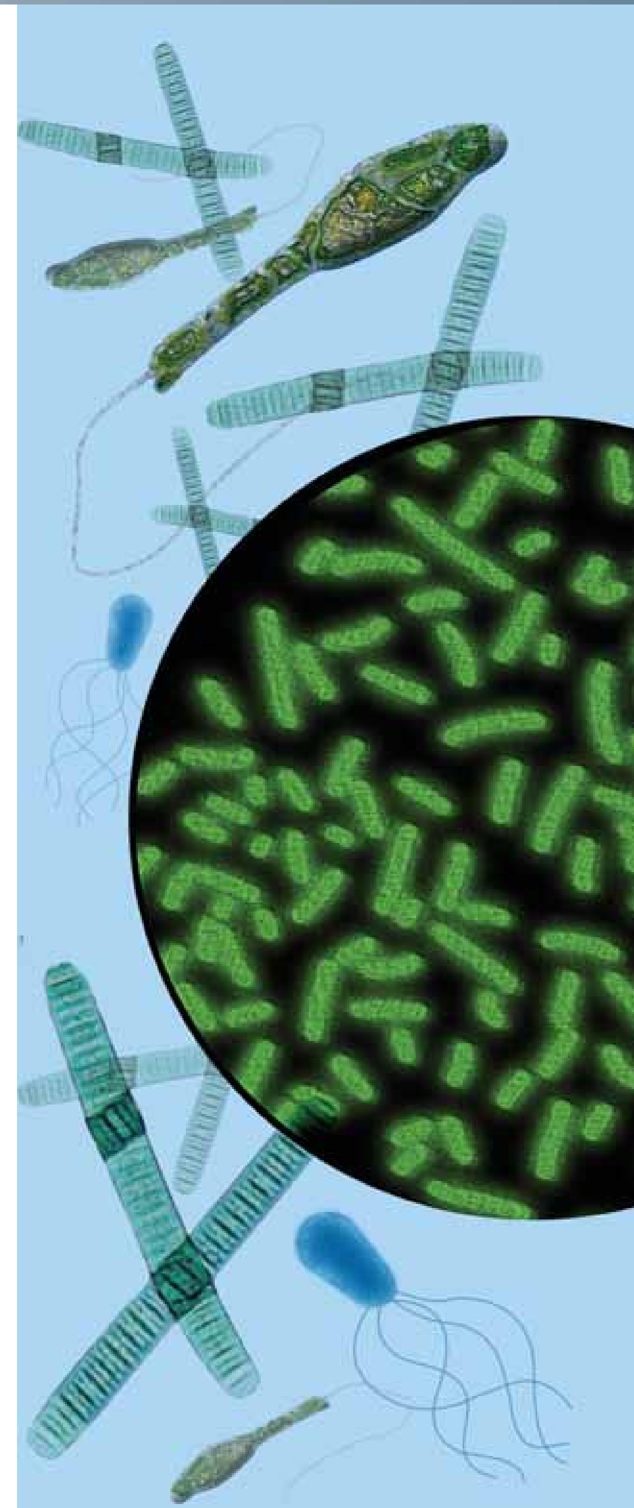
# Chapter 1
# *Studying Life*

Earth is a living planet. Life can be found in places where you least expect it! Tiny living things can be found in the extremely hot openings of undersea volcanoes, and even in hot springs full of acid. Scientists from the University of Colorado have studied tiny organisms that survived for twenty years at the bottom of a dry stream bed in cold Antarctica. When water finally reached them, the organisms sprang to life after only one day, and within a week, an entire community had formed! Researchers wonder if these tough life forms could even exist on the cold, dry surface of Mars. In this chapter you will begin studying life science, a fascinating and sometimes surprising subject.

## Key Questions

1. ***How do you measure the world's largest living thing?***
2. ***Can mud turn into worms?***
3. ***How do you study living things?***



## 1.1 Measurements

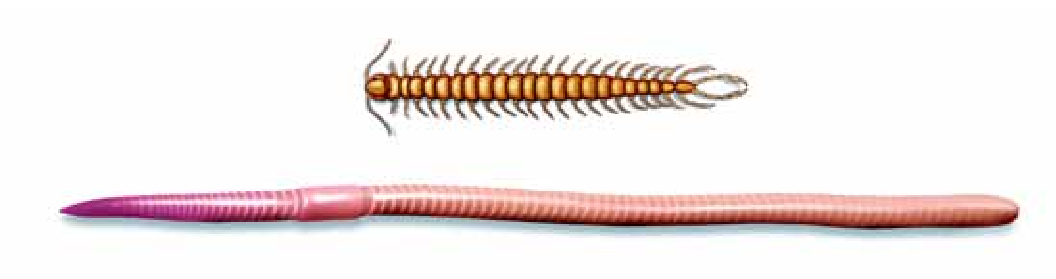
What may be the largest living thing on Earth was discovered in a forest in Oregon. A fungus, known as the honey mushroom, lives 3 feet underground and covers 10 square kilometers (over 1,000 football fields) of the forest floor. Small mushrooms visible above the ground are only a tiny part of this humongous fungus (Figure 1.1). When scientists study living things, they often take measurements like *length* and *mass*. In this section, you will learn about different measurements used by scientists.

**Figure 1.1:** *These small mushrooms are only a tiny part of the giant fungus that lives underground.*

### Measurement and units

**Measurements** A **measurement** is a value that tells the amount of something. A measurement has a *quantity* and a *unit*. For example, 5 centimeters is a measurement because it has a quantity, 5, and a unit, centimeters.

**Units** A **unit** is a fixed amount of something. If you asked someone to walk 5, she would not know how far to go. The units you could use include 5 feet, 5 meters, 5 miles, and 5 kilometers. The centipede in the picture below is 5 centimeters in length. The earthworm is 5 inches in length. Which is a larger unit, centimeters or inches?



**VOCABULARY**

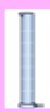
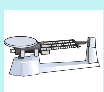
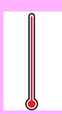
**measurement** - a value that tells the amount of something.

**unit** - a fixed amount of something.

## The International System of Measurement (SI)

Units allow people to communicate amounts. To make sure their measurements are accurate, scientists use a set of standard units that have been agreed upon around the world. Table 1.1 shows the units in the International System of Measurement, known as the SI.

***Table 1.1: Common SI Units***

| Quantity | Unit | Value |
|---|---|---|
| **Length**  | **meter (m)**<br>kilometer (km)<br>decimeter (dm)<br>centimeter (cm)<br>millimeter (mm)<br>micrometer (µm)<br>nanometer (nm) | 1 km = 1,000 m<br>1 dm = 0.1 m<br>1 cm = 0.01 m<br>1 mm = 0.001 m<br>1 µm = 0.000001 m<br>1 nm = 0.000000001 m |
| **Volume**  | **cubic meter ($m^3$)**<br>cubic centimeter ($cm^3$)<br>liter (L)<br>milliliter (mL) | 1 $cm^3$ = 0.000001 $m^3$<br>1 L = 0.001 $m^3$<br>1 mL = 0.001 L |
| **Mass**  | kilogram (kg)<br>gram (g)<br>milligram (mg) | 1 g = 0.001 kg<br>1 mg = 0.000001 kg |
| **Temperature**  | Kelvin (K)<br>Celsius (°C) | 0°C = 273 K<br>100°C = 373 K |

**SOLVE IT!**

The United States uses the English system of measurement. This system uses miles, yards, feet, and inches for length. Conversion factors are useful in converting from English to SI and back again. For example,
1 inch = 2.54 cm.
Use this conversion factor to solve the following problems. The first one is done for you.

1. 10 in. × (2.54 cm/1 in.) = 25.4 cm.
2. 0.50 in. = _____ cm
3. 300 cm = _____ in.
4. 1 m = _____ in.
5. 2 km = _____ in.

## Length and area

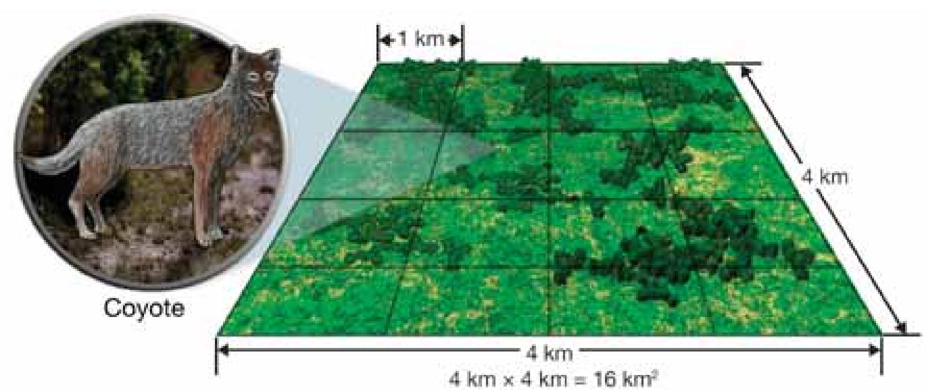
**Measuring length**

**Length** is a measurement of distance. Life scientists measure the length of a living thing along its *greatest* dimension. Figure 1.2 shows a scale that compares the lengths of different living things and the appropriate SI unit to measure each.

What is the length of the fish below? If you measured it to be 10.5 cm, you are correct!

**Measuring area**

**Area** is a measurement of how much surface something has. A coyote occupies a certain area of land called its *territory*. A coyote's territory is about 16 square kilometers ($km^2$). While this area probably has an irregular shape, if a coyote's territory was a perfect square, you could measure the area as shown below.




### VOCABULARY

**length** - a measurement of distance.

**area** - a measurement of how much surface something has.

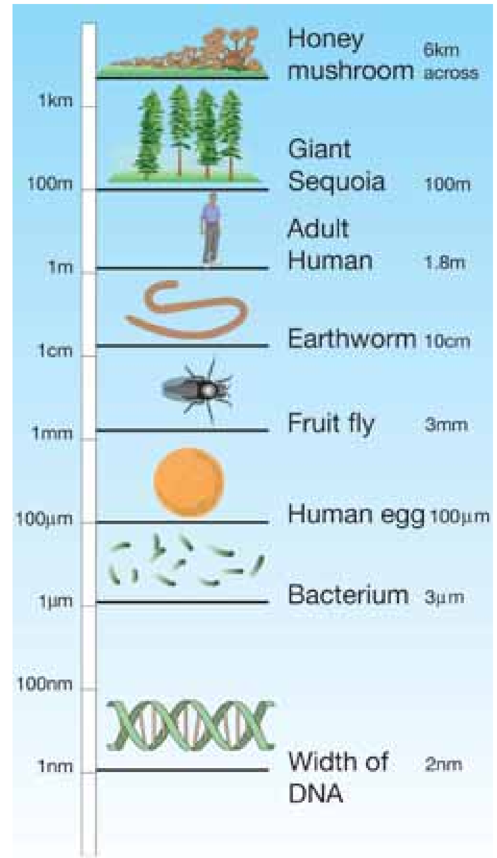



**Figure 1.2:** *Comparing the size of living things and compounds.*

## Volume

**What is volume?** **Volume** is a measurement of the amount of space something occupies. The volume of a solid object is usually measured in cubic meters ($m^3$) or cubic centimeters ($cm^3$). To find the volume of an aquarium, multiply length × width × height as shown below.


**VOCABULARY**

**volume** - a measurement of the amount of space something occupies.

**Measuring the volume of liquids** The volume of a liquid is usually measured in liters (L) or milliliters (mL). One milliliter is equal to one cubic centimeter. Measuring the volume of liquid matter is easy. You simply pour it into a marked container such as a measuring cup, graduated cylinder, or beaker, and read the volume mark. To get the greatest accuracy, there are two things to keep in mind. First, read the mark at eye level. Second, you may notice that the surface of the liquid forms a curve rather than a straight line. That curve is called a *meniscus*. If the meniscus curves downward, (liquid water does this) read the volume at the bottom of the curve as shown in Figure 1.3. A few liquids, like mercury, will form an upward curve. In this case, read the volume mark at the top of the curve.

***1 milliliter (mL) = 1 cubic centimeter ($cm^3$)***

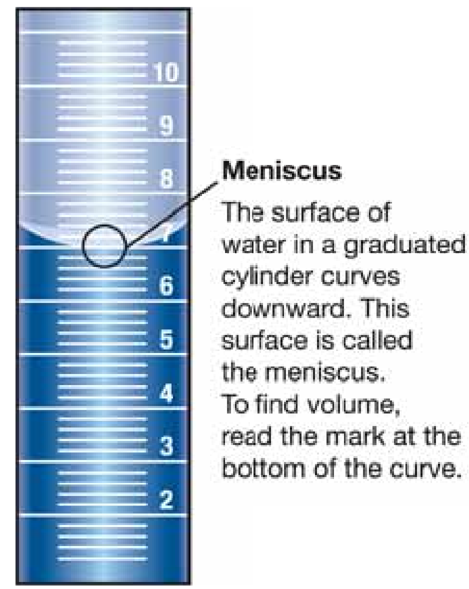
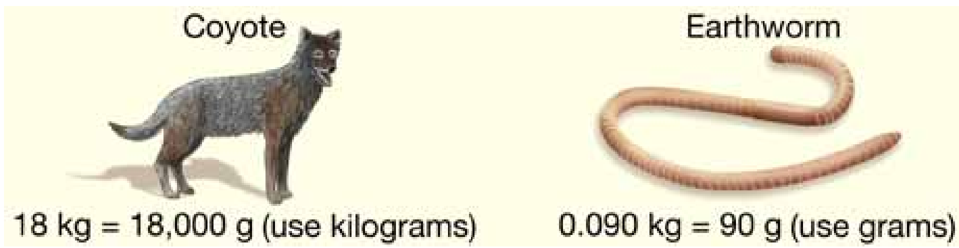



**Figure 1.3:** *The surface of water curves downward. Read the mark at the bottom of the curve.*

## Mass and temperature

**Matter and mass** Everything around you is made of matter and has mass. **Matter** is defined as anything that has mass and takes up space. You are matter and so is air. **Mass** is the measure of the amount of matter that makes up something. The kilogram (kg) is the basic unit for mass. A typical coyote has a mass of about 18 kg.

**Use grams for small living things** There are 1,000 grams in 1 kilogram. The average mass of an earthworm is about 90 grams. This is equal to 0.090 kilograms. Do you see why it's easier to use grams with smaller living things?




**What is temperature?** Most living things can only survive within a certain range of temperatures. For example, corals grow best in waters with a temperature of between 21 and 29 degrees Celsius. **Temperature** is a measure of how hot or cold something is. It has to do with the average motion of the tiny particles (atoms and molecules) that make up matter. As those particles move faster on average, the temperature goes up. As they move slower on average, the temperature goes down.

**Temperature scales** You are most familiar with the Fahrenheit temperature scale (°F). Scientists use the Celsius scale (°C) and Kelvins (K) to describe temperature. In this book, we will use the Celsius scale. Figure 1.4 shows a comparison between the Fahrenheit and Celsius scales.

**VOCABULARY**

**matter** - anything that has mass and takes up space.

**mass** - a measure of the amount of matter that makes up something.

**temperature** - a measure of how hot or cold something is.

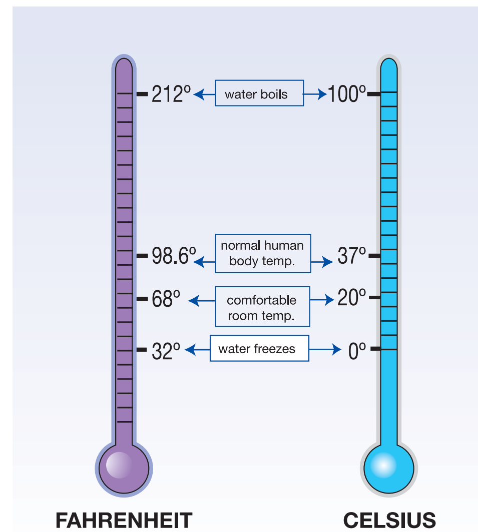



**Figure 1.4:** *The Fahrenheit and Celsius temperature scales.*

## Solutions

**Most of Earth's water is in the form of a solution**

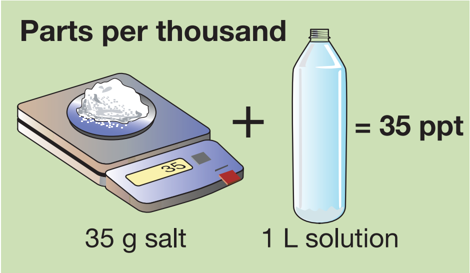
All life depends on water. It's a good thing 70 percent of Earth's surface is covered with it! Almost all of that water exists in solutions. A **solution** is a mixture of two or more substances that are evenly distributed at the molecular level.

**A solution has two parts**

A solution has two parts. The *solvent* is the part of a solution that dissolves another other part called the *solute* (Figure 1.5). Seawater (water found in the oceans) is a solution made of water (the solvent) and dissolved salts (the solute). Spring water is a solution made of water and dissolved minerals. Air is a solution in which nitrogen is the solvent and other gases like oxygen, carbon dioxide, and water vapor are the solutes.

**Measuring concentration**

Scientists use units of *concentration* when measuring levels of dissolved substances in water. A unit of concentration used in studying living things is called *parts per thousand* (ppt). Parts per thousand means that there is 1 part of a solute dissolved in 1,000 parts of a solution. In metric units, parts per thousand is equal to grams of a solute per liter of solution. For example, the concentration of salt in the ocean is 35 parts per thousand. This means that there are 35 grams of salt (the solute) dissolved in every liter of water (the solvent).




**VOCABULARY**

**solution** - a mixture of two or more substances that are evenly distributed at the molecular level.

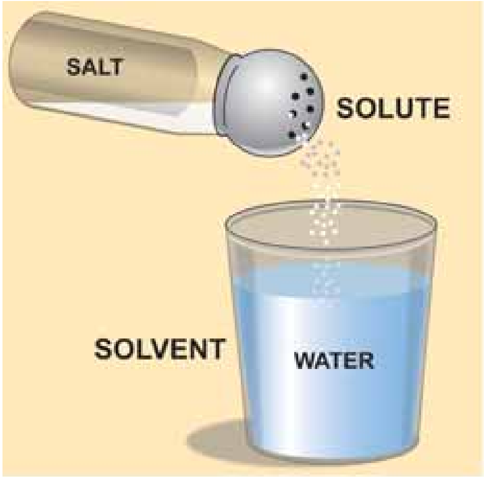
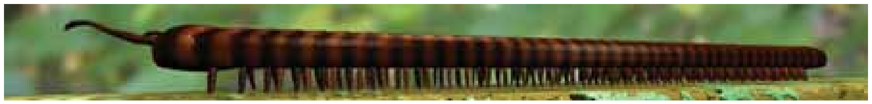


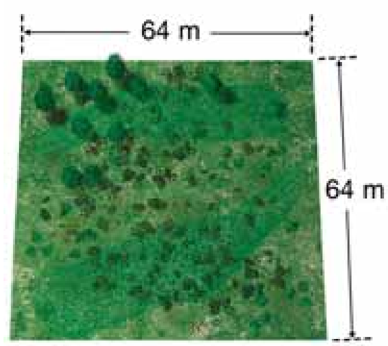

**Figure 1.5:** *Solutions are made when solutes dissolve in solvents. Here, salt is the solute, and water is the solvent.*

## 1.1 Section Review

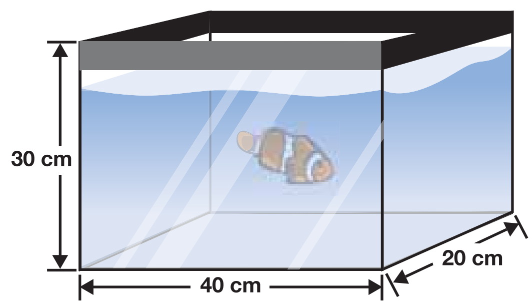
1. Measure the length of the millipede below. Give your answer in meters, centimeters, and millimeters. Which is the best unit to describe its length?



2. An acre of land measures 64 meters by 64 meters. What is the area of an acre of land in square meters?




3. What is the volume of the fish tank (right) in $cm^3$? Given that one $cm^3$ equals one mL, what is the volume of the tank in liters?




4. A marine aquarium is found to contain a salt concentration of 40 ppt. How may grams of salt are in one liter of the solution?

**CHALLENGE**

**Metric conversions**

1. A graduated cylinder contains 50 mL of water. After a marble was added, the volume of the graduated cylinder was 75 mL. What is the volume of the marble? (HINT: 1 mL = 1 $cm^3$)
2. A beetle measure 1 cm across. What is the measurement in millimeters?
3. An aquarium has a volume of 0.45 $m^3$. What is its volume in liters?
4. To convert between degrees Celsius and degrees Fahrenheit, use the following relationships:

   $°C = (°F - 32) \times 0.56$
   $°F = (1.8 \times °C) + 32$

   Convert the following temperatures:

   a. 80°F = ____°C
   b. 32°F = ____°C
   c. 98°C = ____°F
   d. 21°C = ____°F

# 1.2 Thinking Like a Scientist

*Science* is a process of thinking and learning about the world around us. There are many fields of science, each dealing with a different part of our world. For example, the study of matter is called chemistry. The study of outer space is called astronomy. The study of life is called **biology**, and is the subject of this course. How do we go about studying life? In this section, you will learn how to think like a scientist.

**VOCABULARY**

**biology** - the study of life.

**scientific method** - a process used by scientists to find the answers to questions.

## The scientific method

**Worms from mud?** Last spring, heavy rains turned the soil in Maria's backyard into mud. Maria noticed many worms crawling on top of the mud that weren't there before (Figure 1.6). Did she conclude that the worms were made from the mud? Of course not! It is common scientific knowledge that nonliving objects (like mud) cannot turn into living things (like worms). But hundreds of years ago, people actually thought that simple living things like worms and beetles came from nonliving things like mud, dirt, and spoiled food.

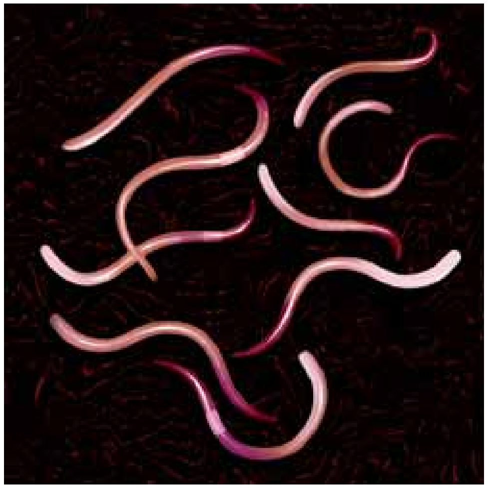


**Figure 1.6:** *Can mud turn into worms?*

**The scientific method** We often take scientific knowledge for granted even though it is the result of the work of many scientists over many years. The **scientific method** is a process used by scientists to answer questions like, "Can a nonliving object turn into a living thing?" It involves asking questions, developing explanations, and testing those explanations to see if they are correct. You can think of the scientific method as an organized way of asking and answering questions.

**Untested observations** The explanation that nonliving objects can give rise to living things was based on untested observations. When scientists started using the scientific method (in the 1600s), they eventually disproved this idea.

## Steps to the scientific method

**Back to the worms**

Even though Maria knew that worms couldn't possibly come from mud, she wondered why they appeared after a heavy rain and weren't seen when it was dry. She had an idea that the worms came to the surface so they wouldn't drown in the wet mud and that they preferred to live underground in moist soil. How could she prove her idea?

**Steps to the scientific method**

Like a scientist, Maria decided to follow the scientific method to try and prove her ideas. While scientists don't always follow the exact same path toward finding answers, it is useful to show the scientific method as a series of steps. The table below shows the steps along with Maria's example.

*Table 1.2: Steps to the scientific method*

| | |
|---|---|
| **1. Make observations or research something.** | Maria noticed worms on the surface of the mud after a heavy rain. |
| **2. Ask a question or state a problem.** | Why do worms come to the surface after a heavy rain? |
| **3. State a hypothesis.** | Worms come to the surface after a heavy rain so they won't drown in wet mud. |
| **4. Test the hypothesis with an experiment.** | Maria set up two tanks. She put 20 worms into each tank. Then she put normal soil into one tank and wet mud into the other. She left both tanks in a window for the day. |
| **5. Draw conclusions based on the test.** | Seventeen of the worms in the wet mud came to the surface while all 20 worms in the other tank stayed under the soil. Maria concluded that worms do not like to stay under wet mud. |

**The hypothesis**

A **hypothesis** is a possible explanation that can be tested with an experiment. A hypothesis is based on observation, prior knowledge, or the results of other experiments.

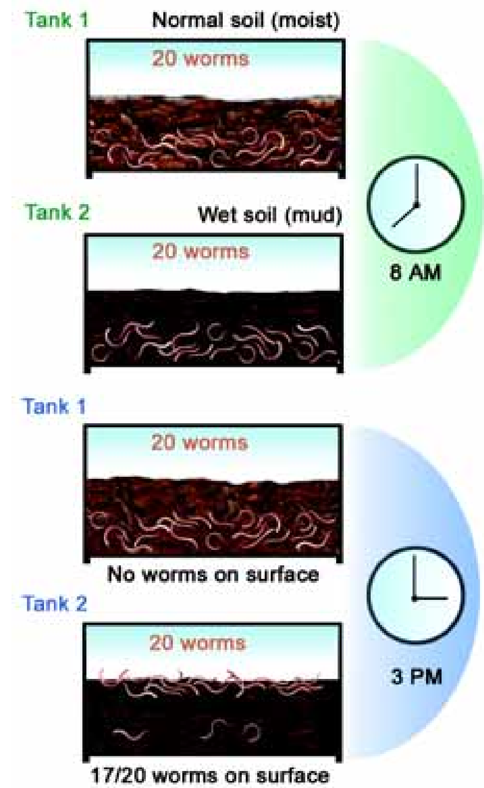



**Figure 1.7:** *Maria's experiment*

**VOCABULARY**

**hypothesis** - a possible explanation that can be tested with an experiment.

## Designing experiments

**Experiments and systems**

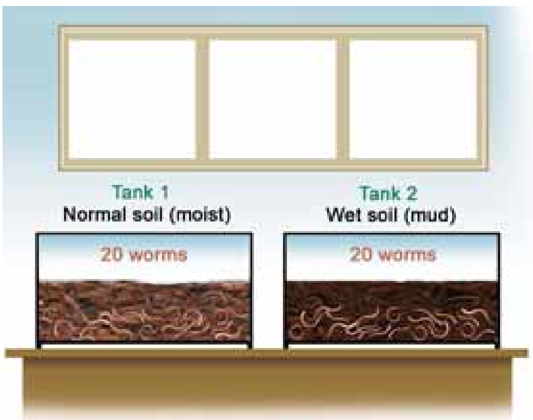
An **experiment** is a controlled test to determine if a hypothesis is supported or refuted. An experiment is designed around a system. A **system** is a group of factors that are related in some way. You choose the system to include the factors you wish to investigate and exclude the factors you think are not important.

**Variables**

A **variable** is a factor that affects how a system works. When designing an experiment, you identify the important variables in the system and change only one variable. You change the variable you want to investigate and keep all of the other variables the same. The variable you change is called the **experimental variable**. The variables you keep the same are called **control variables**.

**Maria's experiment**

When Maria designed her worm experiment, she created a smaller *model* of the system she was studying (her backyard). Her model did not include many of the variables found in her backyard such as plants or other animals. Because of her hypothesis, Maria chose the wetness of the soil as her experimental variable. Her control variables were temperature, light, kind of soil, number of worms, type of worms, and time.




Experimental Variable: Wetness of soil
Tank 1: Normal soil (moist)
Tank 2: Wet soil (mud)
Control variables: same for both tanks

| | |
|---|---|
| Temperature | 21°C (11 AM temp) |
| Light | Window |
| Kind of soil | Soil from back yard |
| Type of worm | Earthworms |
| No. of worms | 20 |
| Time | 7 hours |

### VOCABULARY

**experiment** - a controlled test to determine if a hypothesis is supported or refuted.

**system** - a group of objects, effects, and variables that are related.

**variable** - a factor that affects how a system works.

**experimental variable** - the variable you change in an experiment.

**control variables** - the variables you keep the same in an experiment.

## Data and conclusions

**Multiple trials** Scientists do the exact same experiment many times to make sure their results are valid. Each time you do the same experiment, it is called a *trial*. The results of an experiment are valid only if you get similar results from each trial. Maria conducted four trials of the same experiment. Her data are shown in Figure 1.8.

**Presenting your data** It is important to organize your data so that it can be analyzed and presented. You can organize data into tables, charts, and graphs. Maria put her data into a *bar graph* as shown in Figure 1.9. Which is easier to understand, the table in Figure 1.8 or the bar graph in Figure 1.9?

**Drawing conclusions** After analyzing the data, you should be able to state whether your hypothesis is correct, partially correct, or incorrect. When the data does not support the hypothesis, scientists try to find another explanation for what they observed. Sometimes finding out that a hypothesis is wrong is just as helpful as finding out that it's correct. The results help scientists make another hypothesis and design another experiment. Eventually, they get closer to a correct hypothesis. Does Maria's data support her hypothesis?

**Communicating your results** A *lab report* is a good way to communicate the results of an experiment to others. It should contain your research question, hypothesis, experiment procedures and data, and your conclusion. If you give an oral report to your class, colorful charts and graphs are a good way to show your data. This is the same way scientists present the results of their experiments to other scientists.

**Data from worm experiment:**

| | Number of worms on surface | |
|---|---|---|
| Trial | Tank 1 | Tank 2 |
| 1 | 1 | 14 |
| 2 | 3 | 16 |
| 3 | 2 | 17 |
| 4 | 1 | 18 |

**Figure 1.8:** *Maria's data from four trials.*

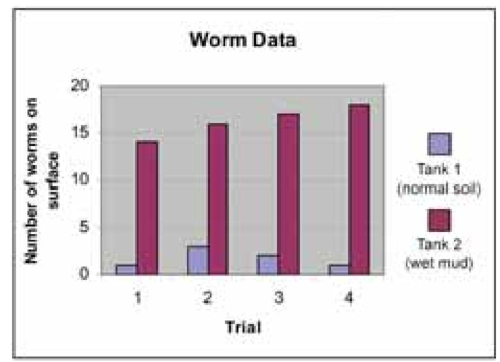


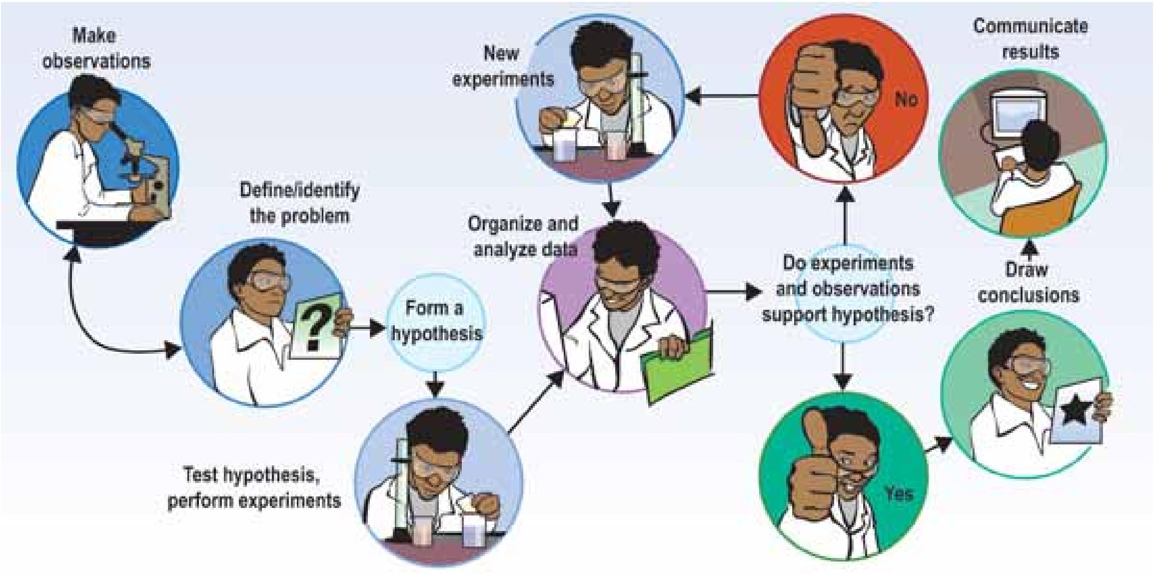

**Figure 1.9:** *A bar graph of Maria's data.*

## Science is an ongoing process

**Theories** When repeated experiments confirm a hypothesis, scientists usually accept it as valid. When repeated experiments support one or more *related* hypotheses, a new theory may develop. A **theory** is an explanation of how a natural process or event is thought to occur. In science, a group of hypotheses becomes a theory only after repeated experiments and observations with similar results.

**Theories can change** In science, no theory is accepted as the absolute truth. Theories often change as more experiments are done. The invention of new technology such as microscopes also leads to changes in theories and the development of entirely new theories. You should think of a theory as the best explanation for something that scientists have come up with to date. But if you wait long enough, it may change!

As you can see, the scientific method is an ongoing process. The diagram below shows how the process often works.




**VOCABULARY**

**theory** - an explanation of how a process or event is thought to occur.

**STUDY SKILLS**

A *mnemonic* is a device used as an aid in remembering. You may be familiar with a mnemonic used to remember the names of the planets, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Here is an example:

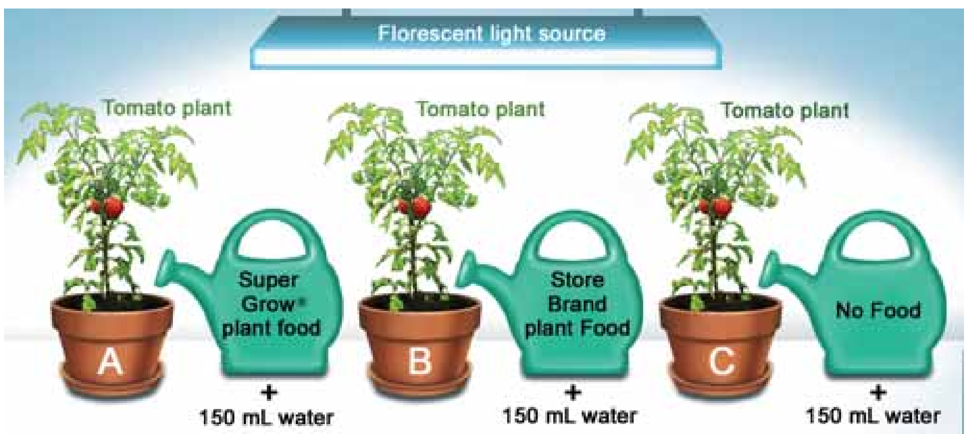
My Very Eager Mother Just Served Us Nectarines

Make up a mnemonic to remember the process of the scientific method. Use the first letter from each step in your mnemonic.

**O**bservations
**Q**uestion
**H**ypothesis
**E**xperiment
**A**nalyze results
**C**onclusions
**C**ommunicate

## 1.2 Section Review

1. Write a hypothesis for the following question: "When a plant is placed near a window, why does it lean and grow toward the window?"
2. A good hypothesis can be tested with an experiment. Which of the following statements is the best hypothesis? Explain your answer.
   a. There were many students absent from class today.
   b. Many students were absent today because the flu is going around.
3. Explain how you would test the hypothesis you chose in the question above.
4. Use the illustration of an experiment below to answer questions a, b, and c.




   a. What is the experimental variable?
   b. What are the control variables?
   c. Write a hypothesis that the experiment could be designed to test.

**CHALLENGE**

In the 1600s, people believed that living things could come from nonliving objects. For example, unrefrigerated meat eventually becomes full of maggots. People living in the 1600s thought the meat actually turned into maggots. In 1668, Francisco Redi, an Italian physician, did an experiment with flies and jars containing meat. His experiment showed that meat does not turn into maggots. This may have been the first controlled experiment!

1. Design an experiment to test the hypothesis that meat does not turn into maggots. Sketch your design and list the experimental and control variables.
2. Present your experiment and results to your class. You could even give your presentation as if it were 1668.

# 1.3 Graphs

A **graph** is a visual way to organize data. Scientists sometimes use graphs to see how changing one variable affects another variable. Graphs are also useful for making comparisons between different sets of data. In this section, you will learn about the types of graphs and how to make a line graph.

**VOCABULARY**

**graph** - a visual way to represent data.

## Types of graphs

**A graph is a picture** A graph is a picture that shows how variables are related. Graphs are easier to read than tables of numbers, so they are often used to analyze data collected during an experiment.

**Types of graphs** Some types of graphs are line, bar, and pie graphs. A *line graph* is used when one variable causes a second variable to increase or decrease in value. For example, the more gas you put in a car, the farther it travels (Graph A). A *bar graph* compares categories of information (Graph B). A *pie graph* is a circular graph that compares categories of information. The data are usually written in percentages.

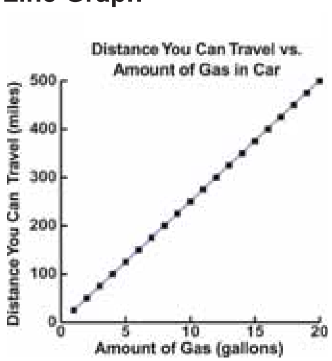
**MY JOURNAL**

Graph C (left) shows how a student spends her time during 24 hours. Answer the following questions about Graph C:

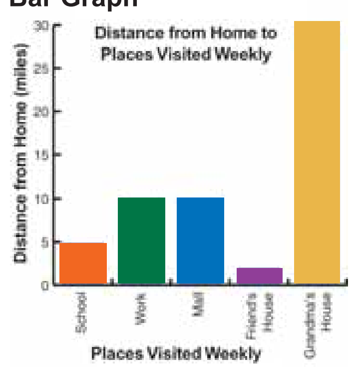
- What percentage of time is spent with after school activities?
- What would the graph look like if the student spent half of her day in school and the other half asleep?

Make a pie graph of how you spent your day. Draw your pie graph in your journal and use colored pencils for each segment.

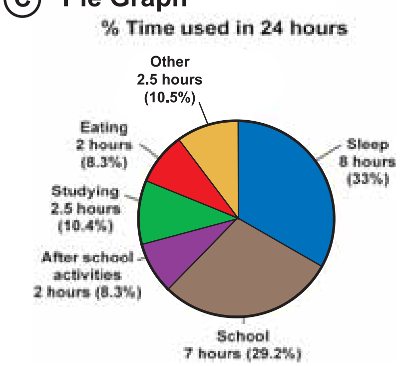
Ⓐ Line Graph




Ⓑ Bar Graph




Ⓒ Pie Graph



## Making a line graph

**Independent and dependent variables**

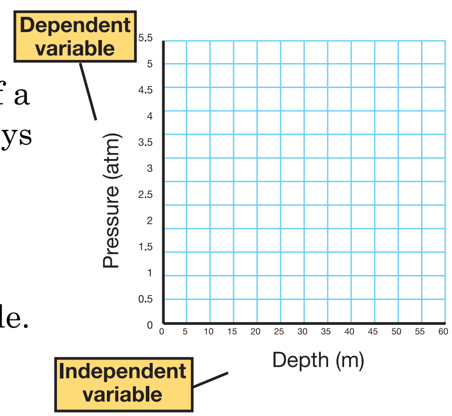
A line graph shows how a change in one variable influences another variable. The **independent variable** is the variable you believe might influence another variable. It is often controlled by the experimenter. The **dependent variable** is the variable that may be influenced by the independent variable. The following example illustrates how to graph variables.

**An example**

As a scuba diver goes deeper under water, she has to think about pressure. How does an increase in depth affect the pressure? Pressure is measured in units of *atmospheres*. You live at Earth's surface under a pressure of 1 atmosphere. Figure 1.10 shows depth and pressure data. A graph can help you visualize the relationship between the depth of water and pressure.

**Step 1: choose x- and y-axis**

Depth is the independent variable because we are interested in how it affects pressure. The independent variable always goes on the $x$-axis of a graph. The dependent variable always goes on the $y$-axis. In this example, pressure is the dependent variable.




**Step 2: make a scale**

To create a scale for a depth versus pressure graph, you first make a scale. The word *scale* refers to size of something. When talking about a graph, scale refers to how each axis is divided up to fit the range of data values. Use the formula below to make a scale for any graph.

**Data range ÷ number of boxes on the axis = value per box**

**VOCABULARY**

**independent variable** - a variable that you believe might influence another variable. The independent variable is sometimes called the *manipulated variable*.

**dependent variable** - the variable that you believe is influenced by the independent variable. The dependent variable is sometimes called the *responding variable*.

| Depth (m) | Pressure (atm.) |
|---|---|
| 0 | 1.0 |
| 5 | 1.5 |
| 10 | 2.0 |
| 15 | 2.5 |
| 20 | 3.0 |
| 25 | 3.5 |
| 30 | 4.0 |
| 35 | 4.5 |
| 40 | 5.0 |

**Figure 1.10:** *Depth of the ocean and pressure data.*

Suppose your graph has 12 boxes on each axis. Figure 1.11 shows how you would create a scale for the *x*-axis. Figure 1.11 also shows how you would create a scale y-axis of the graph for depth and pressure.

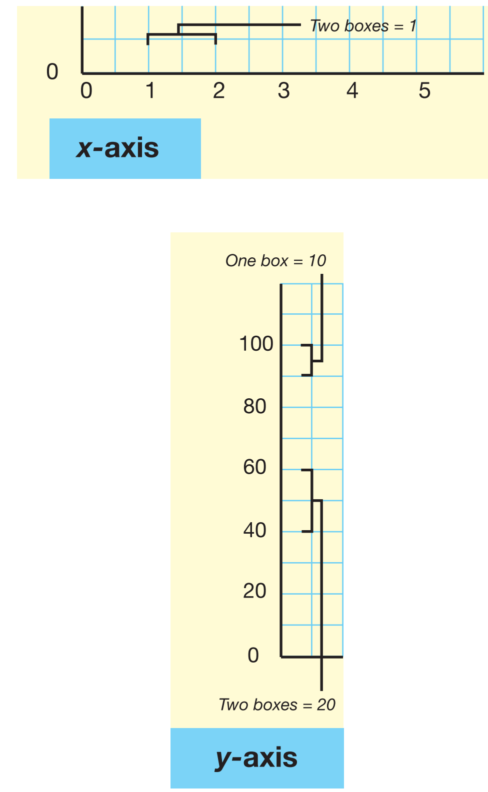
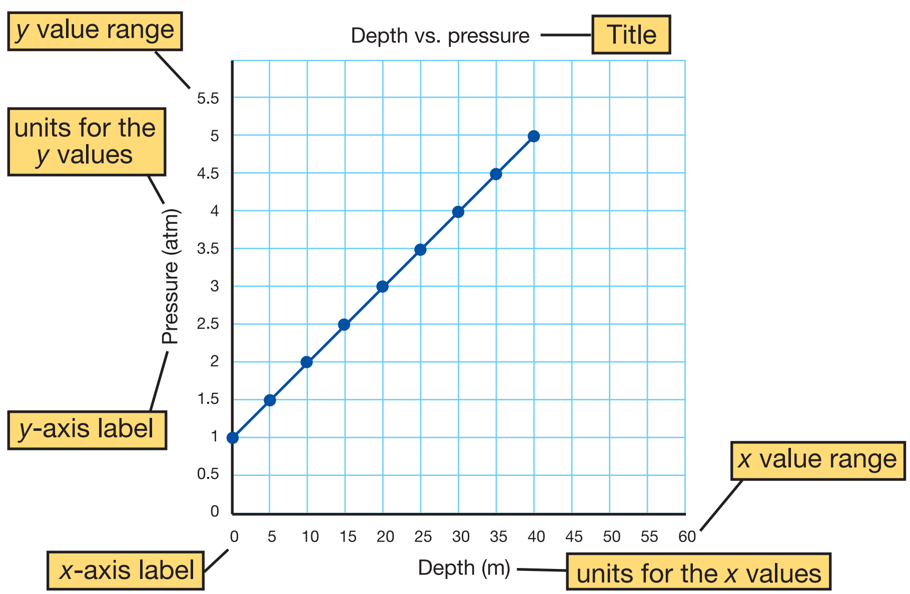



**Figure 1.11:** *How to make a scale for the x- and y-axes for the depth and pressure data.*

**Step 3: plot your data**

Plot each point by finding the *x*-value and tracing the graph upward until you get to the right *y*-value. Make a dot for each point. Draw a smooth curve that shows the pattern of the points (shown below).




**Step 4: create a title**

Create a title for your graph. Also, be sure to label each axis and show units (shown above).

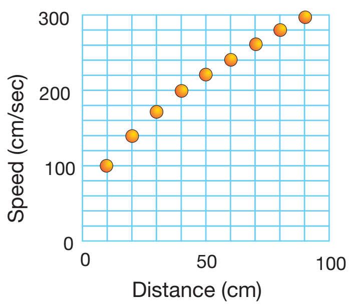
Do you see a relationship between the variables? The next page explains how to recognize relationships on a graph. Read the next page, then see if you can explain what type of relationship is shown in the graph above.

## Identifying relationships between variables on a graph

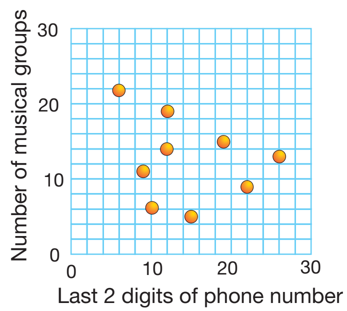
**Patterns indicate relationships** When there is a relationship between the variables the graph shows a clear pattern. The speed and distance variables below show a direct relationship. In a **direct relationship**, when one variable increases, so does the other. When there is no relationship the graph looks like a collection of dots. No pattern appears. The number of musical groups a student listed in one minute and the last two digits of his or her phone number are an example of two variables that are not related.

**Strong Relationship between Variables**

| Distance (cm) | Speed (cm/sec) |
|---|---|
| 10 | 99 |
| 20 | 140 |
| 30 | 171 |
| 40 | 198 |
| 50 | 221 |
| 60 | 242 |
| 70 | 262 |
| 80 | 280 |
| 90 | 297 |




**No Relationship between Variables**




| # of groups | Last 2 digits |
|---|---|
| 10 | 6 |
| 15 | 5 |
| 19 | 15 |
| 6 | 22 |
| 22 | 9 |
| 9 | 11 |
| 26 | 13 |
| 12 | 14 |
| 11 | 19 |

**Inverse relationships** Some relationships are inverse. In an **inverse relationship**, when one variable increases, the other decreases. If you graph how much money you spend against how much you have left, you see an inverse relationship. The more you spend, the less you have. Graphs of inverse relationships always slope down to the right (Figure 1.12).

Describe the relationship in the depth versus pressure graph on the previous page. Did you know that life can exist even under the extreme pressures at the bottom of the ocean?

**VOCABULARY**

**direct relationship** - a relationship in which one variable increases with an increase in another variable.

**inverse relationship** - a relationship in which one variable decreases when another variable increases.

**Inverse Relationship Between Variables**

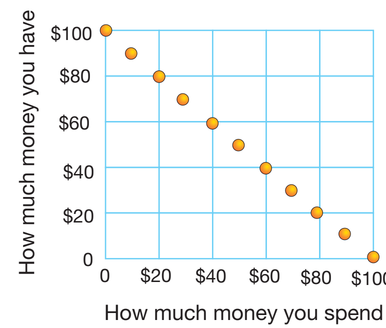


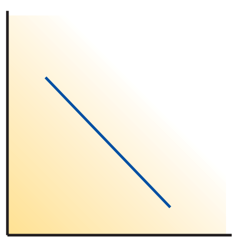

**Figure 1.12:** *Graphs of inverse relationships slope down to the right.*

## 1.3 Section Review

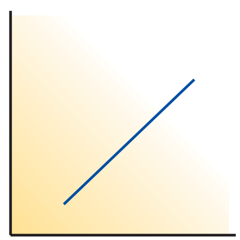
1. What is a graph? What are three types of graphs?
2. Name a situation where you would use a pie graph.
3. List the steps to making a graph.
4. Suppose you want to make a graph of the average temperature for each month of the year. What is the independent variable? What is the dependent variable?
5. Make a line graph of the monthly average temperature. Use the data below:

| Month | Average temperature (°C) | Month | Average temperature (°C) |
|---|---|---|---|
| January | 15 | July | 22 |
| February | 14 | August | 21 |
| March | 15 | September | 18 |
| April | 16 | October | 17 |
| May | 18 | November | 16 |
| June | 19 | December | 16 |

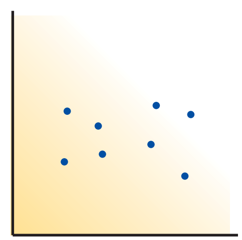
6. For each graph, tell whether it is a direct relationship, inverse relationship, or no relationship.



A



B



C

### SOLVE IT!

**Make a bar graph and pie graph**

1. A bar graph compares categories of information. Here is a data set for making a bar graph. Use this data set to make a bar graph.

**Number of students who bring lunch to school each day**

| Day | Number of Students |
|---|---|
| Mon | 30 |
| Tue | 30 |
| Wed | 30 |
| Thurs | 30 |
| Fri | 5 |

2. A pie graph also compares categories of information. Here is a data set for making a pie graph. Use this data set to make a pie graph.

**Percent of students in afterschool activities**

| Activity | % of Students |
|---|---|
| Soccer | 25% |
| Dance | 25% |
| Karate | 25% |
| Drama Club | 12.5% |
| Math Team | 12.5% |

TECHNOLOGY CONNECTION

# The Role of a Scientist

Imagine waking in the morning knowing what you do may help someone to see. That is what Dr. Lotfi Merabet feels like each morning. He is a scientist and optometrist working to help the blind see again. An optometrist is an eye doctor.

Dr. Merabet thinks about science every day and uses this knowledge to study problems. As a child, he enjoyed science. He was fascinated with understanding how the brain works. Dr. Merabet felt that the brain was the ultimate machine

## Meaningful questions

Asking questions is the first step of the scientific method. Forming meaningful questions is daily routine for Dr. Merabet. His day may include conducting experiments, discussing results, visiting patients, and writing reports. As a research scientist, Dr. Merabet wants to answer one very important question. What happens to the brain when a person is blind?

## The scientific method and the blindfold experiment

Scientists wonder if the brain can change. In order to explore this question, a hypothesis or educated guess is developed. Does the brain change when sight is lost? How does the brain change?

An experiment was set up with two groups of people who could see. One group wore blindfolds and the other group did not. A teacher taught both groups Braille for five days.

Braille is a code that lets blind people read and write. The code feels like bumps or dots on paper. This blindfold experiment used all the steps of the scientific method. Scientists asked questions, made a hypothesis, conducted experiments, collected information, and made conclusions.

A large part of the brain is used for seeing. What would happen to the brain when someone could no longer see? Who would learn Braille better - people with or without blindfolds?

The experiment showed that the blindfolded people had an easier time learning Braille. Scientists concluded that Braille is best learned through touching rather than seeing. For the blindfolded, the brain was no longer concerned with seeing. The brain adapted to the change by improving a person's sense of touch. Where inside the brain did this adjustment take place? Additional experiments must be done to answer this question.

Scientists used a functional magnetic resonance imaging (fMRI) tool for the blindfold study.

The fMRI scanned the brain for activity in the "vision" area. Scientists believe the brain adapted by using different "pathways." The brain was able to adapt to change much like a car driver may change his route due to a detour. The new "pathway" or road has always been there, but is not used until needed.

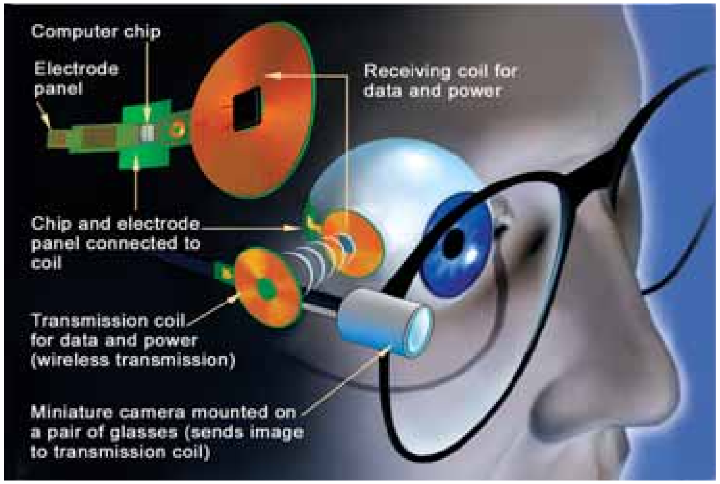
## The Boston Retinal Implant Project

Everyday scientists try to understand and explain the world in which we live. Understanding why things happen will help them find solutions to problems. A goal of science is to study a problem and then create ways to improve the problem. Dr. Merabet is part of a team working on the Retinal Implant Project in Boston, Massachusetts. They are studying how to teach the "blind brain" to see again. The blindfold study was used to understand how the brain adjusts to the loss of sight. This is an important part of the research process - answering meaningful questions. If Dr. Merabet wants to restore sight, he needs to understand how the brain adjusts when vision is lost. The goal of the project is to improve the sight of the blind.

The retina is the part of the eye that helps us to see. It takes in light and creates electrical energy that is sent to the brain. Damage to the retina can cause blindness. The retinal implant is an electronic device. It stimulates the retina by sending a "visual" message to the brain. The implant is very tiny - thinner than a human hair! The implant is considered a prosthesis. A prosthesis is a man-made device that replaces a damaged part of the body. You have probably seen people with an artificial leg or arm. These are prostheses that do the work of a real arm or leg.

Scientists are hoping to develop a prosthetic implant that will help restore sight. For the implant to work, patients wear special glasses containing a small camera. The camera sends signals to the implant using wireless technology.

So far six people have tested the retinal implants. Time has been limited to just a few hours with each person. Some have seen dots of light. Work continues with the hope that the blind will be able to see clear pictures of the world around them.




## Science is a team effort

Science cannot be done in isolation. For the Boston Retinal Implant Project, a team of scientists includes the following: physicians, optometrists, physiologists, biologists, and engineers. Scientists learn from others and must work together each day towards a common goal. Scientific success relies on sharing knowledge with others. A scientist cannot be locked in a lab. He must be an active part of the world in which he lives. Dr. Merabet and other scientists look forward to the new challenges presented each day.

**Questions:**

1. What is the role of a scientist?
2. Describe how the "blindfold study" uses the scientific method.
3. Why do scientists ask meaningful questions?

# CHAPTER ACTIVITY What's Inside the Box?

Science is sometimes like a sealed, black box. You can't always open it to see what's inside. You have to piece together clues and make a model of what you think is inside. For example, scientists can describe what the internal structure of Earth is like, but Earth certainly cannot be cut in half and examined!

The object for a scientist is to narrow the possible explanations to the best one, based on scientific evidence and agreement among different researchers. In this activity, you will investigate some black boxes. You will try to describe what's inside without opening them.

## What you will do

1. Obtain 6 black boxes labeled A through F from your teacher.
2. Perform "tests" on each of 6 different sealed containers, and describe what the internal structure is like. You may shake, rattle, roll, and listen to the sealed containers, but you may not open or destroy the container. No violent shaking!
3. There are three different internal structures. Determine which containers have similar interiors.
4. Make and label a diagram to show what the interior of the sealed container looks like.
5. Pair up with another group and work together to agree on the best explanations and diagrams, as well as proper pairing of similar interiors.
6. Opening the sealed containers may be very tempting, but scientists cannot do this with their black boxes! To really get the point across about black boxes, and to keep the containers usable for other students, we will not open the containers.

## Applying your knowledge

a. Explain further tests that you could do that might require additional equipment, but would not destroy the sealed containers.
b. Explain how you used the scientific method to come to your conclusions about the interior structure of each sealed container. Use the following terms: hypothesis, experiment, data, conclusion, peer review.

# Chapter 1 Assessment

## Vocabulary

Select the correct term to complete the sentences.

| | | |
|---|---|---|
| length | experiment | independent variable |
| volume | variables | graph |
| mass | scientific method | dependent variable |
| measurement | control variable | |
| unit | theory | |
| | experimental variable | |

***Section 1.1***

1. A value that has a quantity and a unit is a ____.
2. A ____ defines the amount of something that is being measured.
3. When measuring the ____ of an insect, scientists calculate the distance from the tip of the head to end of its abdomen.
4. The ____ of an object is calculated differently depending upon its shape but still determines how much space it occupies.
5. When wildlife biologists measure the ____ of a mountain beaver, they determine the amount of matter it occupies.

***Section 1.2***

6. When testing hypotheses and solving problems, scientists use a process called the ____.
7. The test used to determine whether or not the hypothesis is correct is the ____.
8. Scientists identify and test different ____ within the experiment to see how they affect the system.
9. The ____ is a factor within the experiment that changes.
10. By keeping the ____ the same, scientists can investigate the effect of other factors on the system.
11. When a widely accepted explanation of process or event is believed to be true, a ____ is formed which is further supported by many repeated experiments.

***Section 1.3***

12. A _____ shows how variables are related.
13. The _____ is plotted on the $y$-axis of a graph.
14. The _____ is plotted on the $x$-axis of a graph.

## Concepts

***Section 1.1***

1. Which of the following is not a proper SI unit of measurement?
   a. meter
   b. liter
   c. gram
   d. Fahrenheit
2. When measuring the volume of water in a graduated cylinder:
   a. read the mark at eye level and at the bottom of the meniscus.
   b. look down from the top of the cylinder and read the mark just above the curve.
   c. read the mark at the top edges of the meniscus.
   d. raise the cylinder in your hand to eye level to get the most accurate result.
3. An organism that has more mass:
   a. is larger than an organism that has less mass.
   b. weighs more than an organism with less mass.
   c. cannot have more matter than an organism with less mass.
   d. will never have the same mass as an animal that takes up more space.

***Section 1.2***

4. After testing, the hypothesis appears to be false. This indicates:
    a. The experiment is a failure.
    b. The results are of no use.
    c. The design of the experiment was bad.
    d. The data may be useful, but further testing and redesign of the experiment may be needed.
5. A student designs an experiment and gets favorable results after one trial. The student should:
    a. write a paper and publish the results.
    b. redesign the experiment to get more favorable data.
    c. repeat the experiment several times to verify the results.
    d. form a new experiment that supports a related hypothesis.
6. Explain the relationship between hypotheses and theories.

***Section 1.3***

7. What are three types of graphs? Name a situation where you would use each type of graph.

## Math and Writing Skills

***Section 1.1***

1. A freshwater lake extends 12 miles westward 10 miles south and is on average 12 feet deep (1 mile=5280 feet). Determine the surface area and volume of the lake using appropriate units.
2. Calculate the concentration of each solution in ppt:
    a. 12 grams of salt per 2-liters of solution.
    b. 0.5 grams of sugar per 1-liter of solution.

***Section 1.2***

3. A botanist wants to understand if exposure to St. John's wort, a flowering roadside flower, causes skin irritation. In this experiment several types of plants including St. John's wort are rubbed onto the arms of ten volunteers. A skin rash develops in all ten individuals. Can the scientist clearly say that St. John's wort causes skin irritation? Why or why not? Identify any variables and state any changes that could be made to make this experiment more valid.

***Section 1.3***

4. Using the following data, create a graph that clearly and accurately represents the results.

| | # Eggs | # Hatchlings | # Adults 1st year | #Adults 5th year |
|---|---|---|---|---|
| Species A | 200 | 180 | 50 | 26 |
| Species B | 60 | 50 | 28 | 15 |
| Species C | 5 | 4 | 4 | 3 |

Give a possible explanation of the results. Is the data easier to understand in graphical form? Why?

## Chapter Project

**Measurement scavenger hunt**

Find and measure the items in the scavenger hunt list. Make a sketch for each item and include labels with measurements. Submit a report with sketches on notebook paper or create a poster of your findings. Creativity and neatness count!

1. Find something that is 2 meters high.
2. Find something that has a volume of 237 milliliters.
3. Find something that is approximately 3 centimeters thick.
4. Measure the length and width of your bedroom or living room floor in meters and find the area in square meters.