Guide to the Toolkits and Appendices

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Science Skills Toolkit 1

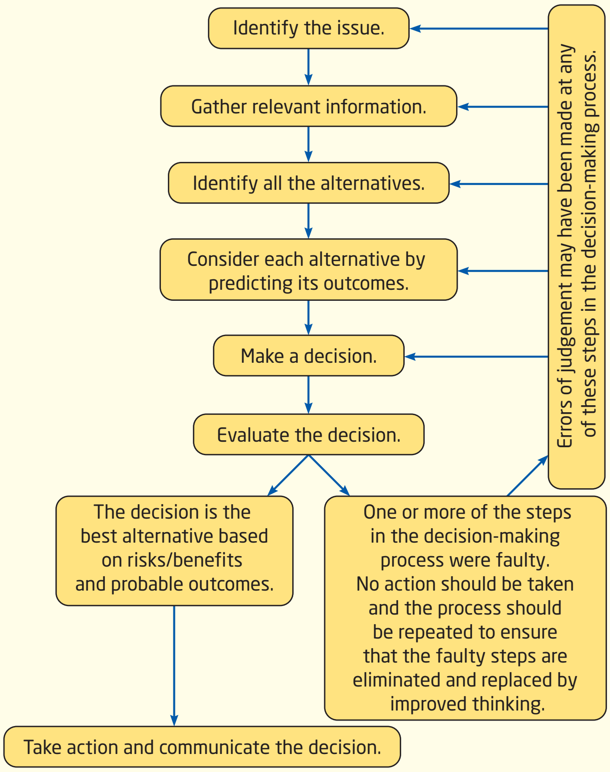
Analyzing Issues—Science, Technology, Society, and the Environment

Can you think of an issue that involves science, technology, society, and the environment? An **issue** is a topic that can be seen from more than one point of view. How about the use of salt to de-ice roads in the winter? Roads are safer in winter when they are clear of ice and snow.

In a conversation with a friend, however, you find out that road salt may damage the environment. How might you use science and technology to solve this problem?

Suppose your town council is in the process of deciding whether to expand its road salting program. How will you analyze this issue and determine what action to take? The concept map on this page shows a process to help you focus your thinking and stay on track.

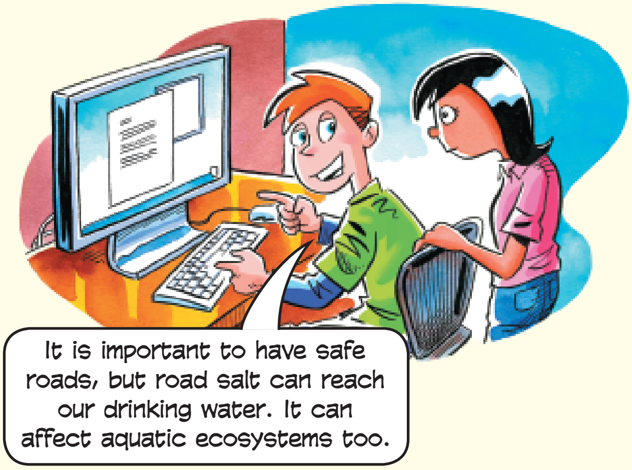
A Process for Analyzing Issues



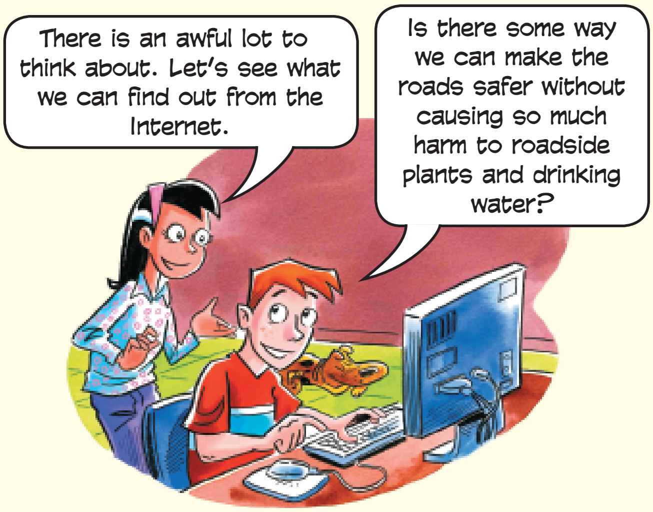
Identifying the Issue

Soon after talking with your friend about road salting, you go to your friend's house. You find your friend sitting in front of the computer, writing a letter to the town council. In it, your friend is asking that the salting program not be expanded to your area.

Gathering Information



Once you have identified the issue, you will need to find out more information.



The Internet and other sources, such as books or experts, are great places to find information about an issue. One thing that is important to do when gathering information is to look for bias.

Bias is a personal and possibly unreasonable judgement of an issue. For example, a person who makes his or her living putting salt on the roads may have a bias that salt does not harm the environment. It is important to check the source of information to determine whether it is unbiased. Refer to **Science Skills Toolkit 8** for more information about how to research information.

Another important part of gathering information is taking notes so that you can analyze what you have learned. You may read about different viewpoints or solutions and advantages and disadvantages for each one. It is helpful to be able to organize your notes in the form of a graphic organizer such as a concept map, a flowchart, or a Venn diagram. You will find information on using graphic organizers in **Literacy Skills Toolkit 5**.

Identifying and Considering Alternatives

Your research may lead you to ask new questions about alternative solutions and how successful they might be. For example, you might think about how a combination of salt and sand would work to keep roads clear of ice. Would this be a safer environmental alternative? Answering these questions often leads to more research or possibly doing your own scientific inquiry.

Making a Decision

When you have all of the information that your research can provide, you will need to weigh the pros and cons of each option and make a decision. Sometimes it helps to organize your thoughts in a PMI chart that lists the pros and cons of an issue, or a t-chart that compares two possible solutions. You will find more information on using these charts in **Literacy Skills Toolkit 5**. It might even be helpful to rate how important you feel each point (pro or con) is.

PMI Chart for Salt Use

Plus	Minus	Interesting
• very effective	• may contaminate drinking water	•
• relatively inexpensive		•
•	•	
•	•	

t-chart Comparing Salt and Sand

Salt	Sand
• more effective than sand	• not as harmful to organisms as salt
•	•
•	•

Your decision will still involve some very human and personal elements. People have strong feelings about the social and environmental issues that affect them. Depending on their point of view, other people may feel differently than you do about an issue. Something that seems obvious to you might not be so obvious to them, and vice versa. Even the unbiased scientific evidence you found during your research might not change people's minds. If you are going to encourage a group to make what you consider a good decision, you have to find ways to persuade the group to think as you do.

Evaluating the Decision

After you have made a decision, it is important to evaluate your decision. Is the decision the best alternative considering the risks and benefits? Have you thought about the possible consequences of the decision and how you might respond to them? If you determine that your decision-making process was faulty—if, for example, you based your decision on information that you later learned was false—you should begin again. If you find that you are comfortable with your decision, the next step is to take action.

Taking Action

Issues rarely have easy answers. People who are affected have differing, valid points of view. It is easier for you to act as an individual, but if you can persuade a group to act, you will have greater influence. In the issue discussed here, you might write a letter to your town council. As a compromise, you might suggest a combination of salt and sand on the roads. Your research can provide you with appropriate statistics. As a group, you could attend a town council meeting or sign a petition to make your views known.

Over time, you can assess the effects of your actions: Are there fewer accidents if less salt is used on roads? Does less salt end up in the water than when more salt alone is used?

Sometimes taking action involves changing the way you do things. After you have presented your findings to the town council, one of your friends makes you stop and think. "I have noticed you putting a lot of salt out on your sidewalk," your friend says. "You could use a bit of time and muscle power to chip away the ice, but that is not the choice you make."

You realize your friend is right—it is not only up to the town council or any other group to act responsibly; it is also up to you and your friends. How easy is it for you to give up an easy way of doing a task in order to make an environmentally responsible decision?

Instant Practice—Analyzing Issues

We live in an energy-intensive society. One of the most common sources of the energy we use is fossil fuels. Complete the following exercise in a group of four.

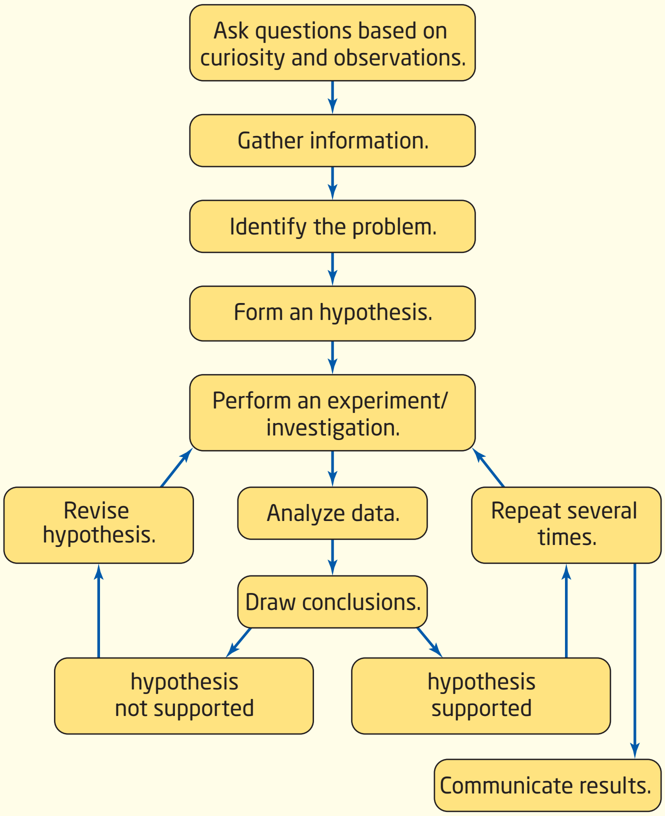
1. Start by dividing your group into two pairs.
2. One pair will research and record the advantages of using fossil fuels and how this use has affected members of our society in a positive way.
3. The second pair will research and record the disadvantages of using fossil fuels and their negative impacts on society.
4. The pairs will then regroup, and both sides can present their findings. Record key points on a PMI chart or a t-chart for comparison.
5. Determine which pair has the more convincing evidence for its point of view concerning the use of fossil fuels.
6. As a group, research alternative energy sources, including advantages and disadvantages of each. Determine the best alternative, based on the information you found in steps 2 and 3 above.

Science Skills Toolkit 2

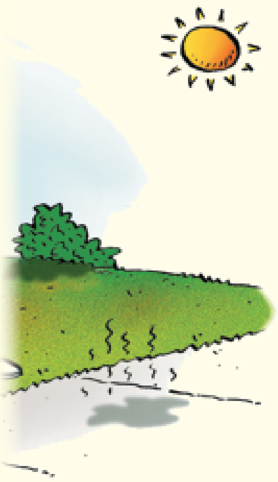
Scientific Inquiry

Scientific inquiry is a process that involves many steps, including making observations, asking questions, performing investigations, and drawing conclusions. These steps may not happen in the same order in each inquiry. However, one model of the scientific inquiry process is shown here:

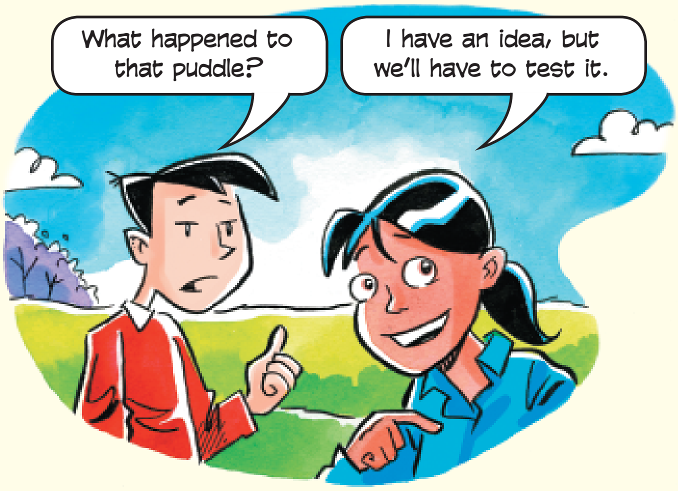
The Scientific Inquiry Process



Making Observations and Asking Questions



The rain has stopped, and the Sun is out. You notice that a puddle of water has disappeared from the sidewalk.



You may have an idea about what happened to the puddle, but you need evidence that supports your idea. In order to test your idea, you need to carry out a scientific inquiry.

Gathering Information and Identifying the Problem

First, you might observe what happens to some other puddles. You would watch them closely until they disappeared and record what you observed.

One observation you might make is “The puddle is almost all gone.” That would be a **qualitative observation**, an observation in which numbers are not used. A little later, you might also say, “It took five hours for the puddle to disappear completely.” You have made a **quantitative observation**, an observation that uses numbers.

Although the two puddles were the same size, one disappeared (evaporated) much more quickly than the other one did. Your quantitative observations tell you that one evaporated in 4 h, whereas the other one took 5 h. Your qualitative observations tell you that the one that evaporated more quickly was in the sunlight. The one that evaporated more slowly was in the shade. You now have identified one problem to solve: Does water always evaporate more quickly in the sunlight than in the shade?

Instant Practice—Making Qualitative and Quantitative Observations

Copy the observations below in your notebook. Beside each observation, write “Qual” if you think it is a qualitative observation and “Quan” if you think it is a quantitative observation.

1. **a.** The bowling ball is heavier than the basketball.
   b. The red ball weighs 5 g more than the blue ball.
2. **a.** The temperature increased by several degrees.
   b. The temperature increased by 2°C.
3. **a.** The water was lukewarm.
   b. The water was cooler than the oil.
4. **a.** The owl ate 3 mice.
   b. The owl was larger than the nighthawk.
5. **a.** The second light bulb was the brightest.
   b. The 60 W bulb was brighter than the 40 W bulb.
6. **a.** The colour of the surface water in the lake was green.
   b. The lake contained 15 species of fish.

Stating an Hypothesis

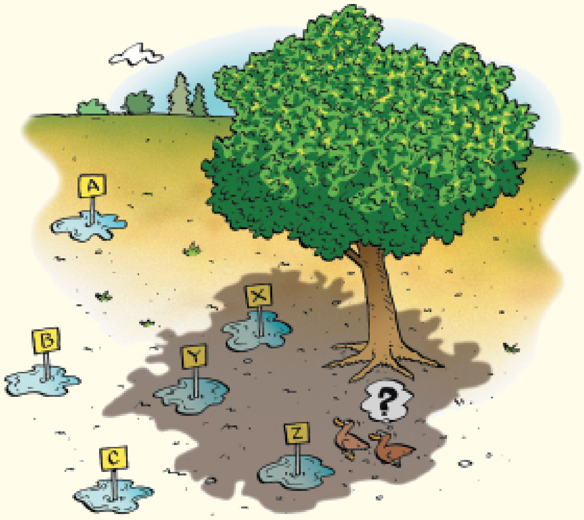
Now you are ready to make an **hypothesis**, a statement about an idea that you can test, based on your observations. Your test will involve comparing two things to find the relationship between them. You know that the Sun is a source of heat energy, so you might use that knowledge to make this hypothesis: If a puddle of water is in the sunlight, then the water will evaporate faster than if the puddle is in the shade.

Instant Practice—Stating an Hypothesis

Write an hypothesis for each of the following situations. You may wish to use an "If…then…" format. For example: *If* temperature affects bacterial growth, *then* bacterial culture plates at a higher temperature will have more bacterial colonies than those at a lower temperature.

1. The relationship between temperature and the state of water
2. The relationship between types of atmospheric gases and global warming
3. The amount of time batteries last in different devices
4. The effect of the colour of flowers on honeybee visitations

As you prepare to make your observations, you can make a **prediction**, a forecast about what you expect to observe. In this case, you might predict that puddles A, B, and C will dry up more quickly than puddles X, Y, and Z. A prediction will help you to decide whether your hypothesis is correct. In the case of the puddles, if puddles A, B, and C do not dry up more quickly than puddles X, Y, and Z, you'll know that your hypothesis was likely incorrect.



Performing an Investigation

As you know, there are several steps involved in performing a scientific investigation, including identifying variables, designing a fair test, and organizing and analyzing data.

Identifying Variables

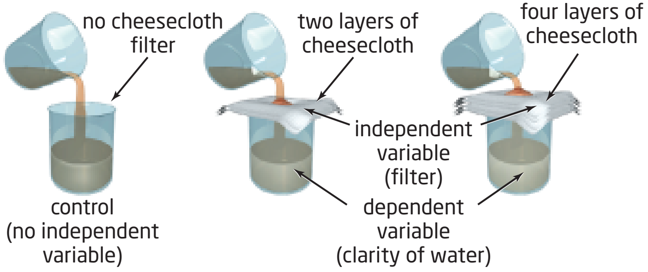
The breeze is one factor that could affect evaporation. The Sun is another factor that could affect evaporation. Scientists think about every possible factor that could affect tests they conduct. These factors are called **variables**.
It is important to test only one variable at a time.

You need to control your variables. This means that you change only one variable at a time. The variable that you change is called the **independent variable** (also called the manipulated variable). In this case, the independent variable is the condition under which you observe the puddle (one variable would be sunlight; another would be wind).

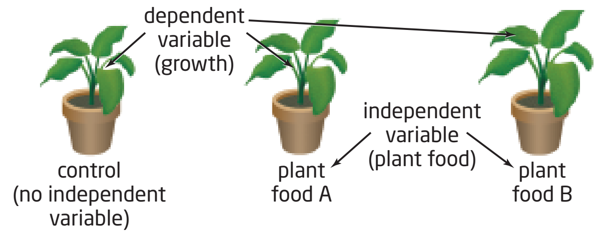
According to your hypothesis, sunlight will change the time it takes for the puddle to evaporate. The time in this case is called the **dependent variable** (also called the responding variable).

Often, experiments have a **control**. This is a test that you carry out with no variables, so that you can observe whether your independent variable does indeed cause a change. Look at the illustration below to see some examples of controls and variables.

(a) A test to findthe best filter for muddy water.



(b) A test to find the best plant food for plant growth.



The control plant is given no additional plant food–only water.

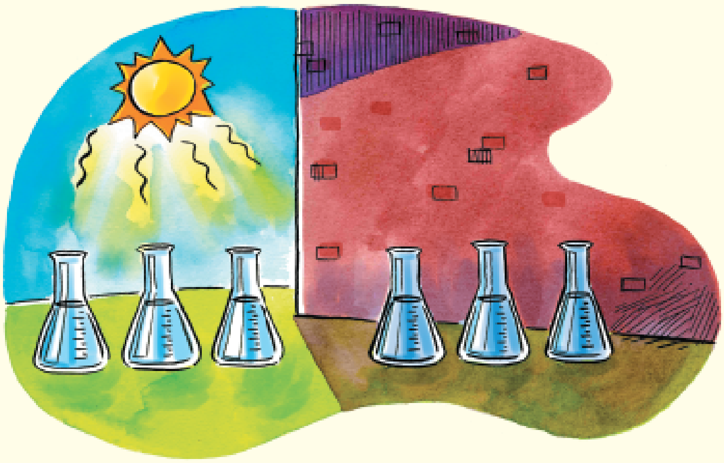
Instant Practice—Identifying Variables

For each of the following questions, state your control, your independent variable, and your dependent variable.

1. Does light travel the same way through different substances?
2. Does adding compost to soil promote vegetable growth?
3. How effective are various kinds of mosquito repellent?

Controlling Variables for a Fair Test A controlled experiment tests only one variable at a time, while keeping all other variables constant. If you consider more than one variable in a test, you are not conducting a **fair test** (one that is valid and unbiased), and your results will not be useful. You will not know whether the breeze or the Sun made the water evaporate.

As you have been reading, a question may have occurred to you: How is it possible to do a fair test on puddles? How can you be sure that they are the same size? In situations such as this one, scientists often use **models**. A model can be a mental picture, a diagram, a working model, or even a mathematical expression. To make sure your test is fair, you can prepare model puddles that you know are all exactly the same.



You can then place the puddles in controlled conditions, where all variables *except* for sunlight remain constant. For instance, you might construct a cardboard wall around your model puddles to ensure that the wind conditions will be the same for all puddles. You might even carry out your test in a laboratory, using a lamp as a model Sun. **Science Skills Toolkit 7** gives you more information on using models.

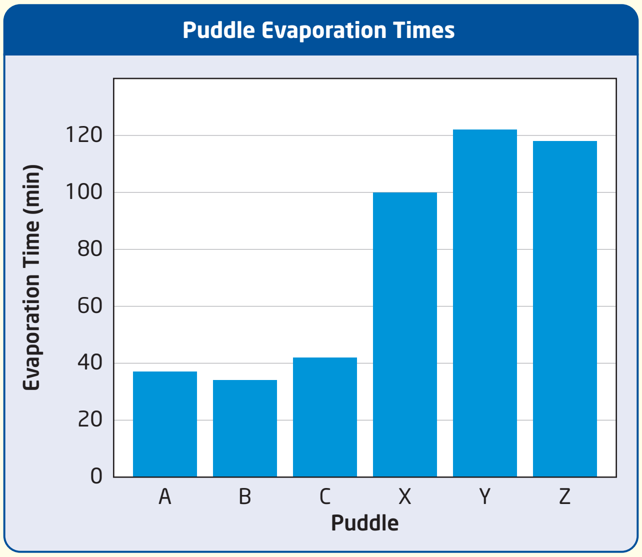
Before you begin your investigation, review safety procedures and identify what safety equipment you may need. Refer to page xii in this textbook for more information on safety.

Recording and Organizing Data Another step in performing an investigation is recording and organizing your data. Often, you can record your data in a table like the one shown below. Refer to **Science Skills Toolkit 10** for more information on making tables.

Table 1 Puddle Evaporation Times

Puddle	Evaporation Time (min)
A	37
B	34
C	42
X	100
Y	122
Z	118

Analyzing and Presenting Data After recording your data, the next step is to present your data in a format so that you can analyze it. Often, scientists make a graph, such as the bar graph below. For more information on constructing graphs, refer to **Numeracy Skills Toolkit 4**.



Forming a Conclusion

Many investigations are much more complex than the one described here, and there are many more possibilities for error. That is why it is so important to record careful qualitative and quantitative observations.

After you have completed all your observations, you are ready to analyze your data and draw a **conclusion**. A conclusion is a statement that indicates whether your results support or do not support your hypothesis. First you need to consider whether your predictions were correct. Then you should ask yourself whether you have considered all of the variables. Then you can decide whether your results support your hypothesis. If you had hypothesized that sunlight would have no effect on the evaporation of water, your results would not support your hypothesis. An hypothesis gives you a place to start and helps you design your experiment. If your results do not support your hypothesis, you use what you have learned in the experiment to come up with a new hypothesis to test.

Scientists often set up experiments without knowing what will happen. Sometimes they deliberately set out to show that something will *not* happen in a particular situation.

Eventually, when an hypothesis has been thoroughly tested and nearly all scientists agree that the results support the hypothesis, it becomes a **theory**.

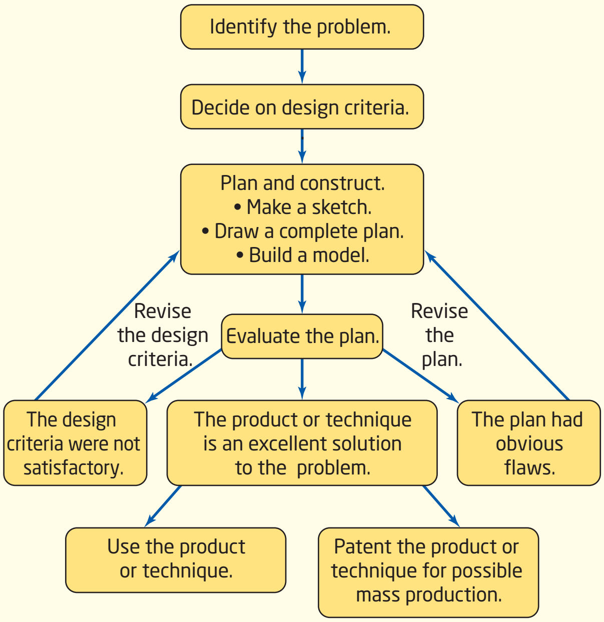
Science Skills Toolkit 3

Technological Problem Solving

Technology is the use of scientific knowledge, as well as everyday experience, to solve practical problems. Have you ever used a pencil to flip something out of a tight spot where your fingers could not reach? Have you ever used a stone to hammer bases or goal posts into the ground? Then you have used technology. You may not know why your pencil works as a lever or the physics behind levers, but your everyday experiences tell you how to use a lever successfully.

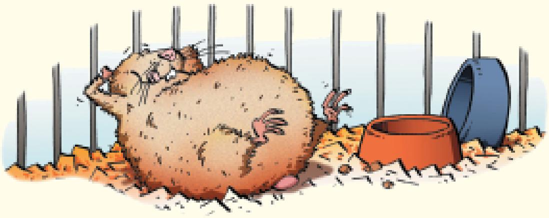
A Process for Technological Problem Solving

People turn to technology to solve problems. One problem-solving model is shown below.


Solving a Technological Problem

Identifying the Problem

When you used that pencil to move the small item you could not reach, you did so because you needed to move that item. In other words, you had identified a problem that needed to be solved. Clearly identifying a problem is a good first step in finding a solution. In the case of the lever, the solution was right before your eyes, but finding a solution is not always quite so simple.



Suppose school is soon to close for a 16-day winter holiday. Your science class has a hamster whose life stages the class observes. Student volunteers will take the hamster home and care for it over the holiday. However, there is a three-day period when no one will be available to feed the hamster. Leaving extra food in the cage is not an option because the hamster will eat it all at once. What devices could you invent to solve this problem?

First, you need to identify the exact nature of the problem you have to solve. You could state it as follows:

The hamster must receive food and water on a regular basis so that it remains healthy over a certain period and does not overeat.

Identifying Criteria

Now, how will you be able to assess how well your device works? You cannot invent a device successfully unless you know what criteria (standards) it must meet.

In this case, you could use the following as your criteria.

1. The device must feed and water the hamster.
2. The hamster must be healthy at the end of the three-day period.
3. The hamster must not appear to be "overstuffed."

How could you come up with such a device? On your own, you might not. If you work with a team, however, each of you will have useful ideas to contribute.

Planning and Constructing

You will probably come up with some good ideas on your own. Like all other scientists, though, you will want to use information and devices that others have developed. Do some research and share your findings with your group. Can you modify someone else's idea? With your group, brainstorm some possible designs. How would the designs work? What materials would they require? How difficult would they be to build? How many parts are there that could stop working during the three-day period? Make a clear, labelled drawing of each design, with an explanation of how it would work.

Examine all of your suggested designs carefully. Which do you think would work best? Why? Be prepared to share your choice and your reasons with your group. Listen carefully to what others have to say. Do you still feel yours is the best choice, or do you want to change your mind? When the group votes on the design that will be built, be prepared to co-operate fully, even if the group's choice is not your choice.

Get your teacher's approval of the drawing of the design your group wants to build. Then gather your materials and build a model of your design. Experiment with your design to answer some questions you might have about it. For example, should the food and water be provided at the same time? Until you try it out, you may be unsure if it is possible (or even a good idea) for your invention to deliver both food and water at the same time. Keep careful records of each of your tests and of any changes you make to your design.

You might find, too, that your invention fails in a particular way. Perhaps it always leaks at a certain point where two parts are joined. Perhaps the food and water are not kept separate. Perhaps you notice a more efficient way to design your device as you watch it operate. Make any adjustments and test them so that your device works in the best and most efficient way possible.

Evaluating

When you are satisfied with your device, you can demonstrate it and observe devices constructed by other groups. Evaluate each design in terms of how well it meets the design criteria. Think about the ideas other groups tried out and why they work better than (or not as well as) yours. What would you do differently if you were to redesign your device?

Science Skills Toolkit 4

Estimating and Measuring

Estimating

How long will it take you to read this page? How heavy is this textbook? You could probably answer these questions by **estimating**—making an informed judgement about a measurement. An estimate gives you an idea of a particular quantity but is not an exact measurement.

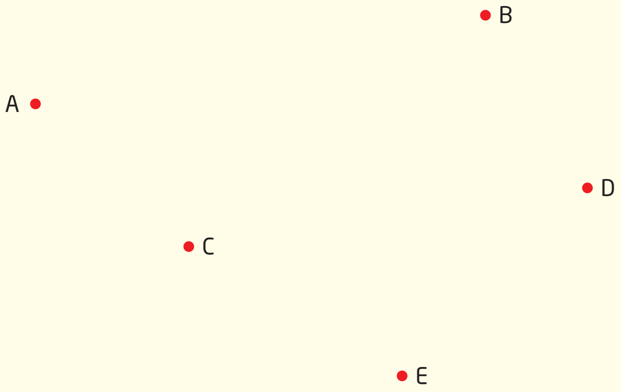
For example, if you were responsible for maintaining the grounds in a local park, you might need to know how many insects live in the park. Counting every insect would be very time-consuming. What you can do is count the number of insects in a typical square-metre area.

Then, multiply the number of insects by the number of square metres in the total area you are investigating. This will give you an estimate of the total population of insects in that area.

Number of insects per square meter x total area of site
= number of insects on site (estimate)

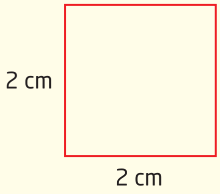
Measuring Length and Area

You can use a metre stick or a ruler to measure short distances. These tools are usually marked in centimetres and/or millimetres. Use a ruler to measure the length in millimetres between points A and C, C and E, E and B, and A and D below. Convert your measurements to centimetres and then to metres.



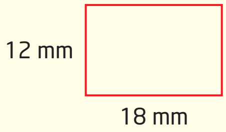
To calculate an area, you can use length measurements. For example, for a square or a rectangle, you can find the area by multiplying the length by the width.

Example 1



Area of square is 2 cm × 2 cm = 4 cm^2

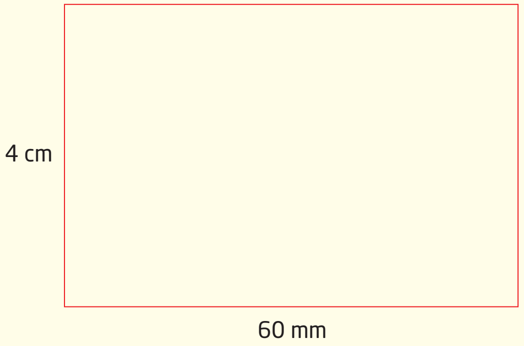
Example 2



Area of rectangle is 18 mm × 12 mm = 216 mm^2

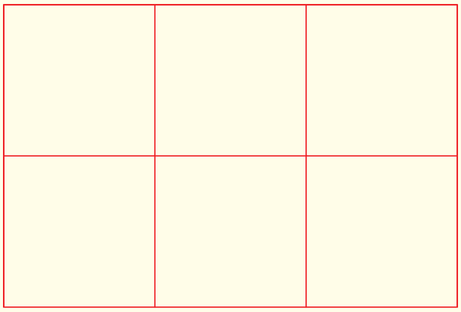
Make sure you always use the same units—if you mix up centimetres and millimetres, your calculations will be wrong. You will find more information on converting between metric units in **Numeracy Skills Toolkit 3**.

Example 3



Area of rectangle is 4 cm x 60 mm
= 40 mm x 60 mm
= 2400 mm^2
OR
= 4 cm x 6 cm
= 24 cm^2

Remember to ask yourself if your answer is reasonable (you could make an estimate to consider this). Look at the square in Example 1 on the previous page. It had an area of 4 cm^2. The area calculated for the rectangle in Example 3 on this page was 24 cm^2. Would you estimate that you could fit 6 (24 divided by 4) of those small squares into the large rectangle? This shows you that your answer is reasonable.

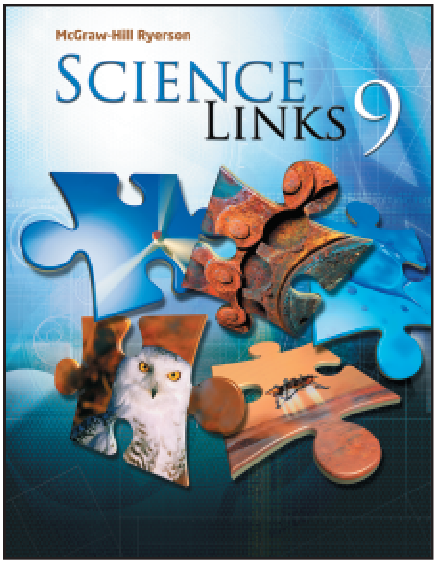


Six of the squares from Example 1 will fit inside the rectangle from Example 3

Instant Practice—Estimating and Measuring

Imagine that all rulers in the school have vanished. The only measurement tool that you now have is a toothpick.

1. Estimate the length and width of your textbook in toothpick units. Compare your estimates with a classmate's estimates.

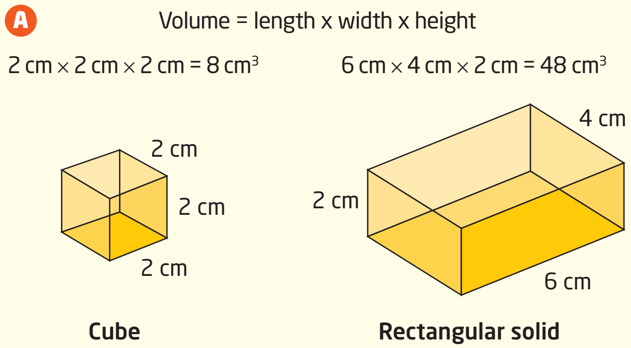


2. Measure the length and width of your textbook with your toothpick. How close was your estimate to the actual measurement?
3. If you had a much larger area to measure, such as the floor of your classroom, what could you use instead of toothpicks to measure the area? (Be creative!)
4. What is your estimate of the number of units you chose (in question 3) for the width of your classroom?

Measuring Volume

The **volume** of an object is the amount of space that the object occupies. There are several ways of measuring volume, depending on the kind of object you want to measure.

As you can see in Diagram A below, the volume of a regularly shaped solid object can be measured directly. You can calculate the volume of a cube by multiplying its sides, as shown on the left in Diagram A. You can calculate the volume of a rectangular solid by multiplying its length × width × height, as shown on the right in Diagram A.



Measuring the volume of a regularly shaped solid

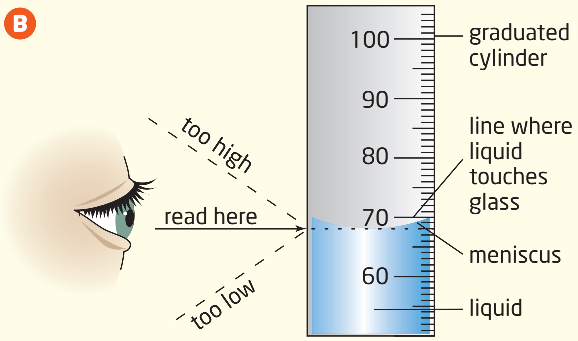
If all the sides of a solid object are measured in millimetres (mm), the volume will be in cubic millimetres (mm^3). If all the sides are measured in centimetres (cm), the volume will be in cubic centimetres (cm^3). The units for measuring the volume of a solid are called cubic units.

The units used to measure the volume of liquids are called capacity units. The basic unit of volume for liquids is the litre (L). Recall that 1 L = 1000 mL.

Cubic units and capacity units are interchangeable. For example,

$1\ cm^3 = 1\ mL$
$1\ dm^3 = 1\ L$
$1\ m^3 = 1\ kL$

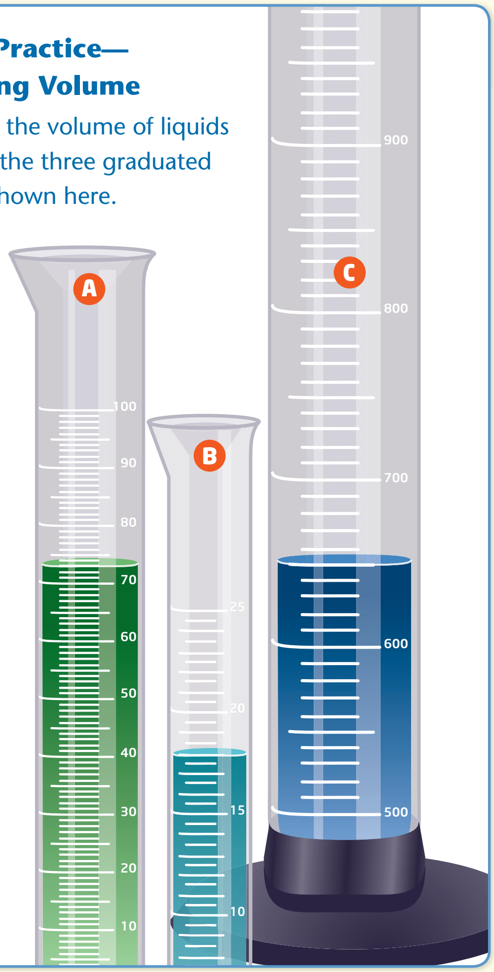
The volume of a liquid can be measured directly, as shown in Diagram B. Make sure you measure to the bottom of the **meniscus**, the slight curve where the liquid touches the sides of the container. To measure accurately, make sure your eye is at the same level as the bottom of the meniscus.



Measuring the volume of a liquid

Instant Practice—Measuring Volume

Determine the volume of liquids present in the three graduated cylinders shown here.



The volume of an irregularly shaped solid object, however, must be measured indirectly, as shown in Diagram C below. This is done by measuring the volume of a liquid it displaces.

When a solid object is placed in liquid, the liquid level will rise. The liquid is displaced, or moved from the place it was originally. The volume of the displaced liquid is equal to the volume of the solid.

C

1. Record the volume of the liquid.
2. Carefully lower the object into the cylinder containing the liquid. Record the volume again.
3. The volume of the object is equal to the difference between the two volumes of the liquid. The equation below the photographs shows you how to calculate this volume.

Measuring the volume of an irregularly shaped solid

volume of object = volume of water with object – original volume of water
= 85 mL – 60 mL
= 25 mL

Measuring Mass

Is your backpack heavier than your friend's backpack? You can check by holding a backpack in each hand. The **mass** of an object is the amount of matter in a substance or object. Mass is measured in milligrams, grams, kilograms, and tonnes. You need a balance for measuring mass.

How can you find the mass of a certain quantity of a substance, such as table salt, that you have added to a beaker? First, find the mass of the beaker. Next, pour the salt into the beaker and find the mass of the beaker and salt together. To find the mass of the salt, simply subtract the beaker's mass from the combined mass of the beaker and salt.

If you are using an electronic balance, you will not need to do any calculations to subtract the mass of the beaker. The balance will do the calculation for you. To measure the contents of a beaker, you can place the empty beaker on the balance and hit the "Tare" or "Zero" or "Re-zero" button to reset the balance to zero. Then add the material to be measured into the beaker. The balance subtracts the mass of the beaker before the contents are even added, so it reports only the mass of the contents.

Instant Practice—Measuring Mass

Use the following information to determine the mass of the table salt. The mass of a beaker is 160 g. The mass of the table salt and beaker together is 230 g.

Measuring Angles

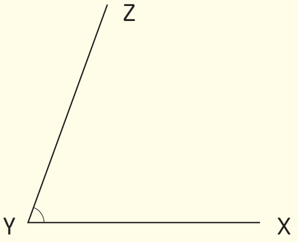
You can use a protractor to measure angles. Protractors usually have an inner scale and an outer scale. The scale you use depends on how you place the protractor on an angle (symbol = ∠). Look at the following examples to learn how to use a protractor.

Example 1

What is the measure of ∠XYZ?

Solution

Place the centre of the protractor on point Y. The 0° 180° line should lie along the line YX so that YX crosses 0° on the inner scale. YZ crosses 70° on the inner scale. So ∠XYZ is equal to 70°.

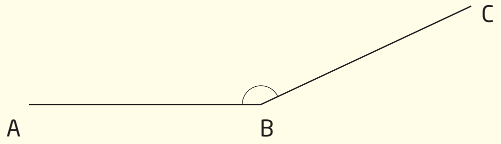


Example 2

Draw ∠ABC = 155°.

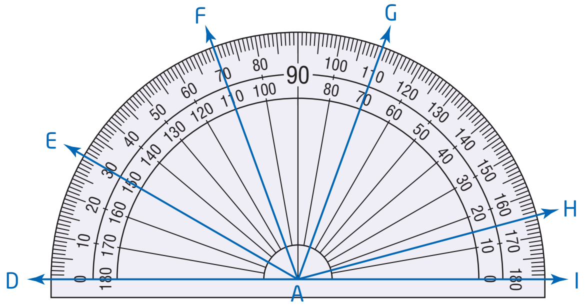
Solution

First, draw a straight line, AB. Place the centre of the protractor on B and line up AB with 0° on the outer scale. Mark C at 155° on the outer scale. Join BC. The angle you have drawn, ∠ABC, is equal to 155°.



Instant Practice—Measuring Angles

1. State the measure of each of the following angles using the following diagram.
   - **a.** DAF
   - **b.** DAH
   - **c.** IAG
   - **d.** HAF
   - **e.** GAD
   - **f.** DAI
   - **g.** EAG
   - **h.** EAI



2. Use a protractor to draw angles with the following measurements. Label each angle.
   - **a.** ABC 50°
   - **b.** QRS 85°
   - **c.** XYZ 5°
   - **d.** JKL 45°
   - **e.** HAL 90°

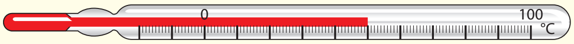
Measuring Temperature

Temperature is a measure of the thermal (heat) energy of the particles of a substance. In the very simplest terms, you can think of temperature as a measure of how hot or how cold something is. The temperature of a material is measured with a thermometer.

For most scientific work, temperature is measured on the Celsius scale. On this scale, the freezing point of water is zero degrees (0°C) and the boiling point of water is 100 degrees (100°C). Between these points, the scale is divided into 100 equal divisions. Each division represents one degree Celsius. On the Celsius scale, average human body temperature is 37°C, and a typical room temperature may be between 20°C and 25°C.

Sometimes scientists use a different unit of temperature called the kelvin (K). Zero on the Kelvin scale (0 K) is the coldest possible temperature. This temperature is also known as absolute zero. It is equivalent to –273°C, which is about 273 degrees below the freezing point of water. Notice that degree symbols are not used with the Kelvin scale.

Most laboratory thermometers are marked only with the Celsius scale. Because the divisions on the two scales are the same size, the Kelvin temperature can be found by adding 273 to the Celsius reading. This means that on the Kelvin scale, water freezes at 273 K and boils at 373 K.



Tips for Using a Thermometer

When using a thermometer to measure the temperature of a substance, here are three important tips to remember.

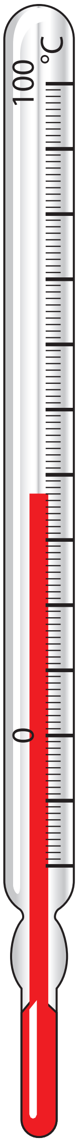
- Handle the thermometer extremely carefully. It is made of glass and can break easily.
- Do not use the thermometer as a stirring rod.
- Do not let the bulb of the thermometer touch the walls of the container.

Instant Practice—Measuring Temperature

Read the temperature, in °C, from the thermometer in each question. Convert your Celsius reading into Kelvin units.

1.

2.



Science Skills Toolkit 5

Precision and Accuracy

No measuring device can give an absolutely exact measure. So how do scientists describe how close an instrument comes to measuring the true result? Quantitative data from any measuring device are uncertain. You can describe this uncertainty in terms of precision and accuracy.

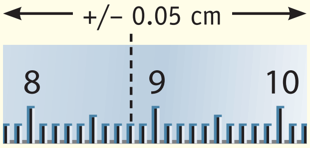
Precision The term **precision** describes both the exactness of a measuring device and the range of values in a set of measurements. The precision of a measuring instrument is usually half the smallest division on its scale.

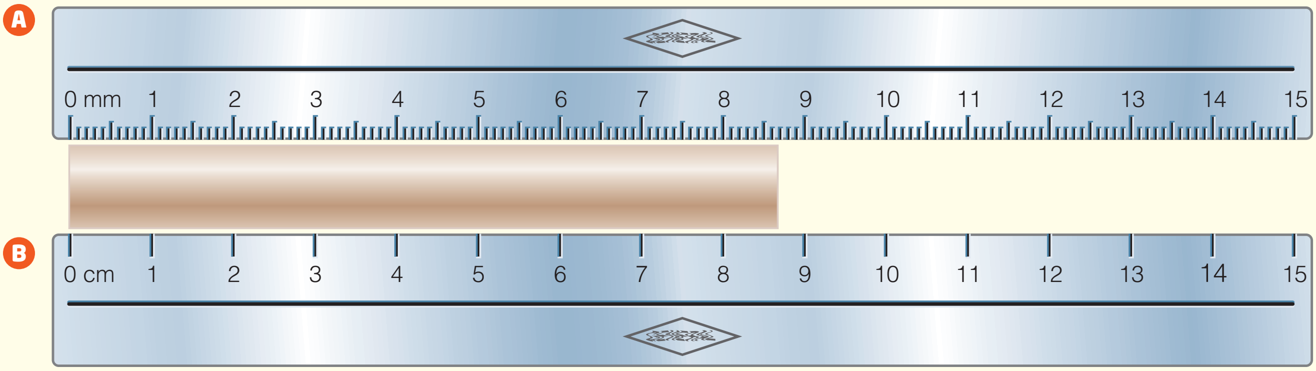
For example, ruler A below is divided in millimetres, so it is precise to ± 0.05 cm. The length of the object below the ruler would be reported as 8.7 ± 0.05 cm, because it is closer to 8.7 than 8.8 cm. Ruler B below is divided in centimetres, so it is precise to ± 0.5 cm. The length of the object above the ruler would be reported as 9.0 ± 0.5 cm, because it is closer to 9 cm than to 8 cm, and the uncertainty must be included in the measurement.

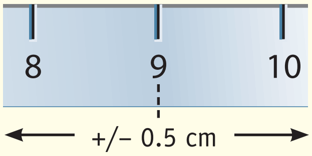
A precise measuring device will give nearly the same result every time it is used to measure the same object. Consider the following measurements of a 50 g object on a balance. Both give the same average mass, but Scale B is more precise because it has a smaller range of measured values (± 0.3 versus ± 0.5).

Table 1 Measurements of Mass on Two Scales

	Scale A Mass (g)	Scale B Mass (g)
Trial 1	49.9	49.9
Trial 2	49.8	50.2
Trial 3	50.3	49.9
Average	50.0	50.0
Range	± 0.5	± 0.3







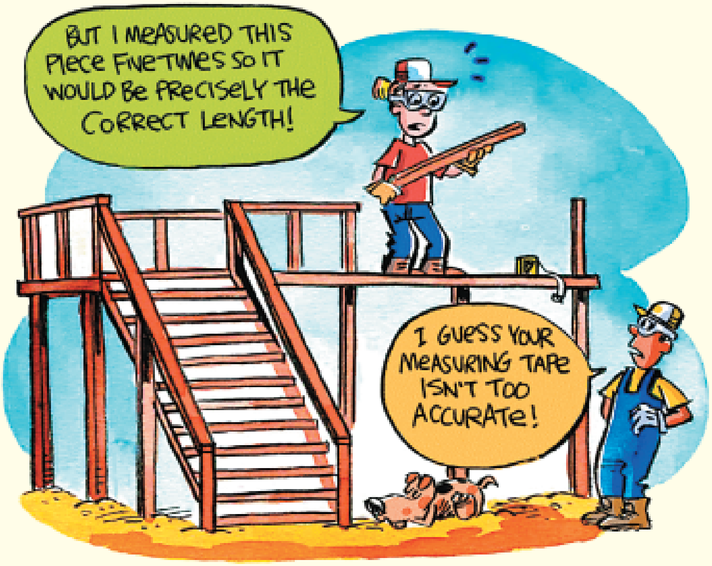
Accuracy How close a measurement or calculation comes to the true value is described as **accuracy**. To improve accuracy, scientific measurements are often repeated and combined mathematically. The average measurements in the table on the previous page are more accurate than any of the individual measurements.

The darts in diagram A below are very precise, but they are not accurate because they did not hit the bull's-eye. The darts in diagram B are neither precise nor accurate. However, the darts in diagram C are both precise and accurate.

A precise but not accurate

B neither precise nor accurate

C precise and accurate



Instant Practice—Precision and Accuracy

1. A student measures the temperature of ice water four times, and each time gets a result of 10.0°C. Is the thermometer precise and accurate? Explain your answer.
2. Two students collected data on the mass of a substance for an experiment. Each student used a different scale to measure the mass of the substance over three trials. Student A had a range of measurements that was ±0.06 g. Student B had a range of measurements that was ±0.11 g. Which student had the more precise scale?
3. You want to get an accurate and precise measure of your height. What do you think is the best way to do this? What did you need to consider to make your decision?

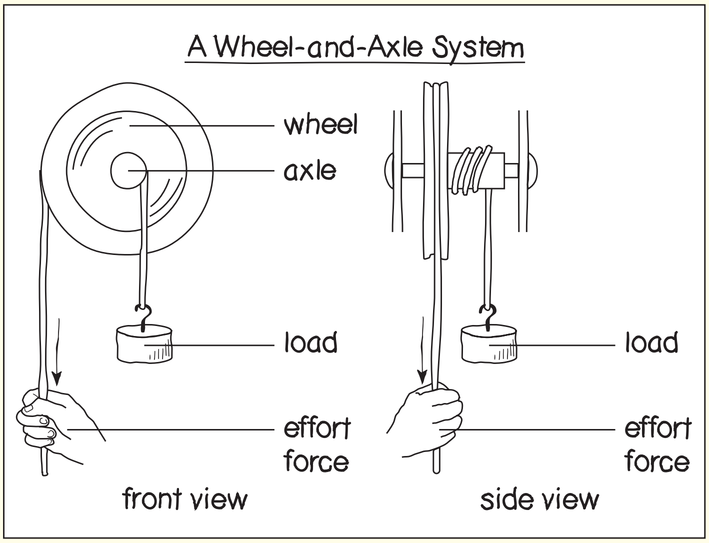
Scientific Drawing

Have you ever used a drawing to explain something that was too difficult to explain in words? A clear drawing can often assist or replace words in a scientific explanation. Drawings are especially important when you are trying to explain difficult concepts or describe something that contains a lot of detail. It is important to make scientific drawings clear, neat, and accurate.

Making a Scientific Drawing

Follow these steps to make a good scientific drawing.

1. Use unlined paper and a sharp pencil with an eraser.
2. Give yourself plenty of space on the paper. You need to make sure that your drawing will be large enough to show all necessary details. You also need to allow space for labels. Labels identify parts of the object you are drawing. Place all of your labels to the right of your drawing, unless there are so many labels that your drawing looks cluttered.
3. Carefully study the object that you will be drawing. Make sure you know what you need to include.
4. Draw only what you see, and keep your drawing simple. Do not try to indicate parts of the object that are not visible from the angle of observation. If you think it is important to show another part of the object, do a second drawing, and indicate the angle from which each drawing is viewed. The diagram to the right includes both a front view and a side view of a wheel-and-axle system.
5. Shading or colouring is not usually used in scientific drawings. If you want to indicate a darker area, you can use stippling (a series of dots). You can use double lines to indicate thick parts of the object.
6. If you do use colour, try to be as accurate as you can. Choose colours that are as close as possible to the colours in the object you are observing.
7. Label your drawing carefully and completely, using lower-case (small) letters. Think about what you would need to know if you were looking at the object for the first time. If you are comparing two objects, label each object and use labels to indicate the points of comparison between them. Remember to place all your labels to the right of the drawing, if possible. Use a ruler to draw a horizontal line from the label to the part you are identifying. Make sure that none of your label lines cross.
8. Give your drawing a title. The drawing shown below is from a student's notebook. This student used horizontal label lines for the parts viewed, and a title—all elements of an excellent final drawing.

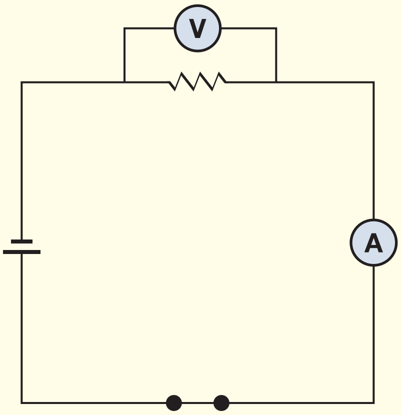


Drawing Circuit Diagrams

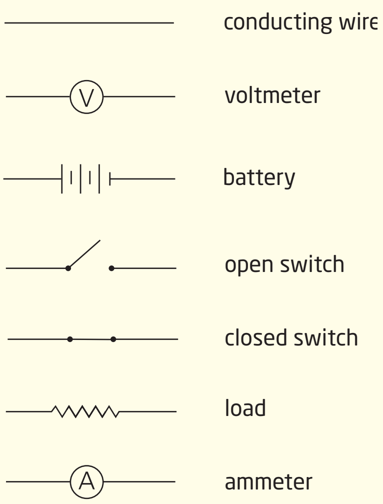
When drawing a diagram of an electric circuit, use the following criteria:

- Draw your diagram using a ruler.
- Make all connecting wires and leads straight lines with 90° (right-angle) corners.
- If possible, do not let conductors cross over one another.
- Your finished drawing should be rectangular or square.

An example of a proper circuit diagram is shown below.



The following symbols are used in circuit diagrams:



Instant Practice—Scientific Drawings

1. Draw and label a diagram of a pair of scissors. Someone who has never seen a pair of scissors before should be able to use your diagram to understand how scissors work. Remember to use stippling or double lines rather than shading to show darker or thicker parts of the scissors.
2. Briefly describe the circuit shown in the circuit diagram on this page.
3. Draw a circuit diagram with at least four components. Write a brief description of the circuit shown by your diagram.

Science Skills Toolkit 7

Using Models and Analogies in Science

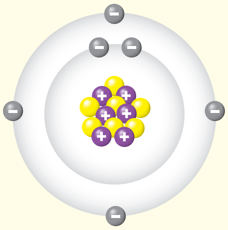
Scientists often use models and analogies to help communicate their ideas to other scientists or to students.

Using Models

When you think of a model, you might think of a toy such as a model airplane. Is a model airplane similar to a scientific model? If building a model airplane helps you learn about flight, then you could say it is a scientific model.

In science, a model is anything that helps you better understand a scientific concept. A model can be a picture, a mental image, a structure, or even a mathematical formula.

Sometimes, you need a model because the objects you are studying are too small to see with the unaided eye. In Unit 2, for example, you will see models used to represent atoms.

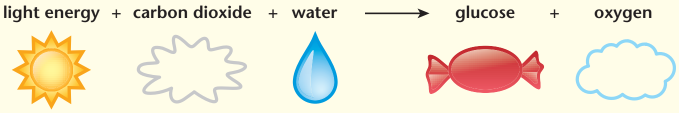


Atoms are so tiny that you cannot see them, even with the strongest of microscopes. A model of an atom can help you to form a mental picture that helps you understand the parts of the atom, even though it doesn't show exactly what an atom looks like.

Sometimes a model is useful because the objects you are studying are extremely large—the planets in our solar system, for example. In other cases, the object may be hidden from view, like the interior of Earth or the inside of a living organism.

A mathematical model can show you how to perform a calculation. If you wanted to explain addition and subtraction to a young child, you might use cookies as a model. By eating a cookie, you could demonstrate subtraction.

Chemical equations are models that are often used in science to help explain how a chemical reaction or series of reactions takes place. In Unit 1, you will see an equation used to represent the process of photosynthesis. Photosynthesis is a complicated process that involves many chemical reactions. An equation helps you to think about the starting materials and end products of the process.



Scientists often use models to test an idea, to find out if an hypothesis is supported, and to plan new experiments in order to learn more about the subject they are studying. Sometimes, scientists discover so much new information that they have to modify their models. Examine the model shown in the photograph below. How can this model help you learn about science?

You can learn about day and night by using a globe and a flashlight to model Earth and the Sun.

Instant Practice—Using Models

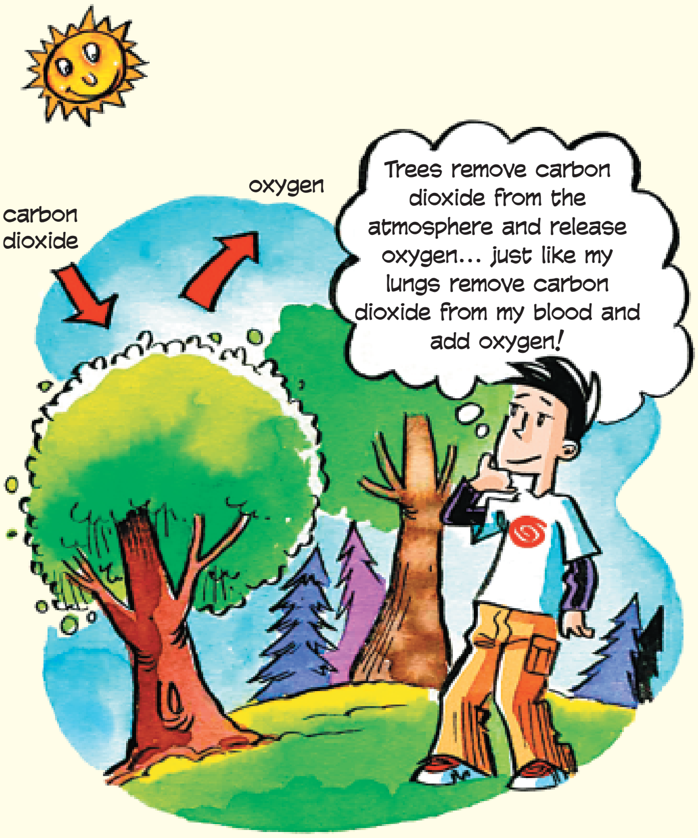
How does using models help each of the following professionals in their work?

- **a.** architects
- **b.** aviation engineers
- **c.** theatre directors
- **d.** geographers
- **e.** landscape designers

Using Analogies

An **analogy** is a comparison between two things that have some characteristic in common. Scientists use analogies to help explain difficult concepts. For example, scientists sometimes refer to plants as the lungs of Earth. Recall that plants take in carbon dioxide (CO_2) from the atmosphere to use during photosynthesis. Plants then release the oxygen (O_2) produced by photosynthesis back into the atmosphere.

In a sense, the plants are "breathing" for Earth. When animals breathe, they take oxygen into their lungs and give off carbon dioxide.



Thinking about photosynthesis in this way may help you to understand the function that plants have in ecosystems. This analogy will only work, though, if you have an idea what lungs do. If you don't know anything about lungs or what they do, an analogy involving lungs won't help you to understand photosynthesis.

Analogies use familiar situations to help explain unfamiliar situations. Picturing an everyday situation, such as the way water moves through a hose, may help you to picture an unfamiliar concept, such as how charge flows through an electric circuit. This is a useful analogy because most people have seen or used a hose, and have an understanding of how water moves through it.

Negative charges are pushed through a circuit in a similar way to how water is pushed through a hose.

Instant Practice—Using Analogies

1. Use an analogy to help explain how organisms in a food web are connected.
2. Look through Unit 4 of this text. Identify two analogies that are used in the unit.

How to Do a Research-Based Project

Imagine if your teacher simply stated that he or she wanted you to complete a research-based project on endangered species.

How do I get started?

This is a really big topic, and it is now your job to decide which smaller part of the topic you will research. One way to approach a research project is to break it up into four stages—exploring, investigating, processing, and creating.

Explore—Pick a Topic and Ask Questions

You need to start by finding out some general things about endangered species. Make a list of questions as you conduct your initial research, such as, What factors cause species to become endangered? Why does it matter? What types of species are endangered? Once you've done some research, you need to focus your topic into a research question.

What is a good research question?

Your research question needs to be specific enough that you can provide a thorough answer within the limits of your project (and in the time you have available). But it shouldn't be so specific that you can answer it in one paragraph!

Suppose, in the course of your research, you decided to learn more about polar bears. A good research question about polar bears would be, Why are polar bears endangered? An even better question could be, What can I do to help prevent polar bear extinction? Both of these questions are deep and can be subdivided into many subtopics.

Investigate—Research Your Topic

When putting together a research project, it is important to find reliable sources to help you answer your question. Before you decide to use a source that you find, you should consider whether it is reliable or whether it shows any bias.

Find Sources of Information There are many sources of information. For example, you can use a print resource, such as an encyclopedia from the reference section of the library.

Another approach is to go on-line and check the Internet. When you use the Internet, be careful about which sites you choose to search for information. You need to be able to determine the validity of a website before you trust the information you find on it.

How can I decide which websites to use?

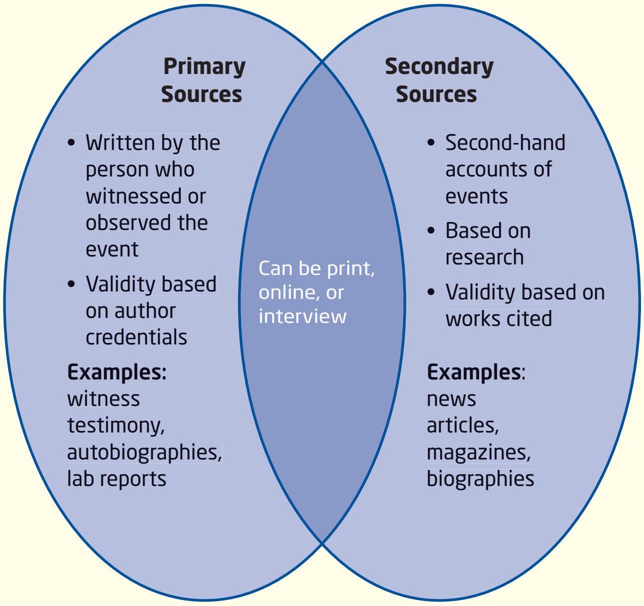
To do this, check that the author is identified, a recent publication date is given, and the source of facts or quotations is identified. It is also important that the website is published by a well-known company or organization, such as a college, university, or government agency.

What if I can't find any sources of information?

If you are having trouble finding *any* information about your topic, or if the only information you can find is on wiki or personal sites, you may want to consider changing your topic. You may also want to contact an expert on your topic. A credible expert has credentials showing his or her expertise in an area. For example, an expert may be a doctor or have a master's degree. Alternatively, an expert could have many years of experience in a specific career or field of study.

No matter which sources you use, it is your responsibility to be a critical consumer of information and to find trustworthy sources for your research.

You should also ask yourself if the sources you are using are primary or secondary. It is okay to use secondary sources, but you should try to include information from primary sources wherever possible.



Primary Sources

- Written by the person who witnessed or observed the event
- Validity based on author credentials

Examples: witness testimony, autobiographies, lab reports

Can be print, online, or interview

Secondary Sources

- Second-hand accounts of events
- Based on research
- Validity based on works cited

Examples: news articles, magazines, biographies

How do I decide whether a source is reliable and unbiased?

Two other things to check for in a source are reliability and bias. To check for reliability, try to find the same "fact" in two other sources. But keep in mind that even if you cannot find the same idea somewhere else, the source may still be reliable if it is a research paper or if it was written by an author with strong credentials. To check for bias, look for judgemental statements. Does the author tend to favour one side of an issue more than another? Are all sides of an issue treated equally? A good source shows little bias.

Source	Information	Reliability	Bias	Questions I Have
The Canadian Encyclopedia website	Polar bears inhabit ice and coastlines of arctic seas.	• author: Brian Knudsen • secondary source • has links to external sites that are reliable	only lists facts	• Why do they live on ice? • Why don't they move south?
Polar Bears International website	shrinking sea ice habitat	• date at bottom of page 2009 • non-profit organization	designed to save the polar bear	• Why is the ice shrinking?

Record Information

How can I organize my research?

As you find information, jot it down on sticky notes or use a chart similar to the one shown above. Sticky notes are useful because you can move them around, group similar ideas together, and reorganize your ideas easily. Using a different colour for each sub-question is even better! Remember to write the source of your information on each sticky note. In addition to writing down information that you find as you research, you should also write down any questions you think of as you go along.

Process—Ask More Questions and Revise Your Work

Now that you have done some research, what sub-questions have you asked? These are the subtopics of your research. Use the subtopics to find more specific information.

What if I have too much information—or not enough?

If you find that you have two or three sub-questions that have a lot of research supporting them and a few that do not have much research, do not be afraid to "toss out" some of the less important questions or ideas.

Don't steal ideas!

Avoid Plagiarism Copying information word-for-word and then presenting it as though it is your own work is called *plagiarism*. When you refer to your notes to write your project, put the information in your own words. It is also important to give credit to the original source of an idea.

Reveal your source!

Record Source Information Research papers always include a bibliography—a list of relevant information sources the authors consulted while preparing them. Bibliographic entries give the author, title, and facts of publication for each information source. Sometimes, you may want to give the exact source of information within the paper. This is done using footnotes. *Footnotes* identify the exact source (including page number) of quotations and ideas. Ask your teacher how you should prepare your list of works cited and your footnotes.

Create—Present Your Work

Before you choose a format for your final project, consider whether your researched information has answered the question you originally asked.

What if my research doesn't answer my question?

If you have not answered this question, you need to either refine your original question or do some more research! As long as your question still meets the criteria of your original assignment, it is okay to change the question so it focusses on the research you have already done. After all, you don't want your hard work to go to waste!

How should I present my work?

Check the guidelines that your teacher gave you. There may be specific instructions or criteria that will help you decide how to present your work. You also need to consider who the audience is for your project. How you format your final project will be very different if it is meant for a Grade 2 class compared to the president of a company or a government official. You could present your project as a poster, graphic organizer, blog, graphic novel, video, or research paper.

Instant Practice

1. Describe the steps you should follow in preparing a project on the topic of renewable forms of energy.
2. The following example is not an effective question on which to base a research project: *How many moons does Jupiter have?* Modify the question to make it an effective research question.
3. Assume that the target audience for your project is a group of Grade 6 students from a local elementary school. What aspects of your project would you need to modify so that you are reaching the intended audience? What would be the best format to use to present your project to your audience?

Using Electric Meters

Using Meters to Measure Potential Difference and Current

Types of Meters

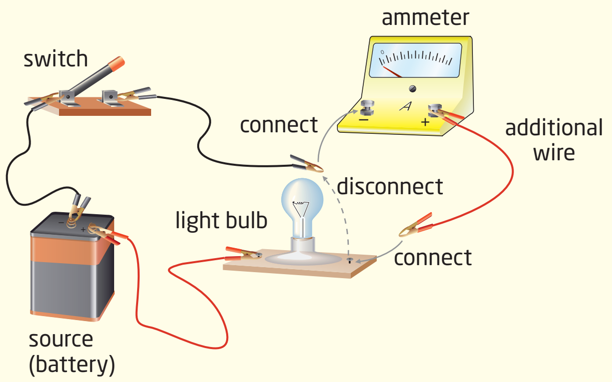
The meters you use in your classroom are either analogue meters or digital meters. **Analogue meters** have a needle pointing to a dial. **Digital meters** display measured values directly as numbers, similar to how a digital watch displays the time directly.

The Terminals of a Meter

All meters have two terminals (connecting points) that you connect to the circuit. The negative terminal (–) is black. The positive terminal (+) is red. In order not to damage the meter, you must take care to connect the meter so that its positive (red) terminal is connected to the positive side of the power source. That is, you should be able to trace from the positive (+) terminal on the meter back to the positive terminal at the source. The negative (–) terminal of the meter is always connected to the negative side of the source. The rule is "positive to positive, and negative to negative."

Connecting an Ammeter

An **ammeter** is used to measure the electrical current in a circuit. Current is the amount of charge passing a given point per second. To measure the current at a given location in an electric circuit, the ammeter must be connected so that all the current is allowed to pass through the ammeter. To do this, disconnect one end of a wire to give the same effect as cutting the circuit where you wish to measure the current. Imagine the ammeter and its connecting wires completing the circuit you just disconnected. Make sure the positive terminal on the ammeter traces back to the positive terminal at the source.



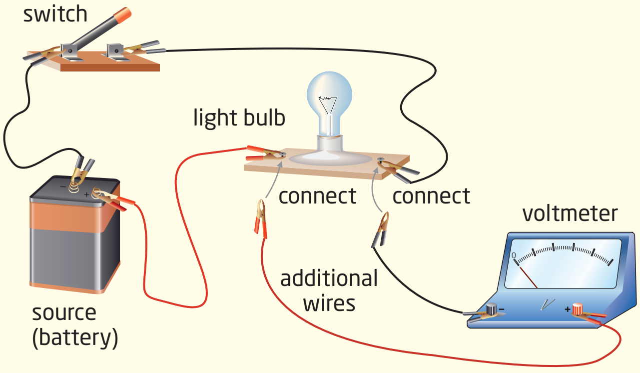
To measure the current through the light bulb, first disconnect the wire connected to the light bulb. Then insert the ammeter into the circuit.

A Analogue meters have a needle pointing to different scales.

B Digital meters display the numerical values directly.

Connecting a Voltmeter

A **voltmeter** is a device used to measure electric potential difference. A potential difference exists between two points in a circuit such as across a battery or a light bulb (load). When connecting a voltmeter to a circuit, you do not need to disconnect or open the circuit. Potential difference is measured between two points in a circuit. Therefore, connect the terminals of the voltmeter to the two connections on the component where you wish to measure the potential difference. Remember the rule "positive to positive and negative to negative," and make sure you can trace the connections on the voltmeter back to the same type of terminal at the source.



Voltmeters are connected across a component in the circuit.

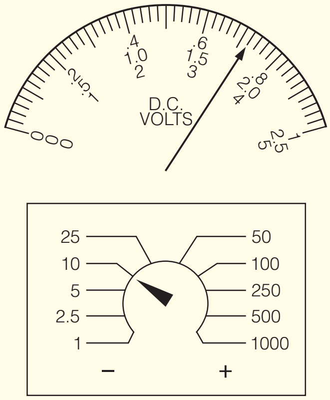
Connecting a Multimeter

Modern digital meters can also be multimeters. Multimeters can be used to measure potential difference, current, and other electrical properties. When using a multimeter, it is important that you position the dial on the correct setting for your application. As well, the connecting wires must be inserted into the correct meter terminals.

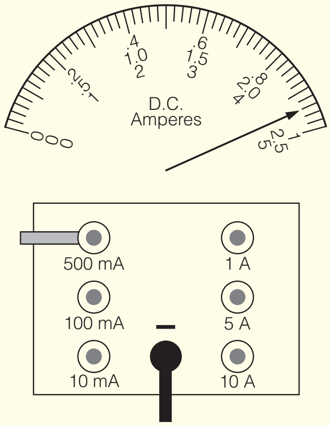
Reading a Meter

A digital meter is easy to read since the measured value is displayed directly as numbers. In order to get the most accurate reading on a digital meter, the meter needs to be set to the appropriate scale. The dial on a digital meter has several settings. For example, if the dial is set on the 2 V range, the meter will measure potential differences between zero and 2 V. Moving the dial to the 200 V setting will allow the meter to measure between zero and 200 V, but with less accuracy. Therefore, when using meters, you must choose the best setting for your measurement. The best approach is to set the meter on the largest scale to obtain an approximate value. Then lower the scale until you have the highest possible reading without going off scale.

This approach is the same for analogue meters. Some analogue meters have a dial, similar to a digital meter, that is used to change the scale. In other analogue meters, the scale is changed by how the wires are connected to the terminals. Once the scale is selected, you obtain your reading from the most appropriate display on the meter.



This voltmeter has its dial set at 10 V. To determine the measured potential difference, look for a number at the top of the scale with the same first digit as 10. The top scale has a maximum value of 1, so now the 1 represents 10 V. To read the scale, multiply the number the needle is pointing to by 10. The dial is reporting 7.2 V.

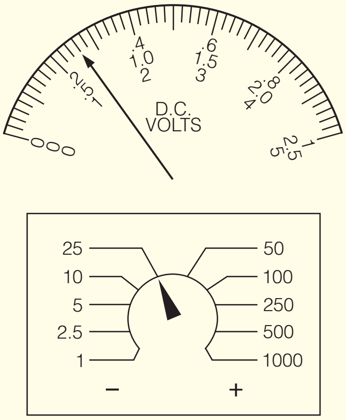


This ammeter has the positive wire connected to the 500 mA scale. The 5 on the bottom scale is the first digit in 500 mA, so the 5 now represents 500 mA. The needle is pointing to 4.7, so the meter is reporting 470 mA of current.

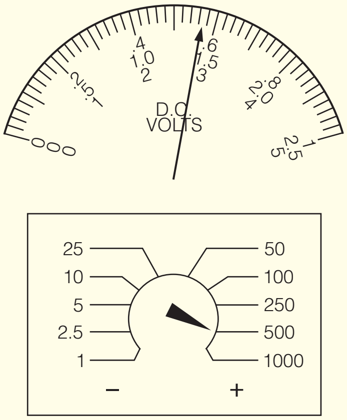
Instant Practice—Using Electric Meters

1. State the colour that is associated with
   a. the positive terminal of a meter
   b. the negative terminal of a meter
2. When you connect a meter to a circuit, to which side of the power source should you always connect the positive terminal of the meter?
3. For which type of meter do you need to disconnect the circuit before connecting the meter to the circuit?
4. A student wishes to use a meter to determine the most accurate measurement possible without damaging the meter. Describe the correct approach for choosing the appropriate scale.
5. Determine the value of current or potential difference indicated by meters A to D shown on this page.

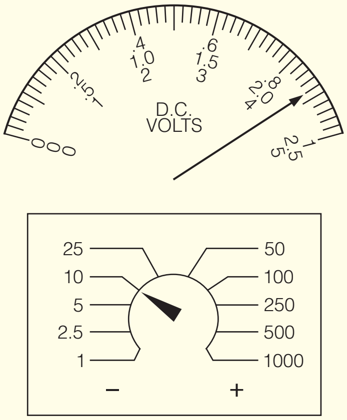
A



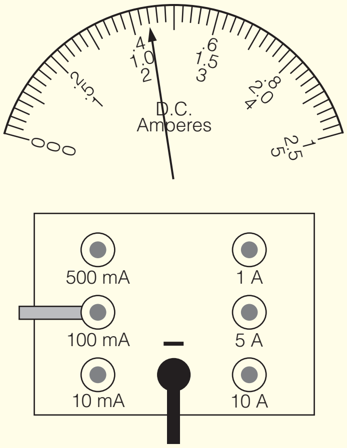
B



C



D



Science Skills Toolkit 10

Creating Data Tables

Scientific investigation is about collecting information to help you answer a question. In many cases, you will develop an hypothesis and collect data to see if your hypothesis is supported. An important part of any successful investigation includes recording and organizing your data. Often, scientists create tables in which to record data.

Planning to Record Your Data Suppose you are doing an investigation on the water quality of a stream that runs near your school. You will take samples of the numbers and types of organisms at two different locations along the stream. You need to decide how to record and organize your data. Begin by making a list of what you need to record. For this experiment, you will need to record the sample site, the pH of the water at each sample site, the types of organisms found at each sample site, and how many of each type of organism you collected.

Creating Your Data Table Your data table must allow you to record your data neatly. To do this you need to create

- headings to show what you are recording
- columns and rows that you will fill with data
- enough cells to record all the data
- a title for the table

In this investigation, you will find multiple organisms at each site, so you must make space for multiple recordings at each site. This means every row representing a sample site will have at least three rows associated with it for the different organisms.

If you think you might need extra space, create a special section. In this investigation, leave space at the bottom of your table, in case you find more than three organisms at a sample site. Remember, if you use the extra rows, make sure you identify which sample site the extra data are from.

Finally, give your table an appropriate title and a number. The title should appear above your table. Your data table might look like the one below.

Table 1 Observations Made at Two Sample Stream Sites

headings show what is being recorded

columns and rows contain data

Sample Site	pH	Type of Organism	Number of Organisms
1		beetle	3
		snail	1
		dragonfly larva	8
2		beetle	6
		dragonfly larva	7

extra rows to collect data in case you need to add observations

Instant Practice—Creating Data Tables

1. You are interested in how weeds grow in a garden. You decide to collect data from your garden every week for a month. You will identify the weeds and count how many there are of each type of weed. Design and draw a data table that you could use to record your data.
2. Many investigations have several different experimental treatments. Copy the following data table into your notebook and fill in the missing title and headings. The investigation tests the effect of increased fertilizer on plant height. There are four plants, and measurements are being taken every two days.

Day 1	Plant 1	5 mL	
	Plant 2	10 mL	10 cm
		15 mL	
		20 mL	

Numeracy Skills Toolkit 1

Scientific Notation

An exponent is the symbol or number expressing the power to which another number or symbol is to be raised, or the number of times the symbol or number (the base) is multiplied by itself. In 10^2, the exponent is 2 and the base is 10. So 10^2 means 10×10.

Table 1 Powers of 10

	Number	Power of 10
Thousands	1000	10^3
Hundreds	100	10^2
Tens	10	10^1
Ones	1	10^0
Tenths	0.1	10^{-1}
Hundredths	0.01	10^{-2}
Thousandths	0.001	10^{-3}

Why use exponents? Consider this. Mercury is about 58 000 000 km, or 58 000 000 000 m, from the Sun. If a zero were accidentally added to this number, the distance would appear to be 10 times larger than it actually is. To avoid mistakes when writing many zeros, scientists express very large and very small numbers in scientific notation.

In scientific notation, a number has the form

$x \times 10^n$ or base $\times$ 10^{exponent}

The base, x, is a number with only one digit to the left of the decimal. The exponent, n, is the number of times 10 is multiplied by itself, and then multiplied by the base.

When you are expressing a decimal number, the exponent will be negative.

$x \times 10^{-n}$

Again, the base, x is a number with only one digit to the left of the decimal. However, 10^{-n}, actually means $\frac{1}{10^n}$. It is the number of times $\frac{1}{10}$ is multiplied by itself, and then multiplied by the base.

Example 1

Mercury is about 58 000 000 000 m from the Sun. Write 58 000 000 000 in scientific notation.

Solution

58 000 000 000. ← The decimal point starts here.
Move the decimal point 10 places to the left.
$= 5.8 \times 10\,000\,000\,000$
$= 5.8 \times 10^{10}$

When you move the decimal point to the left, the exponent of 10 is positive. The number of places you move the decimal point is the number in the exponent.

Example 2

The electron in a hydrogen atom is, on average, 0.000 000 000 053 m from the nucleus. Write 0.000 000 000 053 in scientific notation.

Solution

The decimal point starts here. → 0.000 000 000 053
Move the decimal point
11 places to the right.
$= 5.3 \times 0.000\,000\,000\,01$
$= 5.3 \times 10^{-11}$

When you move the decimal point to the right, the exponent of 10 is negative. The number of places you move the decimal point is the number in the exponent.

Instant Practice—Scientific Notation

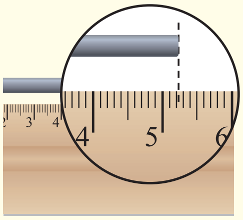
1. Express each of the following in scientific notation.
   - **a.** The approximate number of stars in our galaxy, the Milky Way:
     400 000 000 000 stars
   - **b.** The approximate distance of the Andromeda Galaxy from Earth:
     23 000 000 000 000 000 000 000 m
2. Change the following to standard form (long form of the number).
   - **a.** 9.8×10^5
   - **c.** 5.5×10^{-5}
   - **b.** 2.3×10^9
   - **d.** 6.5×10^{-10}

Numeracy Skills Toolkit 2

Significant Digits and Rounding

Significant Digits

Significant digits represent the amount of uncertainty in a measurement. The significant digits in a measurement include all the certain digits plus the first uncertain digit. In the example below, the length of the rod is between 5.2 cm and 5.3 cm. Suppose we estimate the length to be 5.23 cm. The first two digits (5 and 2) are certain (we can see those marks), but the last digit (0.03) was estimated, so it is uncertain. The measurement 5.23 cm has three significant digits.



Use these rules to determine the number of significant digits (s.d.) in a measurement.

1. All non-zero digits (1–9) are considered significant.

   Examples:
   - 123 m (3 s.d.); 23.56 km (4 s.d.)

2. Zeros between non-zero digits are also significant.

   Examples:
   - 1207 m (4 s.d.); 120.5 km/h (4 s.d.)

3. Any zero that follows a non-zero digit *and* is to the right of the decimal point is significant.

   Examples:
   - 12.50 m^2 (4 s.d.); 60.00 km (4 s.d.)

4. Zeros used to indicate the position of the decimal are *not* significant. These zeros are sometimes called spacers.

   Examples:
   - 500 km (1 s.d.); 0.325 m (3 s.d.); 0.000 34 km (2 s.d.)

5. All counting numbers have an infinite (never-ending) number of significant digits.

   Examples:
   - 6 apples (infinite s.d.); 125 people (infinite s.d.)

Using Significant Digits in Mathematical Operations

When you use measured values in calculations, the calculated answer cannot be more certain than the measurements on which it is based. The answer on your calculator may have to be rounded to the correct number of significant digits.

Rules for Rounding

1. When the first digit to be dropped is less than 5, the digit before it is not changed.

   Example: 6.723 m rounded to two significant digits is 6.7 m.

2. When the first digit to be dropped is 5 or greater, increase the digit before it by one.

   Example: 7.237 m rounded to three significant digits is 7.24 m. The digit after the 3 is greater than 5, so the 3 is increased by one.

Adding or Subtracting Measurements

Perform the mathematical operation, and then round off the answer to the value having the fewest *decimal places*.

Example: $x = 2.3 \text{ cm} + 6.47 \text{ cm} + 13.689 \text{ cm}$
$= 22.459 \text{ cm}$
$= 22.5 \text{ cm}$

Since 2.3 cm has only one decimal place, the answer can have only one decimal place.

Multiplying or Dividing Measurements

Perform the mathematical operation, and then round off the answer to the least number of *significant digits* of the data values.

Example: $x = (2.342 \text{ m})(0.063 \text{ m})(306 \text{ m})$
$= 45.149\ 076 \text{ m}^3$
$= 45 \text{ m}^3$

Since 0.063 m has only two significant digits, the answer must have two significant digits.

Numeracy Skills Toolkit 3

The Metric System

Throughout history, people have developed systems of numbering and measurement. When different groups of people began to communicate with each other, they discovered that their systems and units of measurement were different. Some groups of people created their own unique systems of measurement.

Today, scientists around the world use the metric system of numbers and units. The metric system is the official system of measurement in Canada.

The Metric System

The metric system is based on multiples of 10. For example, the basic unit of length is the metre. All larger units of length are expressed in units based on metres multiplied by 10, 100, 1000, or more. Smaller units of length are expressed in units based on metres divided by 10, 100, 1000, or more.

Each multiple of 10 has its own prefix (a syllable joined to the beginning of a word). For example, *kilo-* means multiplied by 1000. Thus, one kilometre is 1000 metres.

$$1 \text{ km} = 1000 \text{ m}$$

The prefix *milli-* means divided by 1000. So one millimetre is one thousandth of a metre.

$$1 \text{ mm} = \frac{1}{1000} \text{ m}$$

In the metric system, the same prefixes are used for nearly all types of measurements, such as mass, weight, area, and energy. A table of the most common metric prefixes is given at the top of the next column.

Table 1 Commonly Used Metric Prefixes

Prefix	Symbol	Relationship to the Base Unit
giga-	G	10^9 = 1 000 000 000
mega-	M	10^6 = 1 000 000
kilo-	k	10^3 = 1000
hecto-	h	10^2 = 100
deca-	da	10^1 = 10
— (Base Unit)	—	10^0 = 1
deci-	d	10^{-1} = 0.1
centi-	c	10^{-2} = 0.01
milli-	m	10^{-3} = 0.001
micro-	μ	10^{-6} = 0.000 001
nano-	n	10^{-9} = 0.000 000 001

Some Common Base Units:
length — m (metre)
mass — g (gram)
liquid volume — L (litre)
electrical energy usage — W (watt)

Instant Practice—Using Metric Measurements

1. What unit would you use to measure a distance one million (1 000 000 or 10^6) times the size of a metre?

2. What unit would you use to measure a volume that is one-thousandth (0.001 or 10^{-3} times) the size of a litre?

3. A hummingbird has a mass of 3.5 g. Express its mass in mg.

4. For an experiment, you need to measure 350 mL of dilute acetic acid. Express the volume in L.

5. A bald eagle has a wingspan up to 2.3 m. Express the length in cm.

6. A student added 0.0025 L of food colouring to water. Express the volume in mL.

The Easy Way to Do Metric Conversions

When you want to find the relationship between different metric units, you can use **Table 1** on page 368 to help you. You can quickly see how many factors of 10 separate the units if you count the number of rows in the table you need to jump to move from one unit to another.

Example 1

Find the relationship between centimetres and kilometers.

Solution

How many rows in the table do you jump to get from cm to km? Five

That means 1 km = 10^5 cm OR 1 cm = 10^{-5} cm. There are 10^5 or 100 000 cm in 1 km.

The relationship between centimetres and kilometres is $\frac{1\text{ cm}}{10^{-5}\text{ km}}$ or $\frac{10^5\text{ cm}}{1\text{ km}}$.

Example 2

There are 135 mg of sodium in a granola bar. Express this mass in kilograms.

Solution

There are six rows between mg and kg in the table, so 1 mg = 10^{-6} kg OR 1 kg = 10^6 mg.

135 mg = ______ kg

10^6 mg = 1 kg

$$(135\ \cancel{\text{mg}})\left(\frac{1\text{ kg}}{10^6\ \cancel{\text{mg}}}\right) = \frac{135\ \cancel{\text{mg}} \times 1\text{ kg}}{10^6\ \cancel{\text{mg}}}$$

135 mg = 0.000 135 kg or 1.35×10^{-4} kg

There are 1.35×10^{-4} kg of sodium in the granola bar.

You can actually use the metric prefixes table to help you convert units in another way that you might find easier. You can convert easily between metric units by moving the number's decimal to the left or to the right. The table of metric prefixes tells you how many places to move the decimal.

Converting to Larger Units

If you are converting from a small unit to a larger unit, you will move the decimal to the left and fill in the empty spots with zeros. How many places do you move the decimal?

Count the number of rows you need to jump to get from one unit to the other.

Example 3

Convert 5 cm into a measurement in metres.

Solution

How many rows do you jump to get from cm to m (the base unit) in the chart? Two.
Now move the decimal place in 5 two spaces to the left. Wait a minute! Where is the decimal in 5? Whenever a number doesn't seem to have a decimal, the decimal immediately follows the number.

5 = 5.

So if you move the decimal two places to the left, you get.

Now if you fill in the empty space with a zero, you get .05

So 5 cm = 0.05 m.

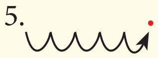
Converting to Smaller Units

If you are converting from a large unit to a smaller unit, you will move the decimal to the right and fill in the empty spots with zeros. Again, count the number of rows that you jump between units to decide how many places to move the decimal.

Example 4 Convert 5 km to a measurement in centimetres.

How many rows do you jump to get from km to cm? Five.

Now move the decimal five places to the right.



If you fill in the empty spaces with zeros, you get 500 000.

So 5 km = 500 000 cm.

Numeracy Skills Toolkit 4

Organizing and Communicating Scientific Results with Graphs

In your investigations, you will collect information, often in numerical form. To analyze and report the information, you will need a clear, concise way to organize and communicate the data.

A graph is a visual way to present data. A graph can help you to see patterns and relationships among the data. The type of graph you choose depends on the type of data you have and how you want to present them. You can use line graphs, bar graphs, and pie graphs (pie charts).

The instructions given here describe how to make graphs using paper and pencil. Computer software provides another way to generate graphs. Whether you make them on paper or on the computer, however, the graphs you make should have the features described in the following pages.

Drawing a Line Graph

A line graph is used to show the relationship between two variables. The following example will demonstrate how to draw a line graph from a data table.

Example

Suppose you have conducted a survey to find out how many students in your school are recycling drink containers. Out of 65 students that you surveyed, 28 are recycling cans and bottles. To find out if more recycling bins would encourage students to recycle cans and bottles, you add one recycling bin per week at different locations around the school. In follow-up surveys, you obtain the data shown in **Table 1**. Compare the steps in the procedure with the graph on the next page to learn how to make a line graph to display your findings.

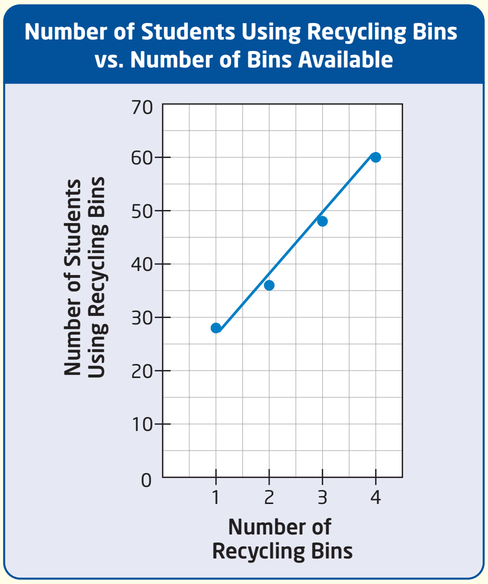
Table 1 Students Using Recycling Bins

Number of Recycling Bins	Number of Students Using Recycling Bins
1	28
2	36
3	48
4	60

Procedure

1. With a ruler, draw an *x*-axis and a *y*-axis on a piece of graph paper. (The horizontal line is the *x*-axis, and the vertical line is the *y*-axis.)
2. The independent (manipulated) variable is usually shown on the *x*-axis, while the dependent (responding) variable is shown on the *y*-axis. To label the axes, write "Number of Recycling Bins" along the *x*-axis and "Number of Students Using Recycling Bins" along the *y*-axis.
3. Now you have to decide what scale to use. You are working with two numbers (number of students and number of bins). You need to show how many students use the existing bin and how many would recycle if there were a second, a third, and a fourth bin. The scale on the *x*-axis will go from 0 to 4. There are 65 students, so you might want to use intervals of 5 for the *y*-axis. That means that every space on your *y*-axis represents 5 students. Use a tick mark at major intervals on your scale, as shown in the graph on the next page.
4. You want to make sure you will be able to read your graph when it is complete, so make sure your intervals on the *x*-axis are large enough.
5. To plot your graph, gently move a pencil up the *y*-axis until you reach a point just below 30 (you are representing 28 students). Now move along the line on the graph paper until you reach the vertical line that represents the first recycling bin. Place a dot at this point (1 bin, 28 students). Repeat this process for all of the data.

6. If it is appropriate, draw a line that connects all of the points on your graph. A graph showing yearly data that rises and falls without a predictable pattern might have a jagged line connecting all of the points. However, this is not always appropriate. Scientific investigations often involve quantities that change smoothly. In addition, experimental data points usually have some error. On a graph, this means that you should draw a smooth curve (or straight line) that has the general shape outlined by the points. This is called a **line of best fit**. If the points are almost in a straight line, draw a straight line as close to most of the points as possible. There should be about as many points above the line as there are below the line. If the data points do not appear to follow a straight line, then draw a smooth curve that comes as close to the points as possible. Think of the dots on your graph as clues about where the perfect smooth curve (or straight line) should go. A line of best fit shows the trend of the data. It can be extended beyond the first and last points to indicate what might happen.
7. Give your graph a title. Based on these data, what is the relationship between the number of students using recycling bins and the number of recycling bins?



Line Graphs of Potential Difference, Current, and Resistance

While most line graphs have the independent variable on the *x*-axis and the dependent variable on the *y*-axis, this is usually not the case for graphs showing the relationship between potential difference and current, potential difference and resistance, or current and resistance.

- In a graph of potential difference and current, the potential difference is shown on the *y*-axis and current is shown on the *x*-axis, even when potential difference is the independent variable. This is because there is a special relationship between potential difference and current that can be shown by graphing them this way.
- In a graph of potential difference and resistance, potential difference is usually shown on the *y*-axis and resistance is shown on the *x*-axis.
- In a graph of current and resistance, current is usually shown on the *y*-axis and resistance is shown on the *x*-axis.

Instant Practice—Line Graph

The level of ozone in Earth's upper atmosphere is measured in Dobson units (DU). Using the information in the table below, create a line graph showing what happened to the amount of ozone over Antarctica during a period of 35 years.

Table 2 Ozone Levels in Earth's Upper Atmosphere

Year	Total Ozone (DU)
1965	280
1970	280
1975	275
1980	225
1985	200
1990	160
1995	110
2000	105

Constructing a Bar Graph

Bar graphs help you to compare a numerical quantity with some other category at a glance. The second category may or may not be a numerical quantity. It could be places, items, organisms, or groups, for example.

Example

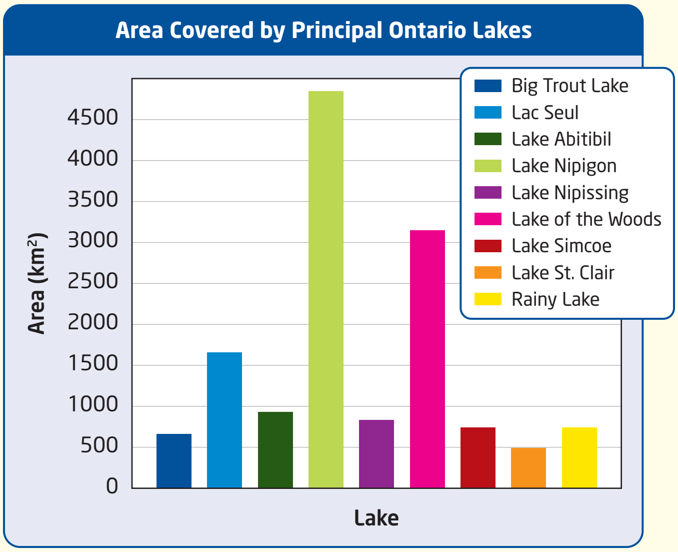
To learn how to make a bar graph to display the data in **Table 3** below, examine the graph in the column as you read the steps that follow.

Table 3 Area Covered by Principal Ontario Lakes

Lake	Area (km²)
Big Trout Lake	661
Lac Seul	1657
Lake Abitibi	931
Lake Nipigon	4848
Lake Nipissing	832
Lake of the Woods	3150
Lake Simcoe	744
Lake St. Clair	490
Rainy Lake	741

Procedure

1. Draw your x-axis and y-axis on a sheet of graph paper. Label the x-axis "Ontario Lakes" and the y-axis "Area (km^2)."
2. Look at the data carefully in order to select an appropriate scale. Write the scale of your y-axis.
3. Using Big Trout Lake and 661 as the first pair of data, move along the x-axis the width of your first bar, then go up the y-axis to 661. Use a pencil and ruler to draw in the first bar lightly. Repeat this process for the other pairs of data.
4. When you have drawn all of the bars, add labels on the x-axis to identify the bars. Alternatively, use colour to distinguish among them.
5. If you are using colour to distinguish among the bars, you will need to make a legend or key to explain the meaning of the colours. Write a title for your graph.



Instant Practice—Bar Graph

Make a vertical bar graph using **Table 5**, which shows each planet's gravitational force in relation to Earth's gravity.

Table 4 Gravitational Pull of Planets

Planet	Gravitational Pull (*g*)
Mercury	0.40
Venus	0.90
Earth	1.00
Mars	0.40
Jupiter	2.50
Saturn	1.10
Uranus	0.90
Neptune	1.10

Constructing a Pie Graph

A pie graph (sometimes called a pie chart) uses a circle divided into sections (like pieces of pie) to show the data. Each section represents a percentage of the whole. All sections together represent all (100 percent) of the data.

Example

To learn how to make a pie graph from the data in **Table 5**, study the corresponding pie graph on the right as you read the following steps.

Table 5 Birds Breeding in Canada

Type of Bird	Number of Species	Percent of Total	Degrees in Section
Ducks	36	9.0	32
Birds of prey	19	4.8	17
Shorebirds	71	17.7	64
Owls	14	3.5	13
Perching birds	180	45.0	162
Other	80	20.0	72

Procedure

1. Use a mathematical compass to make a large circle on a piece of paper. Make a dot in the centre of the circle.
2. Determine the percent of the total number of species that each type of bird represents by using the following formula.

$$\text{Percent of total} = \frac{\text{Number of species within the type}}{\text{Total number of species}} \times 100\%$$

For example, the percent of all species of birds that are ducks is

$$\text{Percent that are ducks} = \frac{\text{36 species of ducks}}{\text{400 species}} \times 100\% = 9.0\%$$

3. To determine the number of degrees in the section that represents each type of bird, use the following formula.

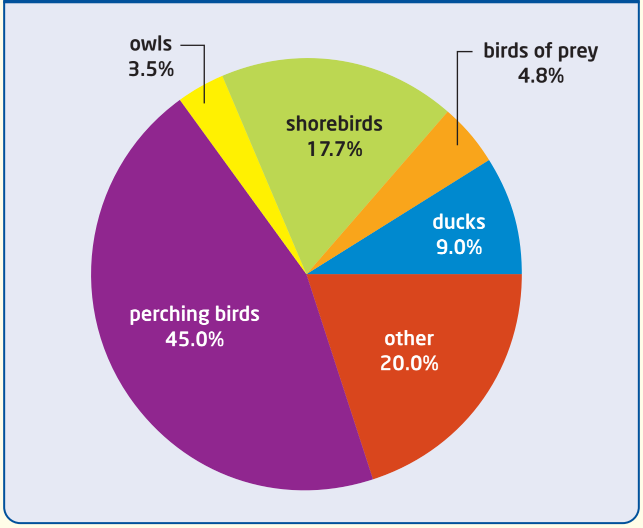
$$\text{Degrees in "piece of pie"} = \frac{\text{Percent for a type of bird}}{100\%} \times 360^\circ$$

Round your answer to the nearest whole number. For example, the section for ducks is

$$\text{Degrees for ducks} = \frac{9.0\%}{100\%} \times 360^\circ = 32.4^\circ \text{ or } 32^\circ$$

4. Draw a straight line from the centre to the edge of the circle. Use your protractor to measure 32° from this line. Make a mark, then use your mark to draw a second line 32° from the first line.
5. Repeat steps 2 to 4 for the remaining types of birds.

Species of Birds Breeding in Canada



Instant Practice—Pie Graph

Use the following data on total energy (oil, gas, electricity, etc.) consumption for 2004 to develop a pie graph to visualize energy consumption in the world.

Table 6 World Energy Consumption in 2004

Area in the World	Consumption (quadrillion btu)
North America	120.62
Central and South America	22.54
Europe	85.65
Eurasia	45.18
Middle East	21.14
Africa	13.71
Eastern Asia and Oceania	137.61

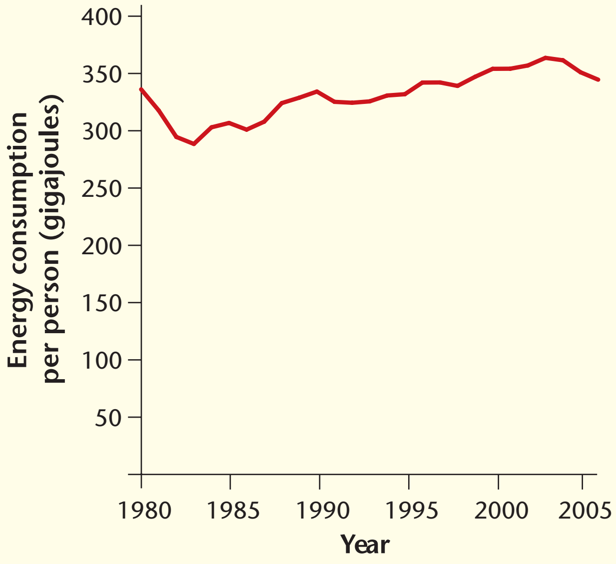
Choosing the Right Graph for the Job

It is important to choose the appropriate type of graph to organize and communicate your data. Some guidelines are given below.

Line Graphs

Line graphs are useful for

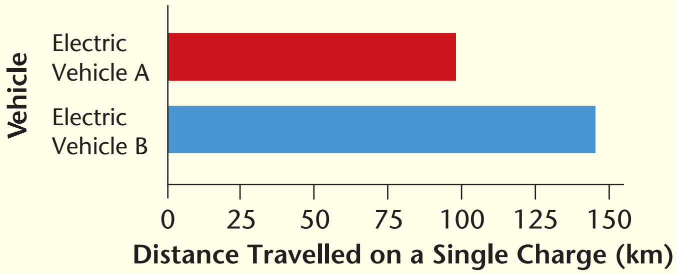
- making comparisons between a large number of categories or across a range of values for the variable that is being tested. For example, the graph below shows the annual energy usage per person from 1980 to 2006. Time is the variable being tested or considered.
- showing general trends in the relationship between variables. Does an increase in the manipulated (independent) variable cause an increase or a decrease in the responding (dependent) variable?
- finding the mathematical relationship between two variables. Rates and ratios can be calculated from a line showing how a variable changes over time.



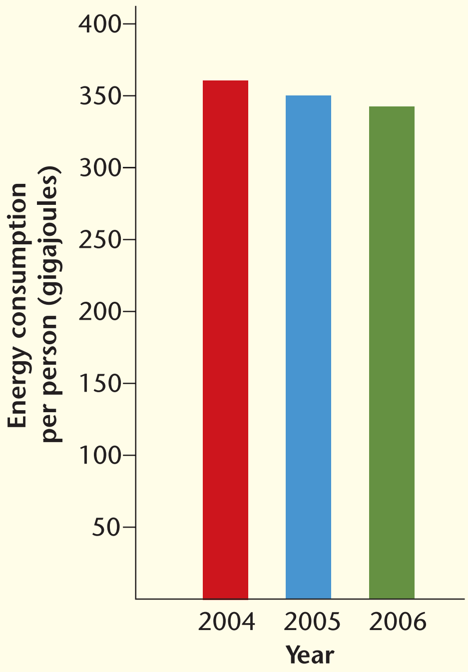
Bar Graphs

Bar graphs are useful for

- comparing a responding (dependent) variable between two distinct types of things, such as plant cells and animal cells, or between competing things, such as brands of a product. For example, this graph compares the distance travelled on a single charge by two different electric cars.



- comparing a responding (dependent) variable among categories within a group, such as provinces in Canada, months in a year, or planets in the Solar System.
- reporting the results of surveys. For example, you might want to show how many people said "Yes" and how many said "No" to each question on a survey.
- showing annual changes. For example, you might use a bar graph to show how energy usage had changed from 2004 to 2006. (However, if you were comparing a large number of categories, such as annual energy use from 1980 to 2006, it would be better to use a line graph.)



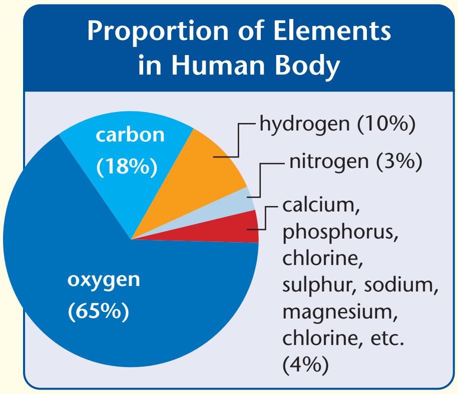
Pie Graphs

Pie graphs are useful for

- quick visual comparisons of proportions between segments of a whole.
- showing, at a glance, the most common category within a fixed set of categories. For example the pie graph on page 373 shows that perching birds are the most common category of the breeding birds sampled.

Limitations of pie graphs include the following:

- They cannot be used to show change over time. They are a snapshot of data collected at one specific time.
- They cannot be used to show complex relationships between variables.
- They must represent categories as percentages of a whole.
- It is difficult to compare similar categories unless the percentages represented by each slice of the pie are clearly labelled, as they are in this example from Unit 2.



Instant Practice—Choosing Graph Types

What would be the best type(s) of graph to use for each purpose?

1. calculating the rate at which a chemical reaction takes place
2. comparing the gravitational pull of each of the planets in our Solar System
3. showing how production of hydroelectricity has changed from 1960 to today
4. comparing the amount of each chemical element present in a product
5. showing the relationship between world population and degree of global warming.

Numeracy Skills Toolkit 5

The GRASP Problem Solving Method

Solving any problem is easier when you establish a logical, step-by-step procedure. One useful method for solving numerical problems includes five basic steps: **Given**, **Required**, **Analysis**, **Solution**, and **Paraphrase**. You can easily remember these steps because the first letter of each word spells the word GRASP.

Example of the GRASP Problem Solving Method

Ruby can afford to spend $45.00 this month on electricity. The company that supplies her home with electrical energy charges 10.9¢ per kWh. Based on her budget, how many kWh of electrical energy can she use in a month?

Given—Organize the given data.

budget = $45.00
cost of electrical energy = 10.9¢/kWh

Required—Identify what information the problem requires you to find.

amount of electrical energy that can be used (kWh)

Analysis—Decide how to solve the problem.

1. Convert cents into dollars. (The units given for Ruby's budget—dollars—do not match the units given for the cost of 1 kWh of electrical energy—cents. Both units need to be the same.)
2. Calculate the number of kWh Ruby can afford to use.
   total cost = amount of energy used × cost per unit of energy

Solution—Solve the problem.

1. Convert units

$1.00 = 100¢

10.9¢ =

$$(10.9¢) \times \left(\frac{\$1.00}{100¢}\right) = \$0.109$$

2. Use the total cost equation.

total cost = (amount of energy used)(cost per unit of energy)

$$\frac{\text{total cost}}{\text{cost per unit of energy}} = \frac{(\text{amount of energy used})\cancel{(\text{cost per unit of energy})}}{\cancel{\text{cost per unit of energy}}}$$

$$\text{amount of energy used} = \frac{\text{total cost}}{\text{cost per unit of energy}}$$

$$\text{amount of energy used} = \frac{\$45.00}{\$0.109}$$

= 413 kWh

Paraphrase—Restate the solution and check your answer.

Restate Ruby has a budget of $45.00 and electrical energy costs 10.9¢, so she can afford to use 413 kWh of electrical energy this month.

Check Multiply the cost of electrical energy by the answer, and you should get $45.00. Round off the numbers to do a quick estimate. If you multiply $0.11 by 400 kWh, you get $44.00, so you know that your answer is reasonable.

Instant Practice—Using GRASP

The company that supplies Ruby's electrical energy raises the price to 11.1¢/kWh. Use the GRASP method to calculate how much Ruby's monthly energy bill will be if she uses 375 kWh.

Preparing for Reading

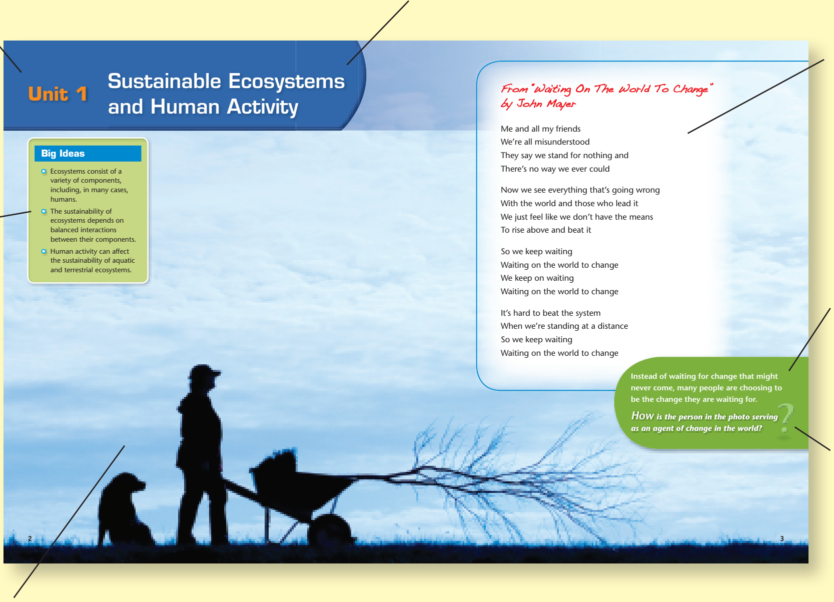
Previewing Text Features

Before you begin reading a textbook, become familiar with the book's overall structure and features. This will help you understand where information can be found and how it will be presented. If you look at the Table of Contents on page v, you will see that this textbook is divided into four *units*. Each unit is divided into *topics*.

The Unit Opener

Each unit begins with a unit opener. It includes several features that will help to get you thinking about the unit. Examine the sample unit opener that is reproduced below.

- The unit number appears at the top left corner of the unit opener in large orange type.
- The unit title appears beside the unit number in large white type.



Unit 1 Sustainable Ecosystems and Human Activity

Big Ideas

- Ecosystems consist of a variety of components, including, in many cases, humans.
- The sustainability of ecosystems depends on balanced interactions between their components.
- Human activity can affect the sustainability of aquatic and terrestrial ecosystems.

From "Waiting On The World To Change"
by John Mayer

Me and all my friends
We're all misunderstood
They say we stand for nothing and
There's no way we ever could

Now we see everything that's going wrong
With the world and those who lead it
We just feel like we don't have the means
To rise above and beat it

So we keep waiting
Waiting on the world to change
We keep on waiting
Waiting on the world to change

It's hard to beat the system
When we're standing at a distance
So we keep waiting
Waiting on the world to change

Instead of waiting for change that might never come, many people are choosing to be the change they are waiting for.

***How** is the person in the photo serving as an agent of change in the world?*

- The lyrics to a song appear in a white box. These lyrics relate to one or more ideas you will explore in the unit.
- The big ideas of the unit are summarized within a light green box. These are the main points that you should keep in mind as you proceed through the unit.
- A statement relates the image or the lyrics, or both, to the content of the unit.
- A question gets you thinking about some of the ideas you will explore in the unit.
- The image relates to the content of the unit. It will get you thinking about ideas you will explore further within the unit.

Instant Practice

1. From what unit is the above sample taken? What does this unit opener tell you about the unit?
2. What is the purpose of each of the features in the unit opener?
3. Find the unit opener for Unit 2. What are the big ideas in that unit?

Preparing for Reading

Previewing Text Features

The Topic Opener

Each unit is broken into *topics*. Each topic explores a question related to the unit. The topic opener contains information about what concepts you will explore, what skills you will develop, and what vocabulary you will learn throughout the topic. It also includes a general introduction to the topic and an activity to get you started. A sample topic opener is shown below.

- The topic number includes the unit number (1) followed by the topic number (1). It appears in the top left corner of the topic opener.
- The topic question forms the title for the topic. It appears in large blue print beside the topic number.
- A brief section of text introduces the topic and prepares you to read further.

Topic 1.1 What are ecosystems, and why do we care about them?

Key Concepts

- Ecosystems are about connections.
- Ecosystems are made up of biotic (alive) and abiotic (not alive) parts that interact.
- Interactions between terrestrial (land) ecosystems and aquatic (water) ecosystems keep all ecosystems healthy.

Key Skills

Inquiry
Literacy

Key Terms

ecology
biotic
abiotic
ecosystem
terrestrial ecosystem
aquatic ecosystem

Everywhere in the world around you, living things are scurrying across the ground, burrowing through the soil, floating in the water, and soaring through the air. Each and every living thing makes its home somewhere. Even your armpit is an attractive home for many forms of life! In fact, dozens of kinds of microscopic organisms live on and inside your body.

Why do some organisms inhabit your body, while others make their home in spruce trees? It all comes down to basic needs. Living things make their homes in the places they do, because these places provide them with what they need to survive.

Starting Point Activity

1. How many ecosystems can you see on these two pages? (Hint: First discuss what the word "ecosystem" means.)
2. Name at least three things that people, trees, and other living things need to survive.
3. State three reasons why a woodpecker can make its home on a spruce tree but not on a human being.

8 MHR • UNIT 1

TOPIC 1.1 WHAT ARE ECOSYSTEMS, AND WHY DO WE CARE ABOUT THEM? • MHR 9

- Each topic is broken into key concepts, or important points, that answer the topic question. These are listed as bullet points.
- Key skills are developed through activities within the topic. They are listed below the Key Concepts.
- Key terms are important words that are defined within the topic. They are listed below the Key Skills.
- A starting point activity lets you explore what you already know about the topic before reading any further.
- One or more images show examples that relate to the topic question.
- A curved green panel on the left side of the left page signals the beginning of a new topic.
- The topic number and title appear again at the bottom right corner of the topic opener. This is called a footer. It also includes the page number and information about the publisher (MHR stands for McGraw-Hill Ryerson).

Instant Practice

1. Describe two pieces of information that you can find in a topic opener.
2. Find the topic question for another topic in Unit 1. How does the image(s) in the topic opener relate to the question?

Preparing for Reading

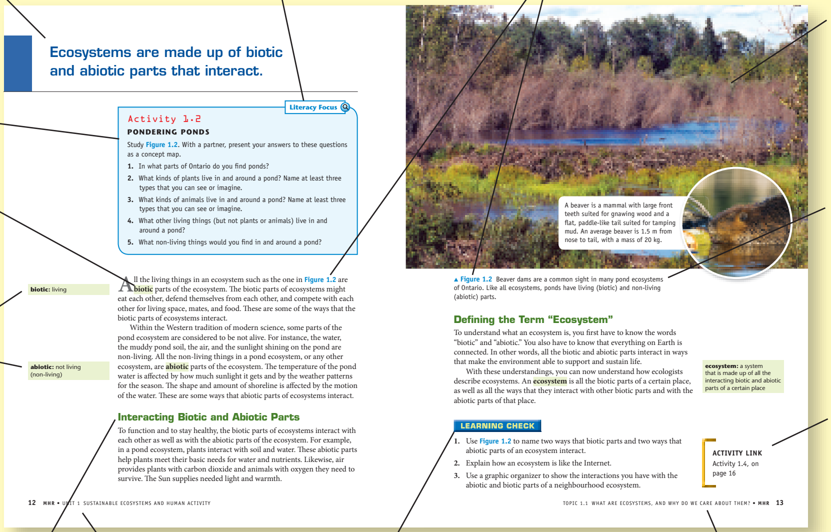
Previewing Text Features

The Main Text

Most of the information related to the key concepts of a unit appears in the main text pages of each topic. This is where you will explore the topic questions in detail, find definitions for important vocabulary, and develop skills through activities related to the topic. Each key concept within a topic takes up one or two pages. These pages contain many features designed to help you find your way while reading.

Examine the pages below. They include several features that will help you understand the content.

- The key concept appears in large blue print at the top of the page.
- Activities are labelled with a key skill focus, such as literacy, numeracy, inquiry, or research.
- Important visuals and their references within the text are identified by a blue figure number.



Ecosystems are made up of biotic and abiotic parts that interact.

Literacy Focus

Activity 1.2

PONDERING PONDS

Study Figure 1.2. With a partner, present your answers to these questions as a concept map.

1. In what parts of Ontario do you find ponds?
2. What kinds of plants live in and around a pond? Name at least three types that you can see or imagine.
3. What kinds of animals live in and around a pond? Name at least three types that you can see or imagine.
4. What other living things (but not plants or animals) live in and around a pond?
5. What non-living things would you find in and around a pond?

biotic: living

abiotic: not living (non-living)

All the living things in an ecosystem such as the one in Figure 1.2 are **biotic** parts of the ecosystem. The biotic parts of ecosystems might eat each other, defend themselves from each other, and compete with each other for living space, mates, and food. These are some of the ways that the biotic parts of ecosystems interact.

Within the Western tradition of modern science, some parts of the pond ecosystem are considered to be not alive. For instance, the water, the muddy pond soil, the air, and the sunlight shining on the pond are non-living. All the non-living things in a pond ecosystem, or any other ecosystem, are **abiotic** parts of the ecosystem. The temperature of the pond water is affected by how much sunlight it gets and by the weather patterns for the season. The shape and amount of shoreline is affected by the motion of the water. These are some ways that abiotic parts of ecosystems interact.

Interacting Biotic and Abiotic Parts

To function and to stay healthy, the biotic parts of ecosystems interact with each other as well as with the abiotic parts of the ecosystem. For example, in a pond ecosystem, plants interact with soil and water. These abiotic parts help plants meet their basic needs for water and nutrients. Likewise, air provides plants with carbon dioxide and animals with oxygen they need to survive. The Sun supplies needed light and warmth.

12 MHR • UNIT 1 SUSTAINABLE ECOSYSTEMS AND HUMAN ACTIVITY

A beaver is a mammal with large front teeth suited for gnawing wood and a flat, paddle-like tail suited for tamping mud. An average beaver is 1.5 m from nose to tail, with a mass of 20 kg.

▲ Figure 1.2 Beaver dams are a common sight in many pond ecosystems of Ontario. Like all ecosystems, ponds have living (biotic) and non-living (abiotic) parts.

Defining the Term "Ecosystem"

To understand what an ecosystem is, you first have to know the words "biotic" and "abiotic." You also have to know that everything on Earth is connected. In other words, all the biotic and abiotic parts interact in ways that make the environment able to support and sustain life.

With these understandings, you can now understand how ecologists describe ecosystems. An **ecosystem** is all the biotic parts of a certain place, as well as all the ways that they interact with other biotic parts and with the abiotic parts of that place.

ecosystem: a system that is made up of all the interacting biotic and abiotic parts of a certain place

LEARNING CHECK

1. Use Figure 1.2 to name two ways that biotic parts and two ways that abiotic parts of an ecosystem interact.
2. Explain how an ecosystem is like the Internet.
3. Use a graphic organizer to show the interactions you have with the abiotic and biotic parts of a neighbourhood ecosystem.

ACTIVITY LINK
Activity 1.4, on page 16

TOPIC 1.1 WHAT ARE ECOSYSTEMS, AND WHY DO WE CARE ABOUT THEM? • MHR 13

- Figures help to explain the text in a visual way.
- Activities appear in a pale blue box.
- Key terms are highlighted in pale green. They also appear in **bold** (dark) print.
- Captions describe or give extra information about images.
- Key terms are defined in the margin, close to where they appear in the text. Definitions are also highlighted in pale green.
- Activity Links give the page numbers of related activities that appear later in the textbook.
- Headings in green print break the text into chunks. These headings give you a clue to what you are about to read.
- The unit number and title appears in the footer on the left page.
- Learning Check questions help you review what you have just read. If you cannot answer these questions, reread the text on these two pages.
- The topic number and title appears in the footer on the right page.

Instant Practice

1. Describe two ways to identify the key terms in a section.
2. Describe two ways to learn more about a visual in this textbook.

Preparing for Reading

Making Connections to Images

Images help to explain or expand on information in the text. Making connections to images help you understand their purpose and meaning. When you look at an image such as the one below (from page 175), start by reading the caption. The caption tells you what is in the image. It may also provide some interesting details.

◂ **Figure 3.6** The Andromeda galaxy is the nearest large galaxy to our own and the most distant object that is still visible to the unaided eye. It is 2.3 million light-years away.

Some people read a textbook by reading the text first and then looking at the images. Other people "read" the images first. If you start by looking at the image, use the figure number to find more information. The figure number in the caption has a matching reference in the text, and both are in bright blue print. The text will tell you more about the figure and how it relates to a key concept.

As you examine an image, think about the answers to these questions:

1. What personal connections can I make to the image, based on what I already know?
2. What do the text and the caption tell me about the image?
3. What else might be in the scene that the image does *not* show?
4. What questions do I have about the image that the text and caption do not answer?

In some places in the textbook, an image may appear without a figure number or a caption. Sometimes the caption is left out because the image is part of an activity. In other places, such as the topic opener, the main text tells you more about the image. Sometimes, the caption is left out on purpose, so that you will ask yourself questions about the image:

1. What does the image show?
2. Why did the author include it?
3. How does it relate to the text?

Literacy Skills Toolkit 2

Reading Effectively

Identifying the Main Idea and Details

The *main* idea of a text is the *most important* idea. Here are some strategies for identifying the main idea of a topic or paragraph.

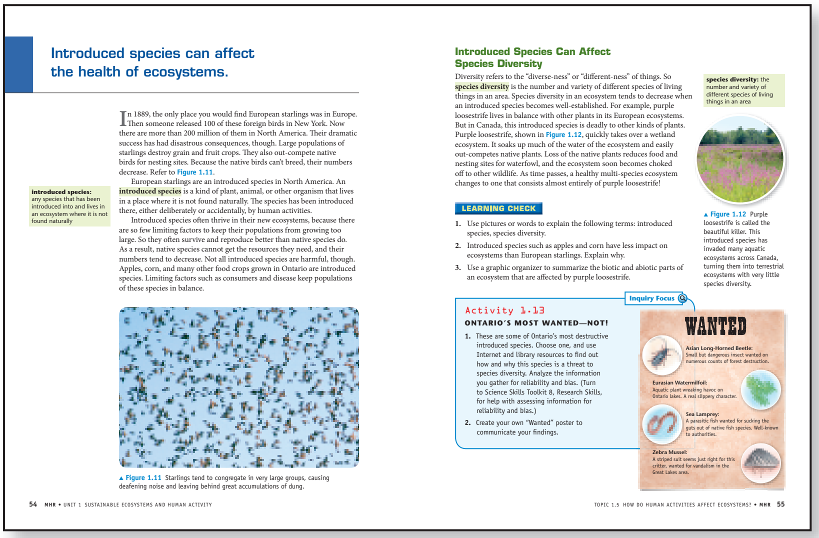
- Pay attention to titles, headings, and subheadings. Note how print size and colour help you identify each of these.
- Look at the images on the page to get a general idea of the content.
- Note any terms that appear in **bold** or *italic* print. Bold print is used to identify key terms. Italics are used to add emphasis to other important words.

Details in the text *support and explain* the main idea. Details might be facts or examples. These phrases are clues that details will follow:

- For instance
- For example
- ...such as

Instant Practice

1. Examine the pages below and identify clues that hint at the main idea.



Introduced species can affect the health of ecosystems.

In 1889, the only place you would find European starlings was in Europe. Then someone released 100 of these foreign birds in New York. Now there are more than 200 million of them in North America. Their dramatic success has had disastrous consequences, though. Large populations of starlings destroy grain and fruit crops. They also out-compete native birds for nesting sites. Because the native birds can't breed, their numbers decrease. Refer to Figure 1.11.

European starlings are an introduced species in North America. An **introduced species** is a kind of plant, animal, or other organism that lives in a place where it is not found naturally. The species has been introduced there, either deliberately or accidentally, by human activities.

introduced species: any species that has been introduced into and lives in an ecosystem where it is not found naturally

Introduced species often thrive in their new ecosystems, because there are so few limiting factors to keep their populations from growing too large. So they often survive and reproduce better than native species do. As a result, native species cannot get the resources they need, and their numbers tend to decrease. Not all introduced species are harmful, though. Apples, corn, and many other food crops grown in Ontario are introduced species. Limiting factors such as consumers and disease keep populations of these species in balance.

▲ Figure 1.11 Starlings tend to congregate in very large groups, causing deafening noise and leaving behind great accumulations of dung.

54 MHR • UNIT 1 SUSTAINABLE ECOSYSTEMS AND HUMAN ACTIVITY

Introduced Species Can Affect Species Diversity

Diversity refers to the "diverse-ness" or "different-ness" of things. So **species diversity** is the number and variety of different species of living things in an area. Species diversity in an ecosystem tends to decrease when an introduced species becomes well-established. For example, purple loosestrife lives in balance with other plants in its European ecosystems. But in Canada, this introduced species is deadly to other kinds of plants. Purple loosestrife, shown in Figure 1.12, quickly takes over a wetland ecosystem. It soaks up much of the water of the ecosystem and easily out-competes native plants. Loss of the native plants reduces food and nesting sites for waterfowl, and the ecosystem soon becomes choked off to other wildlife. As time passes, a healthy multi-species ecosystem changes to one that consists almost entirely of purple loosestrife!

species diversity: the number and variety of different species of living things in an area

▲ Figure 1.12 Purple loosestrife is called the beautiful killer. This introduced species has invaded many aquatic ecosystems across Canada, turning them into terrestrial ecosystems with very little species diversity.

LEARNING CHECK

1. Use pictures or words to explain the following terms: introduced species, species diversity.
2. Introduced species such as apples and corn have less impact on ecosystems than European starlings. Explain why.
3. Use a graphic organizer to summarize the biotic and abiotic parts of an ecosystem that are affected by purple loosestrife.

Inquiry Focus

Activity 1.13

ONTARIO'S MOST WANTED—NOT!

1. These are some of Ontario's most destructive introduced species. Choose one, and use Internet and library resources to find out how and why this species is a threat to species diversity. Analyze the information you gather for reliability and bias. (Turn to Science Skills Toolkit 8, Research Skills, for help with assessing information for reliability and bias.)
2. Create your own "Wanted" poster to communicate your findings.

TOPIC 1.5 HOW DO HUMAN ACTIVITIES AFFECT ECOSYSTEMS? • MHR 55

2. Here is a section of text from the pages shown above. Can you identify any details in this text that might support the main idea?

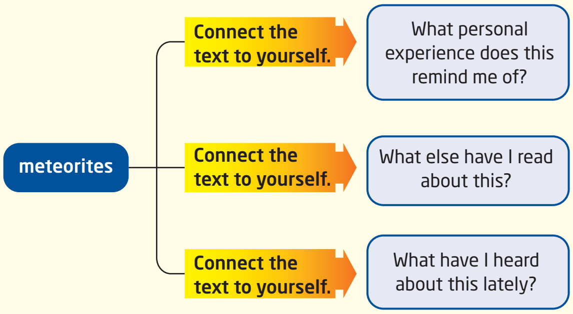
Introduced Species Can Affect Species Diversity

Diversity refers to the "diverse-ness" or "different-ness" of things. So **species diversity** is the number and variety of different species of living things in an area. Species diversity in an ecosystem tends to decrease when an introduced species becomes well-established. For example, purple loosestrife lives in balance with other plants in its European ecosystems. But in Canada, this introduced species is deadly to other kinds of plants. Purple loosestrife, shown in **Figure 1.12**, quickly takes over a wetland ecosystem. It soaks up much of the water of the ecosystem and easily out-competes native plants. Loss of the native plants reduces food and nesting sites for waterfowl, and the ecosystem soon becomes choked off to other wildlife. As time passes, a healthy multi-species ecosystem changes to one that consists almost entirely of purple loosestrife!

Reading Effectively

Making Connections to What You Already Know

You may already know some facts about the concept you are studying. You may have gathered knowledge from reading other texts, from the news, or from your own experiences. This knowledge can help you understand new information.



In Topic 3.3, you will learn about meteorites. You can use a **concept map** like the one above to organize what you already know about meteorites.

Making Inferences (Reading Between the Lines)

Often, a text does not contain *all* the details related to a particular topic. Some details or connections between ideas may be hinted at rather than stated clearly. The writer relies on you to make inferences, or "read between the lines." This involves combining information in the text with what you already know. It also involves thinking about how two pieces of information are related.

Read the following text:

By cutting down a forest near a stream, tree roots that once trapped soil wither and die. Soil and nutrients wash into the stream, and this can harm or kill fish and other living things.

Ask yourself questions about the text and organize your thoughts in a graphic organizer like the one below.

What information does the text provide? The text says...	→	Cutting down a forest near a stream can kill or harm fish.
What does this tell you about forests and nearby streams? The text says.../I think...	→	Forests and nearby streams are connected.
What do you already know about forests? I say...	→	People sometimes cut down trees in forests.
What connection can you make between what you already know and what you just read? And so...	→	Cutting down trees could harm or kill fish in nearby streams.

Reading Effectively

Skim, Scan, or Study

Not all parts of a textbook should be read at the same speed. In general, how fast you should read a chunk of text depends on your purpose for reading. **Table 1** shows three reading speeds, each suiting a different purpose for reading.

Sometimes the features of the text can help you decide how fast you should read. For example, if you see a page that contains several bold, highlighted key terms, you should read the text slowly and carefully. Text in a topic opener can be read more quickly, since it is only an introduction to the topic. It will not likely explore key concepts in detail.

Table 1
Purposes of Reading Speeds

Purpose	Reading Approach (Skim, Scan, or Study)
Preview text to get a general sense of what it contains.	Read quickly (skim).
Locate specific information.	Read somewhat quickly (scan).
Learn a new concept.	Read slowly (study).

Instant Practice

1. Look through Topic 2.4 with a partner. Identify two sections of text that should be read slowly and carefully. Then identify two sections of text that could be skimmed.
2. Can you think of a reason why you would need to scan a section of text?

Asking Questions

As you are reading, stop every now and then to ask yourself questions starting with *who, what, where, why, when,* and *how*.

Read the following paragraph from page 62:

> It began with a single city, Sydney, Australia, in 2007. As 2 million people and 2000 businesses shut down their lights for one hour, they sent a message to the world, to all who might hear. "We are concerned about climate change, and we hope our simple act inspires you to reduce activities that release excess carbon and other substances that contribute to it."

Who sent a message to the world?
What message did they send?
Where did their message begin?
Why did they send this message?
When did this happen?
How did they send a message to the world?

If you can't answer these questions about the text you've just read, you might need to go back and read more carefully.

You can also use these questions to predict what you will read next. Then continue reading to see if your questions are answered by the text. If they are not, write them down. You can discuss them with a partner, ask your teacher, or do some research to find out more.

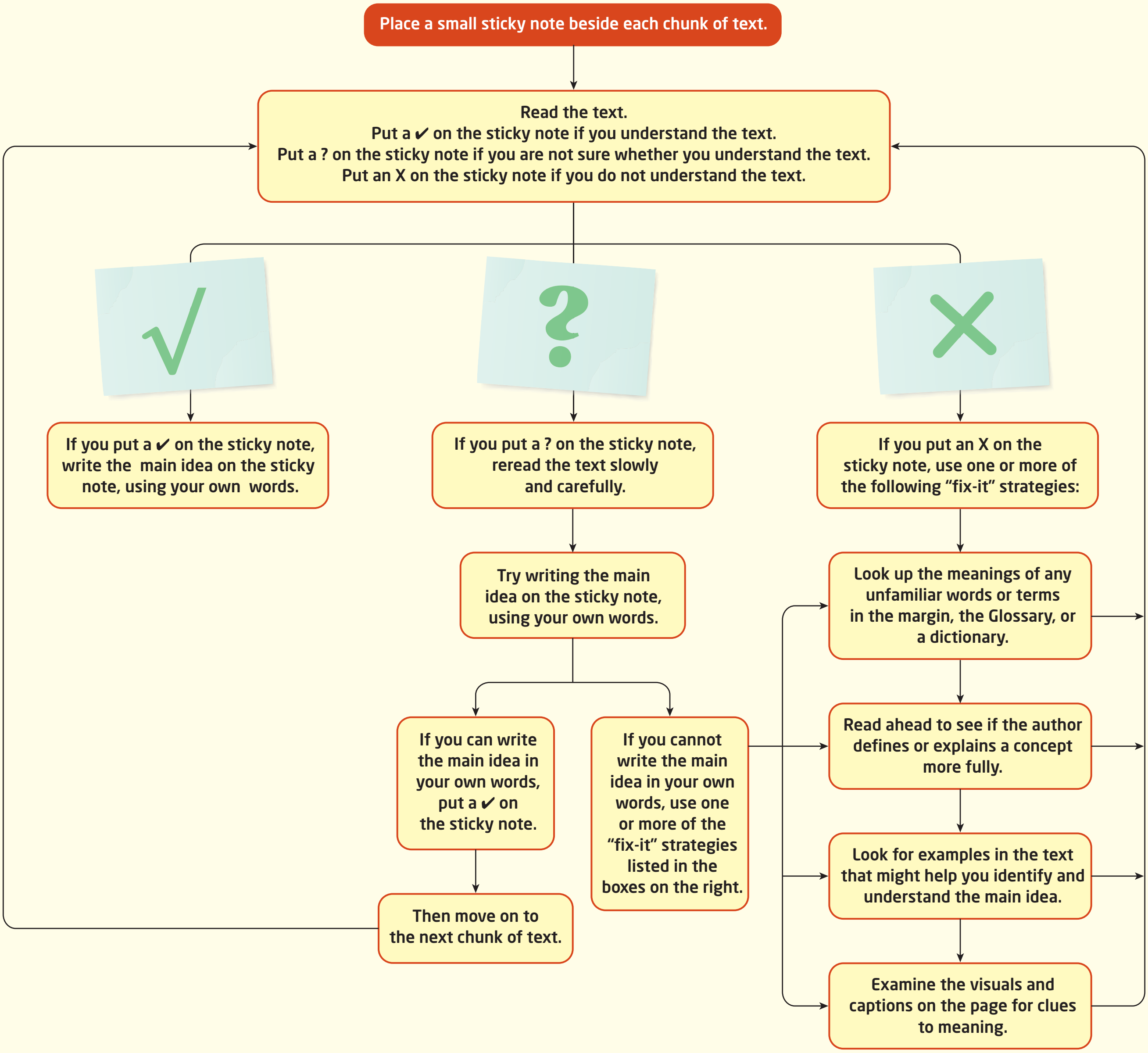
Instant Practice

Use the coloured question words to ask questions that are not answered in the paragraph on the left. Then go to page 62 to see if your questions are answered in the next paragraph.

Reading Effectively

Checking Your Understanding

When you are reading text that contains new ideas and new key terms, stop after each chunk of text to make sure that you understand what you have just read. You can use the steps in the following flowchart to do this.



Place a small sticky note beside each chunk of text.

Read the text.
Put a ✔ on the sticky note if you understand the text.
Put a ? on the sticky note if you are not sure whether you understand the text.
Put an X on the sticky note if you do not understand the text.

If you put a ✔ on the sticky note, write the main idea on the sticky note, using your own words.

If you put a ? on the sticky note, reread the text slowly and carefully.

Try writing the main idea on the sticky note, using your own words.

If you can write the main idea in your own words, put a ✔ on the sticky note.

Then move on to the next chunk of text.

If you cannot write the main idea in your own words, use one or more of the "fix-it" strategies listed in the boxes on the right.

If you put an X on the sticky note, use one or more of the following "fix-it" strategies:

Look up the meanings of any unfamiliar words or terms in the margin, the Glossary, or a dictionary.

Read ahead to see if the author defines or explains a concept more fully.

Look for examples in the text that might help you identify and understand the main idea.

Examine the visuals and captions on the page for clues to meaning.

Instant Practice

1. Make a list of steps you could follow if you were not sure that you had understood a section of text. Number your steps.
2. Make a bulleted list of the four "fix-it" strategies, using your own words.

Literacy Skills Toolkit 3

Reading Graphic Text

Reading Diagrams

A diagram is a simplified drawing that uses symbols to represent objects, directions, and relationships. Reading the labels of a diagram can help you understand these symbols.

To read a diagram

1. **Read the title or caption to understand the main idea of the diagram.**

   For example, the caption of **Figure 3.10** tells you that the movement of the Moon around the Earth results in different *phases* of the Moon. (You will learn about this in Topic 3.2.)

2. **Consider how each part illustrates the main idea.**

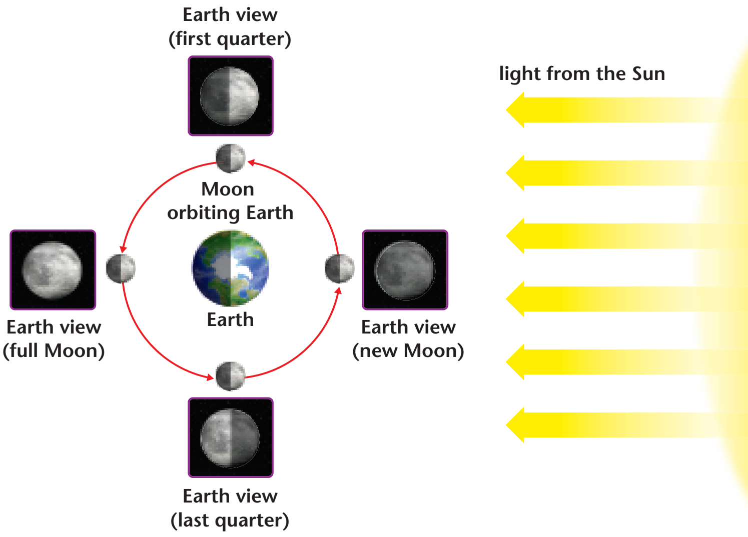
   The diagram shows that the moon has a different appearance when it has a different position in relation to the Earth and the Sun.

3. **Look closely at the labels and reread the caption, if you need to, to understand the details of the diagram.**

   The labels and the illustration show how the Moon appears in different phases.

4. **Find the reference to the diagram in the text to find out additional information, and to understand how the diagram relates to the main idea in the text.**

In the main text, near the figure reference, you find the following information: "The lit-up side of the Moon is always fully lit up, but we can't always see the whole lit-up side. Instead, we see changes in the amount of lit-up surface during a month: the phases of the Moon."



▲ **Figure 3.10** The phases of the Moon are caused by the amount of lit-up surface that we can see from Earth as the Moon orbits our planet.

Instant Practice

Examine **Figure 1.4A** on page 22. Follow the steps above to read the diagram.

1. Explain the main idea of the diagram.
2. How did the caption, labels, and information in the main text help you to understand the diagram?

Reading Graphic Text

Reading Tables

A table contains cells that are organized in rows and columns. Each cell contains data. Each column and row has a heading to help you understand the information in each cell.

To read a table or to find patterns in a table

1. **Read the title of the table.**

   Based on the title, you should be able to predict what kind of information you will see in the cells.

2. **Read the column and row headings carefully.**

3. **Move your eyes left and right across the rows, and up and down along the columns.**

4. **When you look at a cell, look again at the headings.**

   What is the heading of the column containing this cell? What is the heading of this row?

5. **Look for units.** If measurements are included in the table, the column headings should tell you what units are being used to report the measurements.

6. **Look for patterns as you move left to right across a row, or top to bottom down a column.**

   If the column contains numbers, do the numbers increase steadily as you move down the column? Do they decrease steadily?

7. **Look for breaks in patterns.**

   Is there one cell that doesn't fit the pattern in the rest of its column? Think about why this might be the case.

8. **Look for relationships between columns or rows.**

   Do the numbers in one column increase as the numbers in another column decrease? Do numbers increase from top to bottom in every column? What does this tell you?

In **Table 1** below, the number 500 is found in the column labelled "Number of Zebra Mussels (per m^2)" and in the row labelled "1992." This number tells you that 500 zebra mussels per m^2 were found in Lake Ontario in 1992.

The year increases as you look down the first column. The number of zebra mussels per m^2 also increases as you look down the second column. This tells you that the number of zebra mussels in Lake Ontario increased over time.

Table 1
Zebra Mussels in Lake Ontario

Year	Number of Zebra Mussels (per m^2)
1990	0
1991	230
1992	500

Reading Graphic Text

Reading Graphs

1. First read the graph's title.
Predict what relationship, the graph will display, based on the title.

2. Read the labels on each of the sections (pieces of pie) in a pie graph.
What is being compared? In a pie graph, each section represents a percentage of the whole circle. Think about what the whole circle represents.

3. Look for the percentages on each section of a pie graph.
If two sections are similar in size, it can be difficult to compare the size of the sections visually. It helps to compare the percentage of the whole that each section takes up.

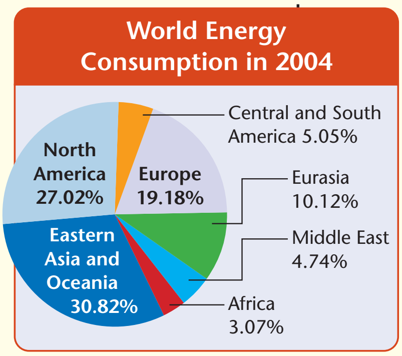
4. Compare the sections of a pie graph.
Which section takes up most of the circle? Which section takes up the least? Is the circle evenly divided into sections?

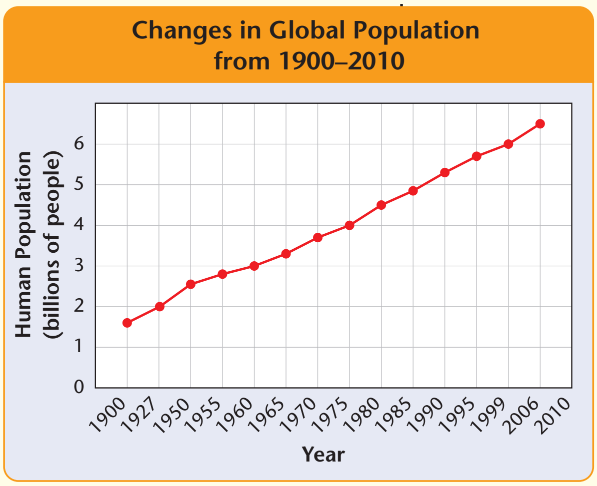
2.) Read the labels on the x-axis and the y-axis of line graphs and bar graphs.
What relationship will the graph display, based on the axis labels?

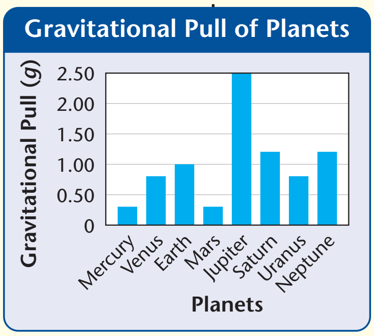
3.) Note the units on the axes and the numbering on the scales of line graphs and bar graphs.
Does the graph use very large units or very small ones?

4.) Look for and describe patterns in the shape of a line graph.
Line graphs show relationships between two sets of numbers. How does an increase in the numbers on the *x*-axis affect the numbers on the *y*-axis? Is the graph a straight line or a curved one? Does it increase or decrease as you look at it from left to right? Does the line zigzag up and down regularly? (This shows that you have graphed a cycle.)

4. Compare the size of the bars in a bar graph.
Describe any pattern you see in how the height of the bar changes between categories.







Word Study

Common Base Words, Prefixes, and Suffixes in Science

Understanding how words are put together can help you figure out their meanings. The list below includes some common *base words* that are used in science. Also listed are some common *prefixes* and *suffixes*, which change the meaning of a base word when they are combined with the base word.

Base Word	Definition	Example
conduct	To lead or act as a channel for	A **conductor** allows electrons to move easily between atoms.
electr(o)	Having to do with electricity	An **electroscope** is a device for detecting an electric charge.
phot(o)	Having to do with light	A **photometer** measures the amount of light that is emitted from a source.
resist	To hold off; to prevent or oppose	A **resistor** decreases the electric current that is flowing through a component.
sustain	To keep going; to maintain	**Unsustainable** means not able to keep going.
Prefix	**Definition**	**Example**
bio-	Having to do with life	**Biocontrol** is the use of living things to control unwanted species.
dis-	Not; the opposite of; having an absence of	A **disinfectant** helps to remove and prevent infection.
infra-	Below; beneath	**Infrared** light has a a lower frequency than red light.
semi-	Half or partial	A **semiconductor** allows electrons to move fairly well between atoms.
non-	Not; having an absence of	A **non-metal** is an element that does *not* have the properties of a metal.
Suffix	**Definition**	**Example**
-al	Relating to	**Environmental** means relating to the environment.
-ic	Relating to; characterized by	**Atomic** means relating to an atom.
-ity	The state or quality of	**Reactivity** is the quality of being reactive.
-ion	The action or process of	**Pollution** is the process of polluting.

Instant Practice

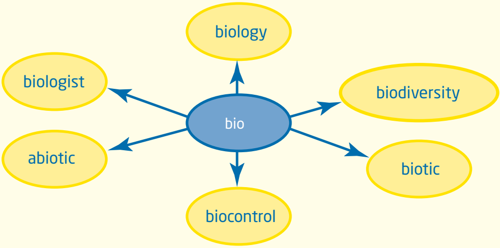
1. Use the table to predict the meaning of conductivity.
2. Think of a word that ends in one of the suffixes listed above. (You can browse through this textbook or a dictionary to find a word, if you wish.) Explain the meaning of your word. Compare your word and definition with words and definitions that your classmates suggest.

Word Study

Word Family Webs and Word Maps

Science textbooks include many words that you may not have seen before. On the last page, you learned that looking at base words, prefixes, and suffixes can help you to understand the meanings of unfamiliar words.

Word Family Webs

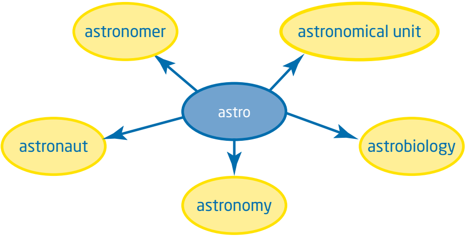


Words that share the same base, prefix, or suffix are related. They make up a word family. A *word family web* can help you see the connections between words in a word family. Then you can figure out unfamiliar words in the family.

The web to the right shows words that all have the prefix *bio*, from the Greek word meaning life. *Biology*, for example, means the study of life. If *ogist* means someone who studies, what does *biologist* mean?

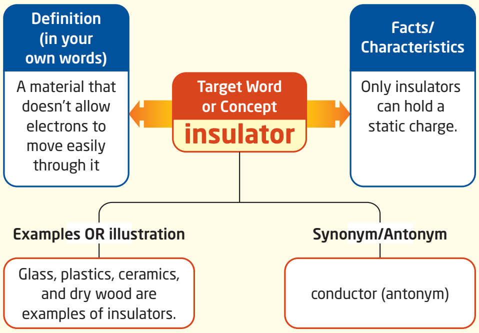
Instant Practice

The prefix *astro* means star. Use this knowledge of the prefix to predict the meanings of unfamiliar words in the web shown. Check your predictions by locating these words in the text. Use the glossary and the index to help you.



Word Maps

A word map helps you organize your thoughts about a word. Look at the word map for the word *insulator*. The map contains the definition of insulator, but it also includes other information that explains the *concept* of an insulator. You might want to add a section to your word map—*non-examples*. What materials are NOT insulators? If you are able to think of non-examples, you know you have a good understanding of the concept.



Instant Practice

1. Create a word map for the word *ecosystem*.
2. Exchange word maps with a partner. Are your maps the same?

Organizing Your Learning: Using Graphic Organizers

When deciding which type of graphic organizer to use, consider your purpose: to brainstorm, to show relationships among ideas, to summarize a section of text, to record research notes, or to review what you have learned before writing a test. Twelve different graphic organizers are shown here. A chart at the end of this toolkit summarizes the function of each organizer to help you decide on the best one for the information you are working with.

T-Chart

A *t-chart* is a simple two-column chart that can be used to compare or show a relationship between two things.

Biotic	Abiotic
• living • examples include...	• not living • examples include...

PMI Chart

A *PMI chart* has three columns. PMI stands for “Plus,” “Minus,” and “Interesting.” A PMI chart can be used to state the good and bad points about an issue. The third column in the PMI chart is used to list interesting information related to the issue. PMI charts help you to organize your thinking after reading about a topic that is up for debate or that can have positive or negative effects.

Grocery stores now charge 5¢ for a plastic grocery bag.

P	M	I
• This may make people want to use fewer plastic bags. • There will be fewer plastic bags heading to landfills. • People may be more likely to bring reusable cloth bags to the store. • Cloth bags are strong and can carry many groceries. • Cloth bags can easily be washed before being re-used.	• The charge may not be high enough to stop people from using plastic bags. • It is easy to forget your reusable bags at home. • Over time, cloth bags can collect bacteria if they are used to carry meat, fish, dairy, and produce. • It is inconvenient to have to pay for bags or bring bags from home.	• Some stores have plastic bag recycling centres. • If you have a certain spot where you always keep your bags, you’ll be more likely to remember them. • Plastic bags were introduced to replace paper bags. At the time, people thought plastic bags were better for the environment than paper ones.

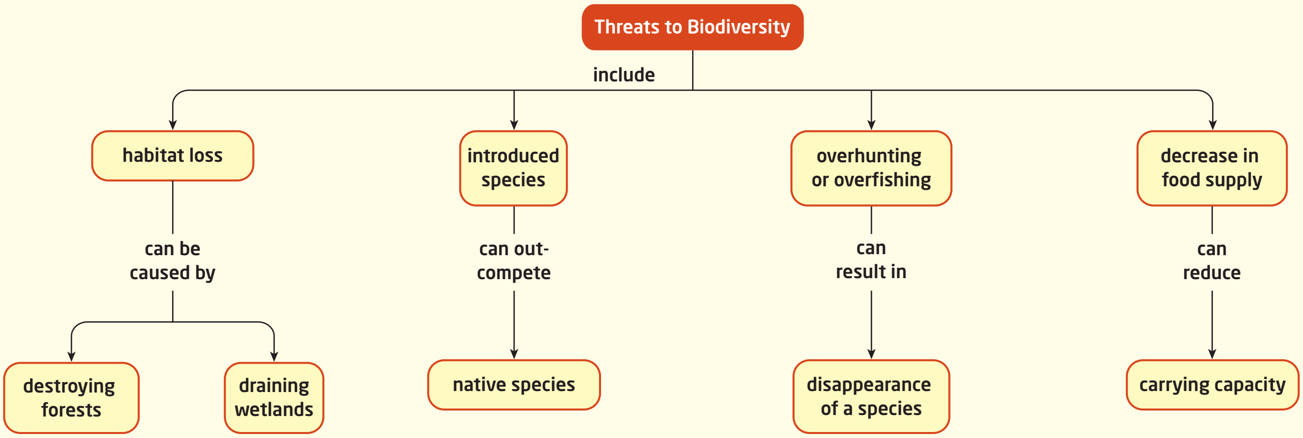
K-W-L Chart

A *K-W-L chart* is used to record what you already know about a topic, what you want to learn about the topic, and what you know after you have read about the topic. It can help you to plan your research about a subject or check your learning after reading about a subject.

What You Know	What You Want to Know	What You Learned
• There are many stars in the sky. • The Sun is a star. • The Sun is the centre of our solar system.	• How many stars are there? • How far away is the nearest star other than our Sun? • Is it part of a solar system too?	• There are so many stars that scientists find it difficult to even estimate how many there are. They estimate that there are 100 000 000 000 (10^{11}) stars just in our galaxy, and possibly 10^{22} to 10^{24} in the whole universe. • The nearest star, Proxima Centauri, is more than four light years away. • Proxima Centauri is part of the Alpha Centauri solar system.

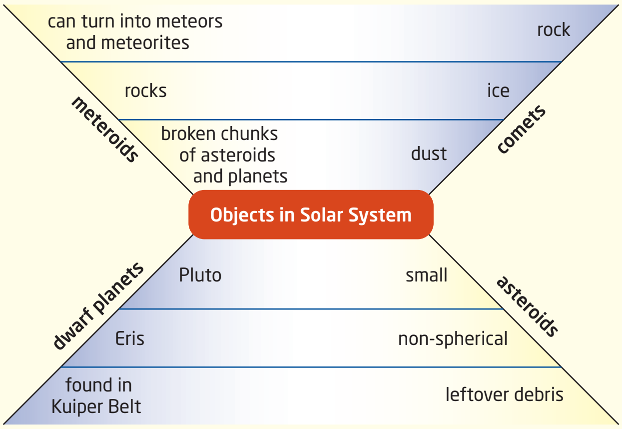
Concept Map

A *concept map* uses shapes and lines to show how ideas are related. Each idea, or concept, is written inside a circle, a square, a rectangle, or another shape. Words that explain how the concepts are related are written on the lines that connect the shapes.



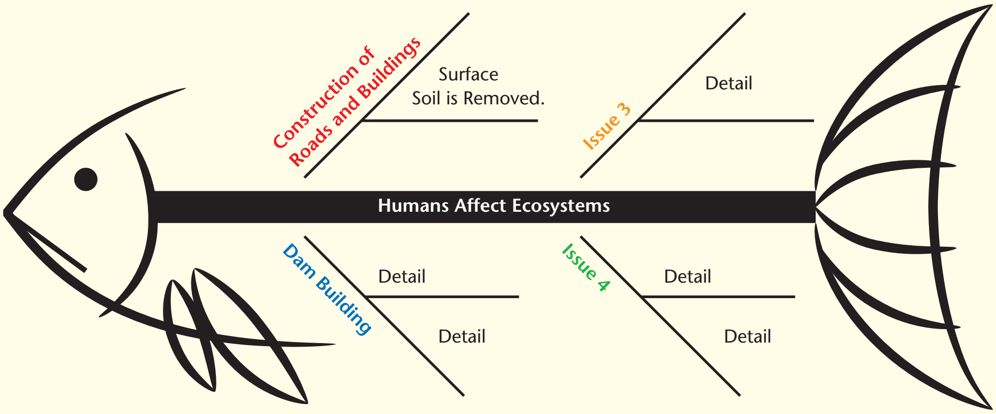
Spider Map

A *spider map* shows a main idea and several ideas related to the main idea. It does not show the relationships among the ideas. A spider map is useful when you are brainstorming or taking notes.



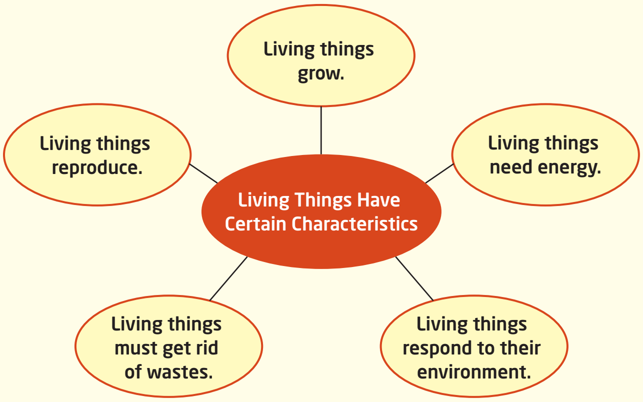
Fishbone Diagram

A *fishbone diagram* looks similar to a spider map, but it organizes information differently. A main topic, situation, or idea is placed in the middle of the diagram. This is the "backbone" of the "fish". The "bones" (lines) that shoot out from the backbone might be used to list reasons that the main situation exists, issues that affect the main idea, or arguments that support the main idea. Finally, supporting details shoot outward from these issues. Fishbone diagrams are useful for planning and organizing a research project. You can clearly see when you don't have enough details to support an issue. Then you can do more research.



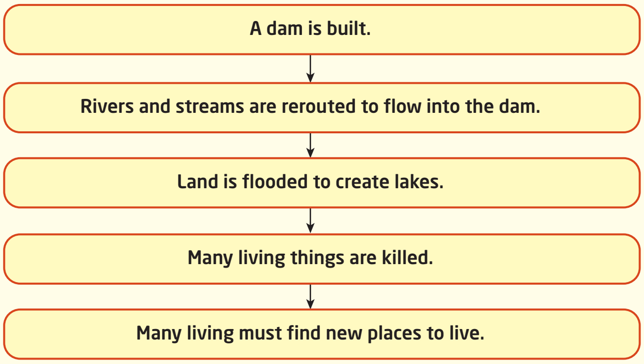
Main Idea Web

A *main idea web* shows a main idea and several supporting details. The main idea is written in the centre of the web, and each detail is written at the end of a line going from the centre.



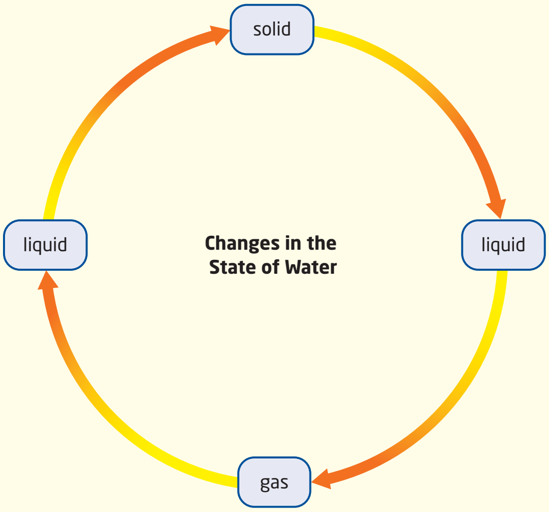
Flowchart

A *flowchart* shows a sequence of events or the steps in a process. A flowchart starts with the first event or step. An arrow leads to the next event or step, and so on, until the final outcome. All the events or steps are shown in the order in which they occur.



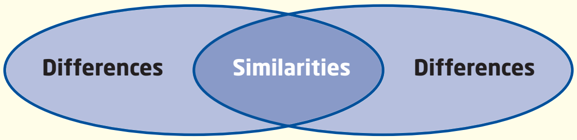
Cycle Chart

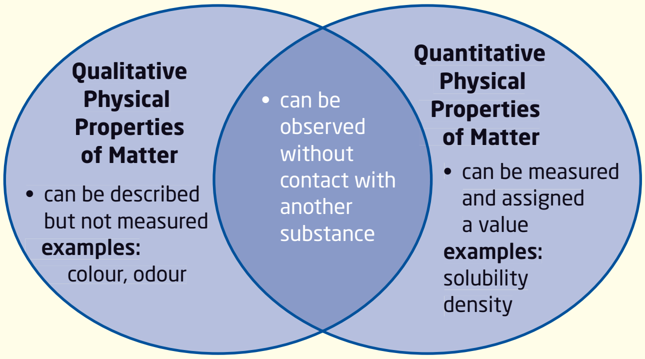
A *cycle chart* is a flowchart that has no clear beginning or end. All the events are shown in the order in which they occur, as indicated by arrows, but there is no first or last event. Instead, the events occur again and again in a continuous cycle.



Venn Diagram

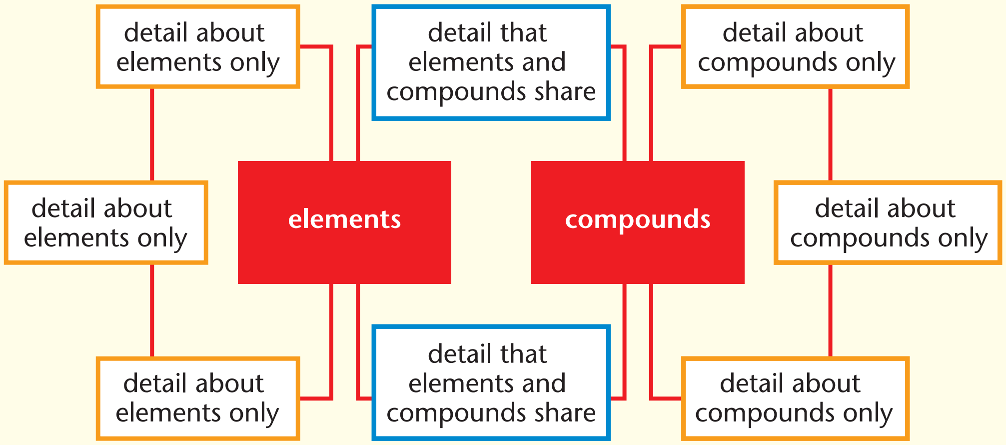
A *Venn diagram* uses overlapping shapes to compare concepts (show similarities and differences).





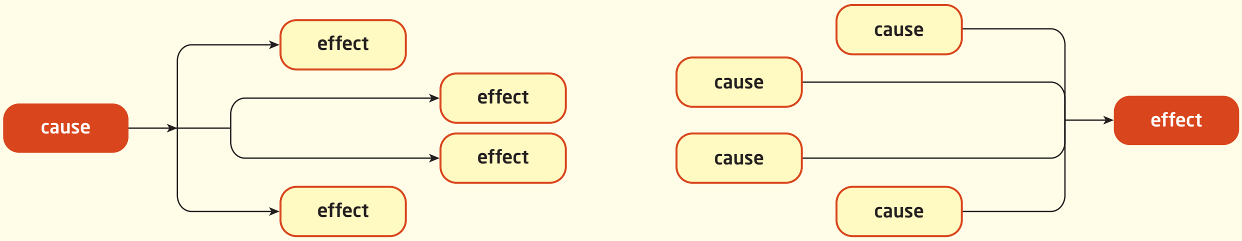
Double Bubble Organizer

Like a Venn diagram, a *double bubble organizer* is used to concepts (show similarities and differences). It separates the details that two concepts share and the details that they do not share.



Cause-and-Effect Map

The first *cause-and-effect map* below shows one cause that results in several effects. The second map shows one effect that has several causes.



Which Organizer Should I Choose?

When you are trying to decide how to organize information, you can use the following chart to help you.

What are you trying to do with your graphic organizer?	t-Chart	PMI-Chart	K-W-L Chart	Concept Map	Spider Map	Fishbone Diagram	Main Idea Web	Flowchart	Cycle Chart	Venn Diagram	Double Bubble Organizer	Cause-and-Effect Map	Word Map (see page 389)
Brainstorm				X	X		X						
Show relationships among ideas or words				X		X	X						X
Check your understanding			X			X		X	X	X	X	X	X
Compare (show similarities and differences)	X									X	X		
Examine the pros and cons of an issue	X	X											
Examine the causes and/or effects of an action or issue				X		X		X				X	
Take notes		X	X	X	X	X	X						
Plan your research			X			X		X					
Show a process or series of events								X	X				
Show a continuous series of events									X				

Instant Practice

1. Create a Venn diagram that compares two of your favourite science topics.
2. Draw a spider map that reflects what you know about electricity.

Properties of Common Substances

KEY TO SYMBOLS:
Common names of substances are enclosed in parentheses.
(*) water solution of a pure substance (e) element (c) compound

Name	Formula	Common Use or Important Feature
acetic acid (vinegar) (c)	CH_3COOH	used in the manufacture of cellulose ethanoate; vinegar is a 5 to 7 percent solution in water
aluminum (e)	Al	used in aircraft, cooking utensils, and electrical apparatus
ammonia (c)	NH_3	used as refrigerant and in manufacture of resins, explosives, and fertilizers
argon (e)	Ar	used in electric lights
beryllium (e)	Be	used for corrosion-resistant alloys
boron (e)	B	used for hardening steel and for producing enamels and glasses
bromine (e)	Br_2	used to make certain pain-relieving drugs; liquid causes severe chemical burns; vapour is harmful to lungs
calcium (e)	Ca	very abundant; essential to life
calcium carbonate (limestone) (c)	$CaCO_3$	main ingredient in chalk and marble
calcium hydroxide (slaked lime) (c)	$Ca(OH)_2$	aqueous solution used to test for CO_2
carbon (diamond) (e)	C	very hard; used for drilling through rock
carbon (graphite) (e)	C	very soft; used in lubricants, pencil leads, and electrical apparatus
carbon dioxide (c)	CO_2	does not support combustion and is denser than air; used in fire extinguishers and as a refrigerant at –78.5°C
chlorine (e)	Cl_2	poisonous; used to kill harmful organisms in water
copper (e)	Cu	soft metal; good conductor of heat
ethanol (ethyl alcohol) (c)	C_2H_5OH	derived from fermentation of sugar; used as solvent or fuel; found in wine
fluorine (e)	F_2	similar to chlorine
gold (e)	Au	very soft metal; highly resistant to tarnishing
glucose (c)	$C_6H_{12}O_6$	simple sugar; human body converts most sugars and starches to glucose
hydrochloric acid (*)	HCl	corrosive acid; properties vary according to concentration
hydrogen (e)	H_2	highly flammable; liquid form used as rocket fuel
hydrogen peroxide (c)	H_2O_2	thick and syrupy when pure; an antiseptic
iodine (e)	I_2	crystals sublime readily to form poisonous violet vapour
iron (e)	Fe	rusts readily; soft when pure

DEFINITIONS:
deliquescent: able to absorb water from the air to form a concentrated solution
sublime: to form a vapour directly from a solid

Appearance (at room temperature: 20°C)	Melting Point (°C)	Boiling Point (°C)	Density (g/cm^3 or g/mL)
colourless liquid with pungent smell	16.6	118.1	—
silver-white metal	659.7	2519	2.7
very soluble gas with pungent smell	–77.8	–33.4	less dense than air
inert gas	–189	–185	denser than air
hard, white metal	1280	2471	1.85
brown, amphorous powder or yellow crystals	2075	4000	2.37(brown), 2.34 (yellow)
red-brown liquid	–7.2	58.8	3.12
soft, white metal that tarnishes easily	845	1484	1.55
white solid	decomposes at 900°C	—	2.93
white solid	decomposes at 522°C	—	2.24
colourless, solid crystals	3500	3930	3.51
grey-black solid	4492	4492	2.25
colourless gas with a faint tingling smell and taste	—	—	—
green gas	–101.6	–34.6	denser than air
shiny, reddish solid	1084	2562	8.95
colourless liquid	–114.5	78.4	0.789
greenish yellow gas	–270	–188	—
shiny, yellow solid	1063	2856	19.3
white solid	146	decomposes before it boils	1.54
colourless liquid	varies	varies	varies
colourless gas	–259	–253	much less dense than air
colourless liquid	–0.4	150.2	1.45
violet-black, solid crystals	114	184	4.95
shiny, silver solid	1535	2861	7.86

Appendix

Properties of Common Substances

KEY TO SYMBOLS:

Common names of substances are enclosed in parentheses.

(*) water solution of a pure substance (e) element (c) compound

Name	Formula	Common Use or Important Feature	
lead (e)	Pb	soft metal; forms poisonous compounds	
lithium (e)	Li	used in alloys; its salts have various medical uses	
magnesium (e)	Mg	used in photography; compounds used in medicine; essential to life	
mercury (e)	Hg	only liquid metal; forms poisonous compounds	
methane (c)	CH_4	main constituent in natural gas	
neon (e)	Ne	discharge of electricity at low pressures through neon produces an intense orange-red glow	
nickel (e)	Ni	used for nickel plating and coinage, in alloys, and as a catalyst	
nitrogen (e)	N_2	will not burn or support burning; makes up 80 percent of air	
oxygen (e)	O_2	must be present for burning to take place; makes up 20 percent of air	
platinum (e)	Pt	used in jewellery; alloyed with cobalt, used in pacemakers	
polyethylene (polythene) (c)	$(C_2H_4)n$	polymer of ethylene; used as insulating material; flexible and chemically resistant	
potassium (e)	K	essential to all life; found in all living matter; salts used in fertilizers	
propane (c)	C_3H_8	flammable; used as fuel	
silver (e)	Ag	soft metal; best-known conductor of electricity	
sodium (e)	Na	used in preparation of organic compounds, as coolant, and in some types of nuclear reactors	
sodium chloride (table salt) (c)	NaCl	used to season or preserve foods	
sucrose (sugar) (c)	$C_{12}H_{22}O_{11}$	made from sugar cane or sugar beets	
sulfur (brimstone) (e)	S_8	used to make dyes, pesticides, and other chemicals	
tin (e)	Sn	soft metal; rust resistant	
titanium (e)	Ti	alloys are widely used in the aerospace industry	
water (c)	H_2O	good solvent for non-greasy matter	
zinc (e)	Zn	used in alloys such as brass and galvanized iron	

DEFINITIONS:
deliquescent: able to absorb water from the air to form a concentrated solution
sublime: to form a vapour directly from a solid

Appearance (at room temperature: 20°C)	Melting Point (°C)	Boiling Point (°C)	Density (g/cm³ or g/mL)
shiny, blue-white solid	327.4	1750	11.34
silver-white metal (least dense solid known)	179	1340	0.534
light, silvery-white metal that tarnishes easily in air	651	1107	1.74
shiny, silvery liquid	−38.9	356.6	13.6
odourless, flammable gas formed from decaying organic matter	−182.5	−161.5	—
colourless, odourless gas	−248	−246	—
silvery-white, magnetic metal that resists corrosion	1455	2913	8.90
colourless gas	−209.9	−195.8	slightly less dense than air
colourless gas	−218	−183	slightly denser than air
silver-white solid	1769	3824	21.41
tough, waxy, thermoplastic material	—	—	—
silvery-white, soft, highly reactive, alkali metal	63.5	759	0.86
colourless gas	—	−42.17	—
shiny, white solid	961	2162	10.5
soft, silvery-white metal; very reactive	97.5	892	0.971
white, crystalline solid	801	1465	2.16
white solid	170	decomposes at 186°C	1.59
yellow solid	112.8	444.6	2.07
shiny, slightly yellow solid	231.9	2602	7.31
lustrous white solid	1666	3287	4.5
colourless liquid	0	100	1.00
hard, bluish-white metal	419	907	7.14

Glossary

How to Use This Glossary

This Glossary provides the definitions of the key terms that are shown in boldface type in the text. Definitions for other important terms are included as well. The Glossary entries also show the numbers of the topics where you can find the boldface words.

1.1 = Unit 1, Topic 1
U2GR = Unit 2 Get Ready
SST1 = Science Skills Toolkit 1
NST1 = Numeracy Skills Toolkit 1
LST1 = Literacy Skills Toolkit 1
App = Appendix

A pronunciation guide, using the key below, appears in square brackets after selected words.

a = mask, back
ae = same, day
ah = car, farther
aw = dawn, hot
e = met, less
ee = leaf, clean
i = simple, this
ih = idea, life
oh = home, loan
oo = food, boot
u = wonder, Sun
uh = taken, travel
uhr = insert, turn

A

abiotic [ae-bih-AW-tik] not living (non-living); for example, rocks or sunlight (1.1)

accuracy how close a measurement or calculation comes to the true value (SST5)

ammeter a device that measures the current in an electrical circuit; measured in the unit amperes (A) (4.4, SST9) ▼

analogue meter a device that displays measurements, such as current or potential difference, with a needle pointing to a dial (SST9) ▼

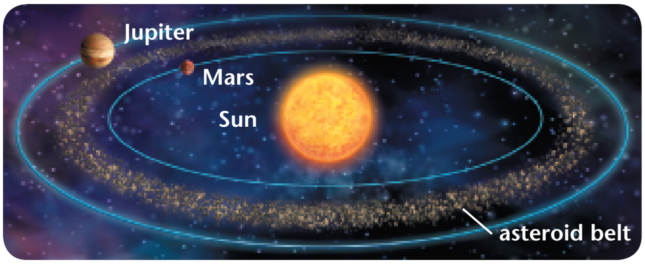
ampere (A) [AM-peer] the unit of measure that describes the amount of current flowing through a wire in an electrical circuit; ampere is abbreviated as amps (4.4)

analogy a comparison between two things that have some feature in common; uses a familiar situation to help explain an unfamiliar situation; for example, the Internet is sometimes called an information superhighway because it allows large amounts of information to travel back and forth very efficiently; this is an analogy that helps you to understand the Internet (SST7)

aquatic ecosystem an ecosystem that is based mostly or totally in water; for example, the beaver pond shown here is an aquatic ecosystem; it includes the beaver, the plant life in and around the water, and other living parts, as well as non-living parts such as the water itself and the dead trees that the beavers have used to make their dam. (1.1) ▼

asteroid a rocky object in space that orbits the Sun and is found in the area between the orbits of Mars and Jupiter (3.3)

asteroid belt the region of the solar system where most asteroids are located; contains rocky chunks of various sizes that orbit the Sun between the orbits of Mars and Jupiter (3.3) ▼

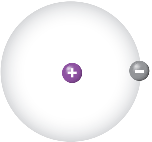


astronomer [uh-STRON-uh-mer] a scientist who studies astronomy (3.1)

astronomical unit [as-truh-NOM-i-kuhl YOO-nit] a measurement equal to the distance between Earth and the Sun, about 150 million km; abbreviation is A.U. (3.1)

atmosphere the layer of gases above Earth's surface (3.2) ▼

atom the smallest unit of an element that displays the same properties as the element, for example, hydrogen (2.4) ▼



atomic number [uh-TOM-ik NUM-ber] the number of protons in the nucleus of an atom; for example, the atomic number for helium is 2 (2.4)

atomic structure the arrangement of the parts of an atom; for example, the atomic number for helium is 2 (2.4)

aurora light shows in Earth's upper atmosphere; created by solar wind; the Northern Lights are an aurora often seen in Canada (3.2) ▼

B

battery a source of electrical energy; for example, a 9 V battery (4.4) ▼

bias a point of view that influences a decision and prevents a fair and balanced judgement (SST1, SST8)

bibliography a list of information sources you have used to help you create a research-based project (SST8)

biocontrol the use of living things to control the introduced species in an ecosystem; for example, this European beetle has been used to help control the growth of purple loosestrife (a species that is harmful to aquatic ecosystems)(1.6) ▼

biodiversity all the different species that live in an ecosystem, as well as all the different ecosystems within and beyond that ecosystem (1.6)

biomass energy energy produced from living or recently living things; for example burning wood produces biomass energy (4.1)

biotic [bih-AW-tik] living; for example, insects or plants (1.1)

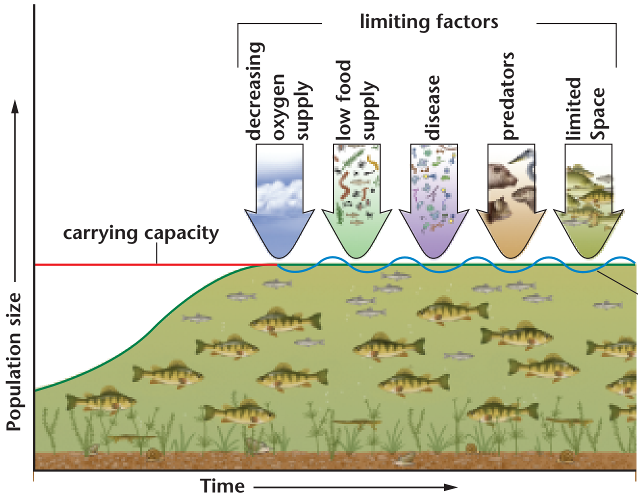
bog a type of wetland in which the water is acidic and low in nutrients (1.6) ▼

boiling point a constant for known substances, it is the temperature at which a liquid turns into a gas and its abbreviation is B.P.; the boiling point of water is 100°C (App)

C

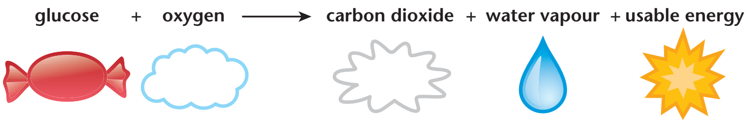
calendar a way of showing days, organized into a schedule of larger units of time such as weeks, months, seasons, or years; usually a table or a chart; our calendar is linked to the appearance of the Moon in the night sky (3.2)

carrying capacity the largest population that an ecosystem can support (1.4) ▼

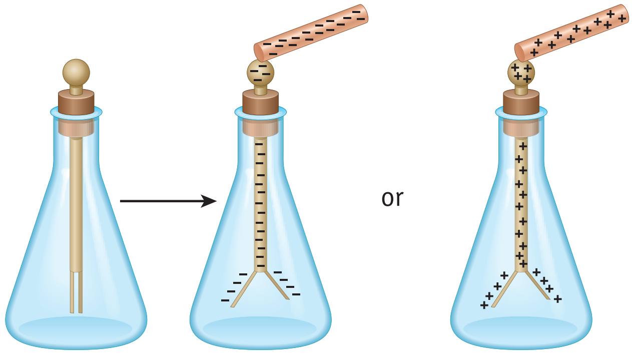


celestial object [suh-LES-chuhl AWB-jekt] any object that exists in space, such as a planet, a star, or the Moon; a star is a celestial object (3.1)

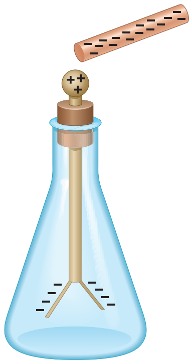
cellular respiration a process in the cells of most living things that converts the energy stored in chemical compounds into usable energy; the equation below shows the materials needed for and the materials produced by this process (1.2) ▼



charging by contact causing a neutral object to become charged by touching it with a charged object; for example, getting a shock when you touch a charged doorknob ▼



charging by induction causing a neutral object to become charged by bringing a charged object near to, but not touching, the object; for example, having your hair stand up when you bring a charged comb near to, but not touching it (4.3) ▼



chemical formula a short form used to represent a molecule; uses letters and numbers; only pure substances have chemical formulas; H_2O is the chemical formula for water (2.5)

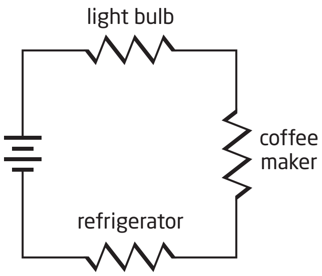
chemical property the ability of a substance to change or react, and to form new substances when interacting with other substances, for example, zinc reacts with hydrochloric acid to produce hydrogen gas (2.2)

chemical reaction any change that occurs when substances interact to produce new substances with new properties; changes in the chemical and physical properties of the pure substances let you know that a chemical reaction has occurred; when vinegar and baking soda are combined, they react to produce frothy bubbles, as shown (2.6) ▼

chemical symbol a short form used to represent the name of an element; C is the chemical symbol for carbon (2.5)

circuit breaker a safety device that keeps a circuit from carrying too much current and starting a fire; a circuit breaker is placed in series with circuits that lead to outlets and appliances; each of the large black switches in the photo below is a circuit breaker and each controls a separate circuit within a building's electrical system (4.6) ▼

circuit diagram a diagram that uses standard symbols to represent the parts in an electric circuit and how they are connected; the circuit below includes a source and three loads (U4GR, 4.4, SST6) ▼



combustibility the ability of a substance to catch fire and burn in air (2.2)

comet chunks of loosely held rock and ice that come from the outer parts of the solar system; Halley's Comet is a well known comet that passes by the Earth about every 75 or 76 years. (3.3) ▼

competition when two or more members of a population compete for the same resource in the same location at the same time; for example, wolves and cougars are in competition for rabbits, which they eat for food (1.4)

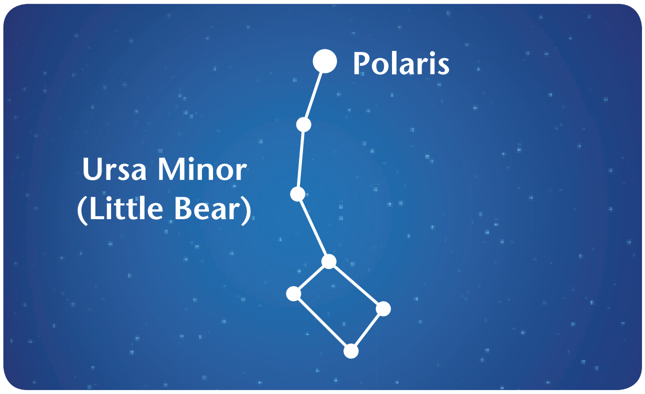
compound a pure substance that can be broken down into smaller parts using chemical properties; water and carbon dioxide are both examples of compounds; all parts of a compound will contain identical molecules; in distilled water, as shown below, all parts will contain identical H_2O molecules (2.3) ▼

conclusion a statement that indicates whether your results support or do not support your hypothesis (SST2)

conductivity describes how easily a substance lets heat or electricity move through it (2.2, 4.2)

conductor a material that lets heat and electricity move through it easily; conductors are usually metals (2.3, 4.2)

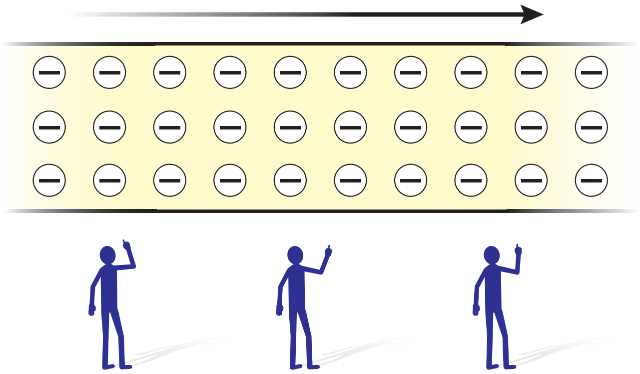
constellation a group of stars that seem to form a shape or pattern in the night sky; the Little Dipper is an example of a constellation (3.1) ▼



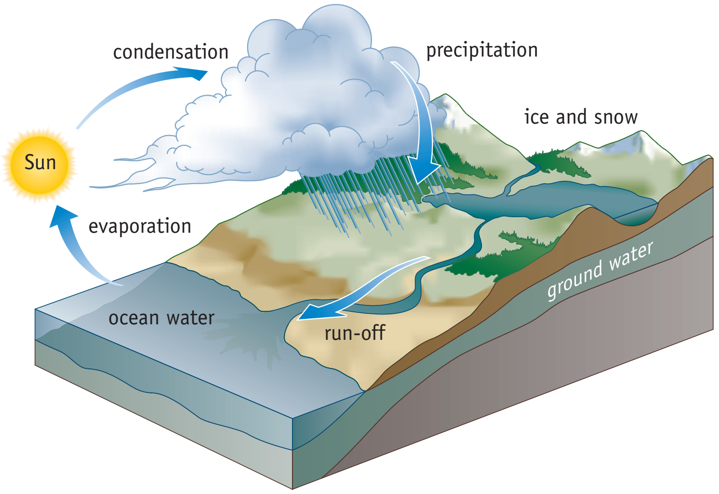
consumer any living thing that gets the energy it needs by eating producers or other consumers; dogs and cats are both consumers (1.2)

control a test that an experimenter carries out with no variable; this test can be compared to a test in which an independent variable is manipulated by the experimenter, to see whether the independent variable does indeed cause a change in the dependent variable (SST2)

current a flow of electrical charges; an electric current carries energy from a source (such as a battery) to an electrical device (such as a flashlight), along wires; electric current is measured in amperes; this measurement represents how many units of charge pass a point every second, as shown here (4.4) ▼



cycle a pattern of change that is continuous, or a process that repeats itself forever; for example, in the water cycle, shown here, water moves continuously through ecosystems (1.3) ▼



D

decomposer an organism that obtains energy by consuming dead plant and animal matter; mushrooms are one type of decomposer, which is why they are often found growing on decaying logs (1.3)

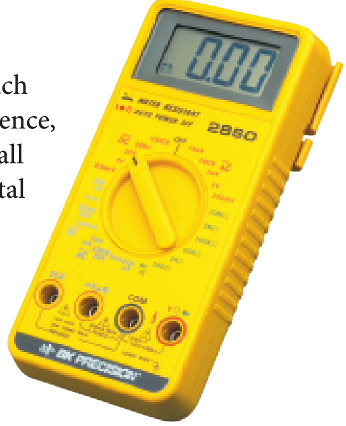
decomposition a kind of reactivity that can break down a substance into its parts; for example, water can be broken down into hydrogen and oxygen by decomposition (2.2)

deforestation the practice of clearing forests for logging or other human uses, and never replanting them (1.5) ▼

density describes how compact a substance is, and is calculated by dividing mass by volume, or D = m/v (2.2)

dependent variable the factor that is observed; the experimenter in a test looks for changes in the dependent variable in response to the independent variable (the one controlled by the experimenter); also called the responding variable (SST2)

digital meter a device that displays measured values, such as current or potential difference, directly as numbers on a small screen, similar to how a digital watch displays the time directly (SST9) ▶



discharged state of an object when it has lost its excess charge; for example, a doorknob with excess negative charge becomes discharged when it passes the excess charge to the hand of someone who touches the knob (4.3)

ductile easily stretched into a wire or hammered thin (2.3)

ductility ability to be stretched into a wire without snapping; copper has high ductility, so it can be stretched into wire (2.3) ▼

dwarf planet a rocky object whose gravitational pull isn't strong enough to keep other rocks out of its orbit; most are found in orbit beyond Neptune; Pluto is a dwarf planet (3.3)

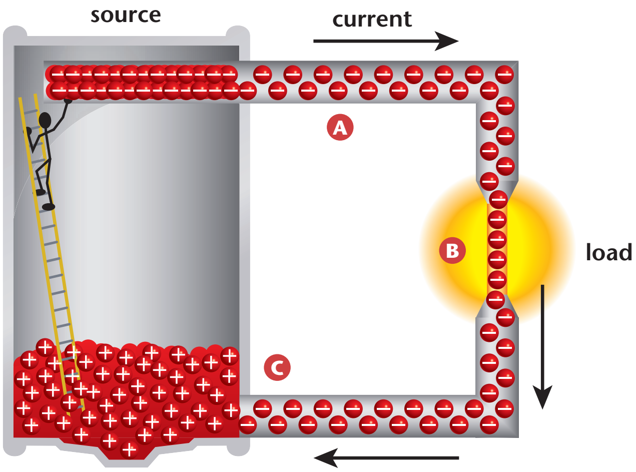
E

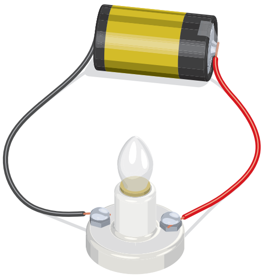
eclipse the phenomenon in which one celestial object moves directly in front of another celestial object, as viewed from Earth; eclipses seen from Earth can be solar (when the Moon moves between the Earth and the Sun) or lunar (when the Earth moves between the Sun and the Moon) (3.2)

ecology the scientific study of the connections between everything on Earth, both biotic and abiotic (1.1)

ecosystem a system that is made up of all the interacting biotic and abiotic parts of a certain place (1.1)

electrical circuit the connection of a source, a load, and a conductor that allows a current to flow; an electrical circuit is always a closed path (4.4) ▼

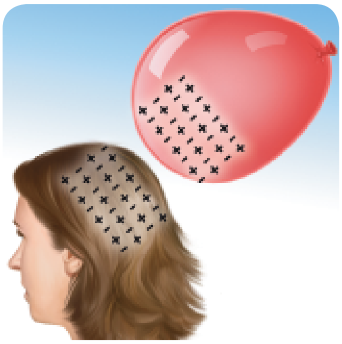




electrical current *see current*

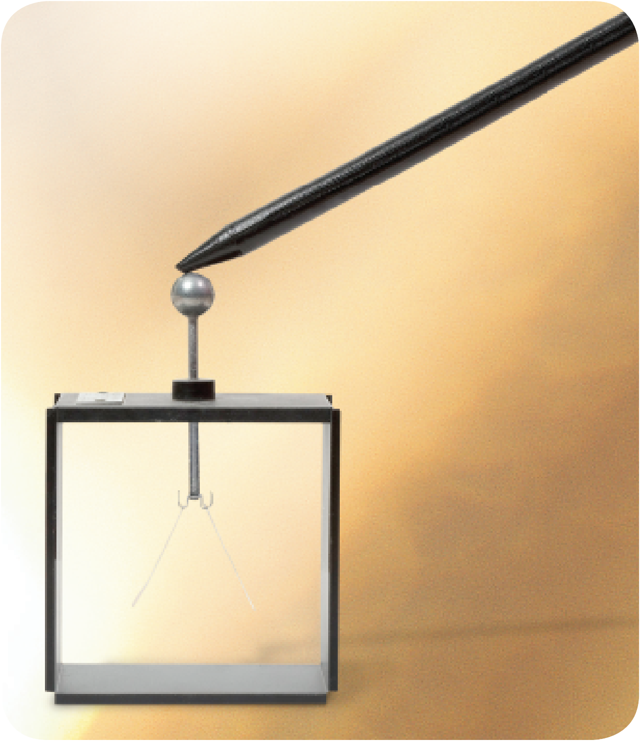
electrical energy a form of energy given off when charged particles interact; like all forms of energy it can be changed into other forms to power electrical devices (4.1)

electrically neutral an object that has an equal number of positive charges and negative charges; this object is not electrically charged; for example, both the balloon and the person's hair in this diagram are electrically neutral because they both have equal numbers of positive and negative charges (4.2) ▼

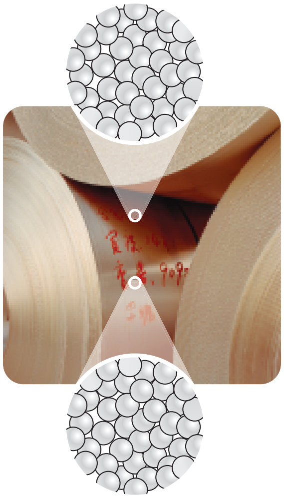


electron a particle of an atom that surrounds the nucleus; has a charge of negative one (2.4)

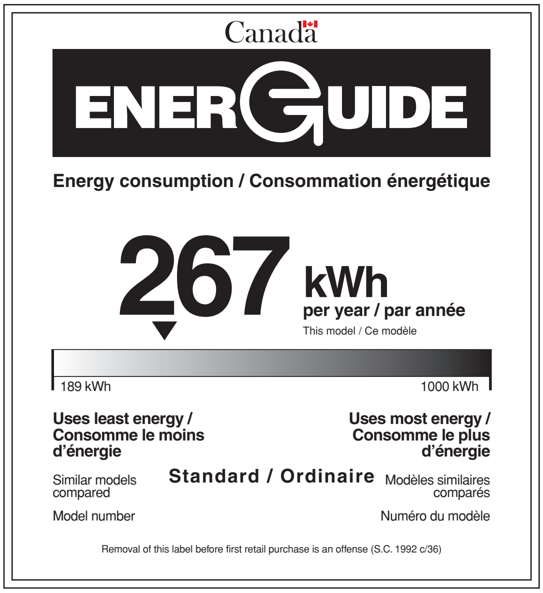
electroscope a device for testing an object to find out if it is charged (4.3) ▼



element a pure substance that cannot be broken down into simpler parts by chemical methods; all the elements are listed on the Periodic Table; all of the particles in an element are identical, as shown below in the element aluminum (2.3) ▼



EnerGuide label a label that shows about how much energy an appliance uses in one year of normal use; this label is put on all new appliances sold in Canada (4.7) ▼



Canada

ENERGUIDE

Energy consumption / Consommation énergétique

267 kWh
per year / par année
This model / Ce modèle

189 kWh
1000 kWh

Uses least energy / Consomme le moins d'énergie

Uses most energy / Consomme le plus d'énergie

Similar models compared

Standard / Ordinaire

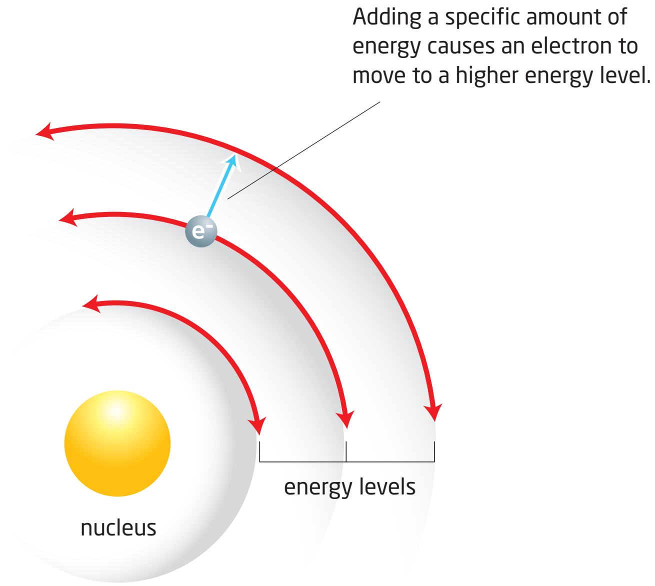
Modèles similaires comparés

Model number

Numéro du modèle

Removal of this label before first retail purchase is an offense (S.C. 1992 c/36)

energy level the cloud-like region around the nucleus of an atom (2.4) ▼



ENERGY STAR® label a label on an electrical appliance that means that the appliance or equipment meets or exceeds the government standards for electrical efficiency (4.7) ▼

environmental farm plan a volunteer-membership program in which farmers examine and make plans to reduce environmental impacts of farms (1.6)

equilibrium a stable, balanced, or unchanged system (1.6)

estimating making an informed judgement about a measurement; an estimate gives you an idea of a particular quantity but is not an exact measurement (SST4)

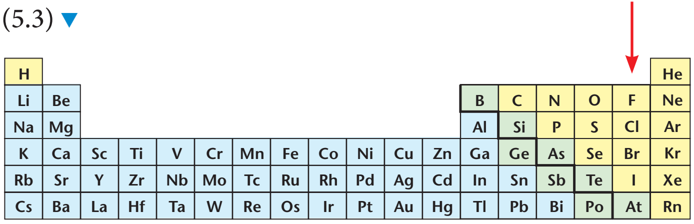
evaporation the change of state from a liquid to a gas; evaporation of the water in a puddle can cause the puddle to dry up (U2GR, SST2)

extinction the death of all of the individuals of a species; for example, dinosaurs became extinct millions of years ago (SST8)

F

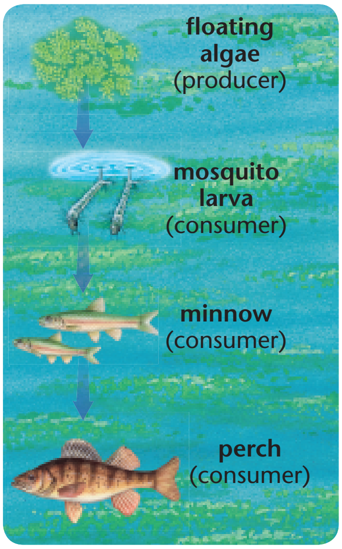
fair test a test with only one independent (manipulated) variable; a that is valid and unbiased (SST2)

family a vertical column of elements in the periodic table also known as a group; Group 17 is shown here (5.3) ▼

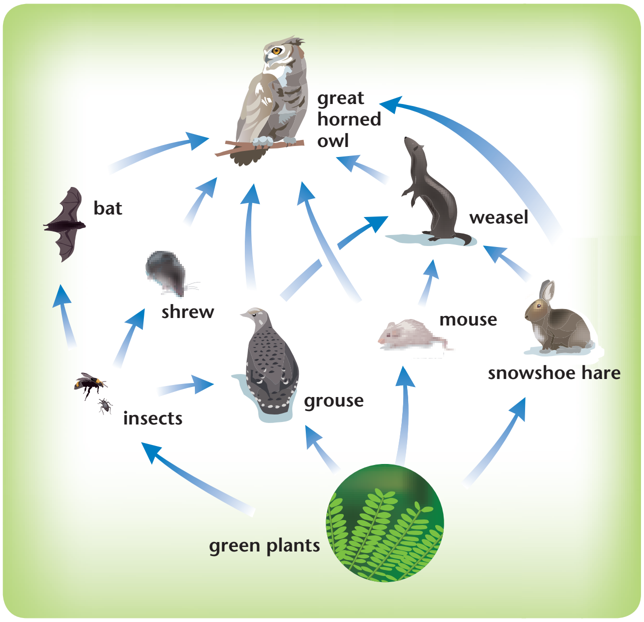


H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

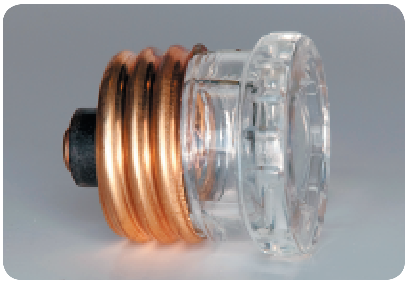
food chain a model that describes how the energy that is stored in food is transferred from one living thing to another (1.2) ▼



food web a model that describes how energy in an ecosystem is transferred through two or more food chains (1.2) ▼



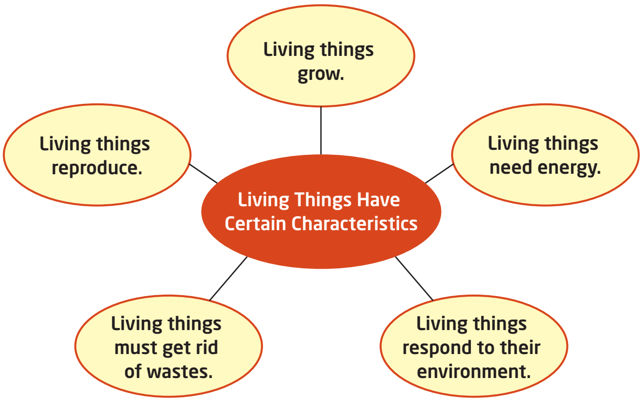
fuse a safety device that is found in older buildings and some appliances; like a circuit breaker, it keeps a circuit from carrying too much current, and is placed in series with other circuits that lead to appliances and outlets (4.6) ▼



G

galaxy a collection of many billions of stars, planets, gas, and dust, held together by gravity, as shown below; Earth is in the Milky Way galaxy (3.1) ▼

graphic organizer a chart or a combination of words and shapes that helps you to record and organize information; often used to show relationships between different ideas or pieces of information; graphic organizers include flowcharts, Venn diagrams, spider maps, and many more; a main idea web is shown here (LST5) ▼



gravitational pull the force of attraction that any two masses have for each other; the Sun's gravitational pull keeps Earth orbiting the Sun, and the gravity of the Earth pulls objects towards the center of the planet (3.1)

grounding connecting a conductor to Earth's surface so that charges can flow safely to the ground; a metal rod is used to ground the metal parts of large tank trucks while they are refueling, as shown (4.3) ▼

H

habitat area where an organism lives (1.6, SST8)

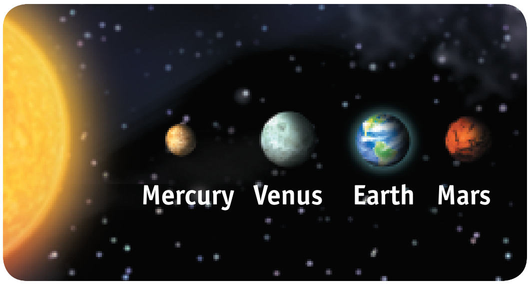
host the living thing on which a parasite feeds (1.4)

hypothesis a statement about an idea that you can test, based on your observations (SST2)

I

independent variable the factor that an experimenter changes in a test (also called the manipulated variable) (SST2)

inner planets the four planets in our solar system that are closest to the Sun: Mercury, Venus, Earth, and Mars; they are rocky, have cratered surfaces, are relatively small, and have no or few moons (3.3) ▼



insulator material that does not allow heat and electricity to move through it easily; insulators are often made of plastic or rubber (2.6)

introduced species any species that has been introduced into and lives in an ecosystem where it is not found naturally; for example, purple loosestrife has invaded Ontario's wetlands, forcing out other plants that used to live there (1.5) ▼

issue a topic that can be seen from more than one point of view (SST1)

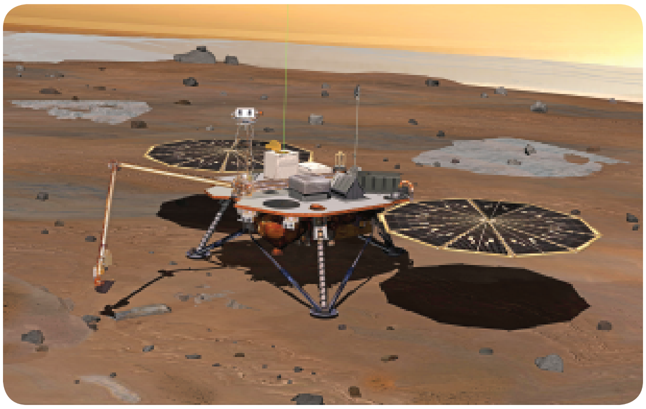
K

kilowatt (kW) a unit of electrical energy usage; 1 kW = 1000 W (4.7)

kilowatt hour (kWh) a measure of the number of watts of energy used in one hour (4.7)

L

lander a spacecraft designed to land on a celestial object; for example, the *Phoenix Mars Lander* has done some exploration of the surface of Mars (3.4) ▼



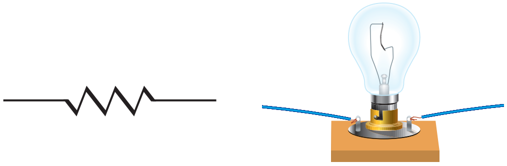
lightning rod a metal sphere or point that is attached to the highest part of a building and connected to the ground; protects buildings and people by allowing charges from lightning to travel safely from the air to the ground (4.3) ▼

light-year a measurement equal to the distance that light travels in one year, about 9.5×10^{12} km; abbreviation is *ly* (3.1)

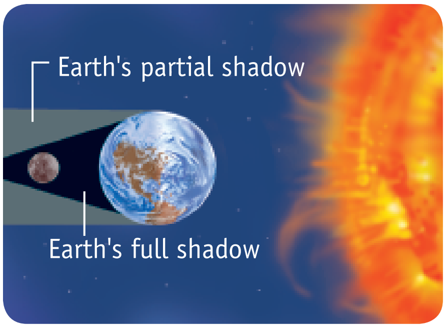
limiting factor any resource that limits the size to which a population can grow; food is a limiting factor to the growth of a population (1.4)

literacy the ability to identify, understand, analyze, create, and communicate using printed and written materials in various situations; for example, having the skills needed to view a video or read a newspaper article or web page, question the text, apply it to what you are learning in science, and express your opinion about it. (LST1-5)

load the part of an electrical circuit that requires electricity to work; an oven, a light bulb, and a computer are all examples of loads (4.4) ▼



lunar eclipse an event where Earth moves directly between the Sun and the Moon so that Earth casts its shadow on the Moon (3.2) ▼



lustre the ability to reflect light, or shine; silver has a high lustre and so is popular for jewellery; sodium metal is also lustrous, as shown here (2.2) ▼

M

magnetosphere the area of space that contains a planet's magnetic field; the magnetosphere offers Earth some protection from the damaging effects of the solar wind (3.2)

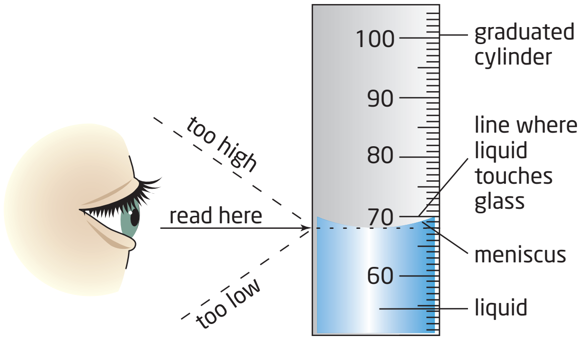
malleability ability of a substance to be bent or shaped by hammering without breaking; the malleability of steel makes it possible to make a sheet of steel into a car door panel or a trash can (2.3) ▼

manipulated variable the factor that an experimenter changes in a test (also called the independent variable) (SST2)

mass the amount of matter in a substance or object; mass is measured in milligrams, grams, kilograms, and tonnes (U2GR, 2.1, SST4)

matter anything that has mass and occupies space (volume) (2.1)

meniscus the slight curve where a liquid touches the sides of its container; to measure the volume of a liquid accurately, make sure your eye is at the same level as the bottom of the meniscus (SST4) ▼



metal typically, an element that is solid at room temperature, shiny, malleable, ductile, and a good conductor; for example, aluminum, iron, calcium (2.3)

metalloid an element that shares some properties with metals and some properties with non-metals (2.4)

meteor [MEE-tee-uhr] a meteoroid that hits Earth's atmosphere and burns up, making a streak of light across the sky, as in the Leonid meteor shower, shown (3.3) ▼

meteorite [MEE-tee-uhr-iht] a meteoroid that survives Earth's atmosphere and lands on Earth's surface; the crater shown below was formed by a meteorite (3.3) ▼

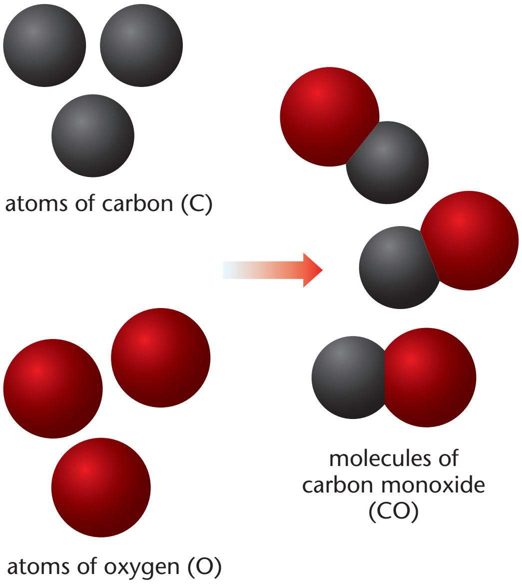
meteoroid [MEE-tee-uhr-oid] in space, a chunk of rock, metal, or both, shed from asteroids or comets; the streak of light in this image is a meteoroid passing through the Milky Way (3.3) ▼

Milky Way the galaxy that includes the solar system; looks like a hazy white band in the night sky (3.1) ▼

mixture matter that can be separated into parts using differences in physical properties; saltwater is a mixture of salt and water (2.3)

model anything that helps you understand a concept or process; can be a mental picture, a diagram, a structure, a working device, a chemical equation, or even a mathematical expression; can also be used to simplify a situation to allow you to test an hypothesis under conditions in which only one independent variable is changing (SST2, SST7)

molecule [MAWL-uh-kyul] a type of particle that is made up of two or more atoms bonded together; carbon monoxide is an example of a molecule (2.5) ▼



multimeter a device that measures several different electrical quantities, including potential difference, current, and resistance (SST9) ▼

N

negative charges the type of electrical charges that can be rubbed off a material; negative charges are associated with electrons (4.2)

neutron located in the nucleus of an atom, has no charge (2.4)

non-metal typically, an element that is solid at room temperature, dull, brittle, not ductile, and a poor conductor (2.3)

non-renewable energy source a source of energy, such as fossil fuels and uranium, that cannot be replaced or restocked in a human lifetime (4.1)

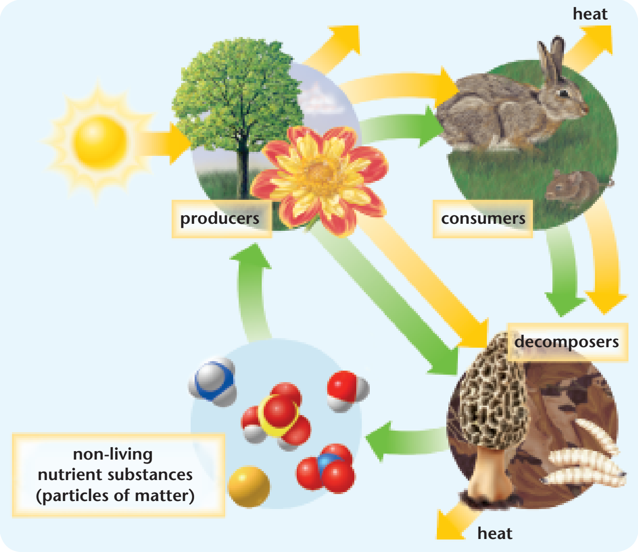
nuclear fusion [NOO-klee-er FYUSH-uhn] the process of energy production in which hydrogen atoms collide violently to form a helium atom, releasing great amounts of energy; happens naturally in our Sun; nuclear fusion is occurring continuously in the Sun and creating huge amounts of heat and light; nuclear fusion reactions involving atoms of other elements, such as uranium, are used to produce nuclear energy, which then can be converted into electrical energy (3.2, 4.1)

nucleus in chemistry, the charged centre of an atom; contains the atom's protons and neutrons (2.4)

numeracy the ability to identify, understand, analyze, solve problems, apply solutions, and communicate using numbers, mathematical language, symbols, equations, and graphs; for example, having the skills needed to take information from a graph and use formulas, addition, subtraction, multiplication, and/or division to solve a problem and clearly express your answer (NST1-5)

nutrient a chemical that a living thing needs to live and grow; plants absorb nutrients from the soil in the form of minerals, such as potassium and phosphorus (1.3)

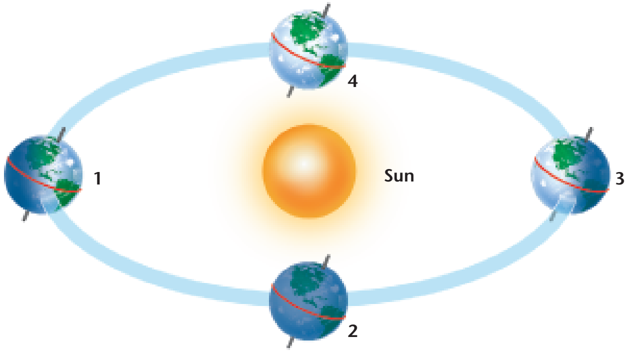
nutrient cycle the pattern of continual use and reuse of a nutrient; the carbon cycle is a nutrient cycle; a general nutrient cycle is shown below (1.3) ▼



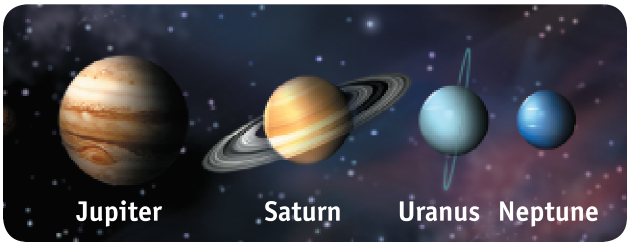
O

ohm (Ω) [OHM] the unit used to measure resistance in an electric circuit (4.4)

orbit a circular path, caused by gravitational pull, in which one object travels around another; for example, Earth travels in an orbit around the Sun (3.1) ▼

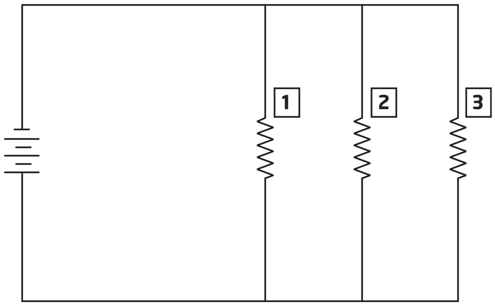


outer planets the four planets of our solar system that are farthest from the Sun: Jupiter, Saturn, Uranus, and Neptune; they are gassy with no solid surface, relatively large, and have many moons (3.3) ▼



P

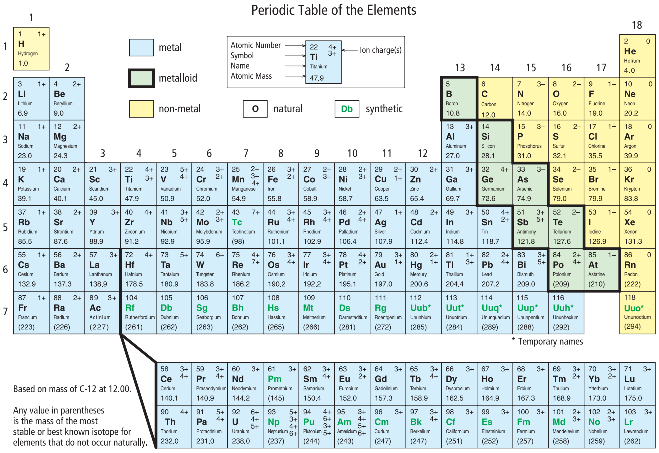
parallel circuit a circuit that has two or more paths for the current to follow; the current in each branch in a parallel circuit is less than the current through the source (4.5) ▼



parasite a living thing that lives on or inside another living thing and uses it or its tissue for food or shelter; a tapeworm is a parasite (1.4)

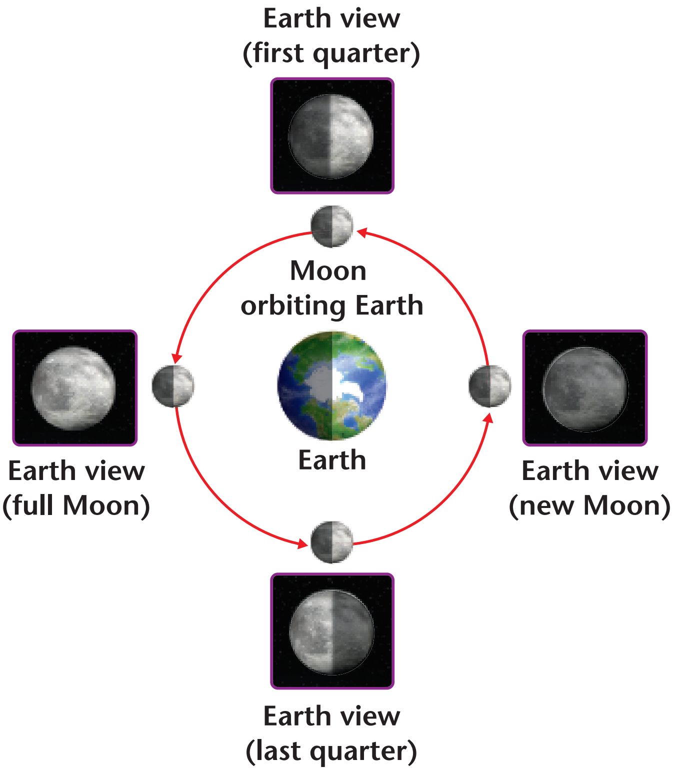
period a horizontal row of elements in the periodic table; for example, sodium, magnesium, aluminum, silicon, phosphorus, sulfur, chlorine, and argon make up period 3 of the periodic table (2.4)

periodic table a system for organizing the elements into columns and rows, so that elements with similar properties are in the same column (2.4) ▼



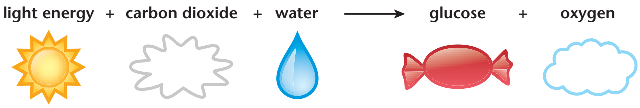
phantom load the electricity that is used by an appliance or device when it is turned off or in stand-by mode; some people are measuring the phantom load in their homes to find out how much energy they are wasting (4.7)

phases of the Moon the monthly changes in the amount of the *lit-up* side of the Moon we can see; the Moon's light is actually reflected sunlight (3.2) ▼



photosphere the surface layer of the Sun (3.2)

photosynthesis a process in the cells of plants, algae, and some bacteria that converts light energy from the Sun into stored chemical energy that can be used by other living things; the equation for this process, shown below, summarizes the materials necessary for and the materials produced by photosynthesis (1.2) ▼



physical property the way matter looks, feels, smells or tastes; one physical property of gold is its lustre (2.2)

plagiarism copying information word-for-word and then presenting it as though it is your own work (SST8)

planet an object in the sky that orbits one or more stars (and is not a star itself), is spherical, and does not share its orbit with another object (U3GR, 3.1, 3.3) ▼

population all the individuals of a species that live in a certain place at a certain time (1.4)

positive charges the type of electrical charges that are left behind when negative charges are rubbed off a material; positive charges are associated with protons (4.2)

potential difference used to describe the amount of energy a source can provide; the potential difference across a source is the difference between the energy of a unit of charge entering one end of a source, and the energy of a unit of charge leaving the other end of the source; potential difference is measured in volts, so its measurement is called voltage (4.4)

precipitate a solid substance that can form when certain dissolved substances are mixed together (2.2) ▼

precision describes both the exactness of a measuring device and the range of values in a set of measurements; the precision of a measuring instrument is usually half the smallest division on its scale (SST5)

predation a relationship between two different species in which one species feeds on another (1.4)

predator an organism that hunts, kills, and eats other organisms; for example, a lynx is a predator that eats hares (1.4) ▼

prediction a forecast about what you expect to observe; a prediction will help you decide if your hypothesis is correct (SST2)

prefix a part added to the beginning of a word that changes the meaning of a base word; for example, in the word *undo*, *un-* is a prefix (meaning *not*) that changes the meaning of the base word, *do*, to mean the opposite or reverse action (LST4)

prey an organism that is eaten as food by a predator; for example a snowshoe hare is prey to a lynx (1.4) ▼

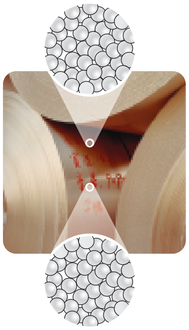
producer any living thing that gets the energy it needs by making its own food; for example, grass is a producer that makes its food by photosynthesis (1.2)

proton [PROH-tawn] a particle of an atom that is inside the nucleus; has a positive charge (2.4)

pure substance a substance made up of only one kind of matter; for instance, copper, distilled water, and aluminum are all pure substances (2.3) ▼


copper particles


distilled water particles


aluminum particles

Q

qualitative observation an observation that can be described, but not measured using numbers; for example, “The ruler is brown,” or “The ruler is long.” (SST2)

quantitative observation an observation that can be measured and assigned a numerical value; for example, “The ruler is 30 cm long.” (SST2)

R

radioactive the property of some elements to give off rays of energy as the element breaks down; these rays are given off as the result of a nuclear reaction, and can be harmful to living things (3.5)

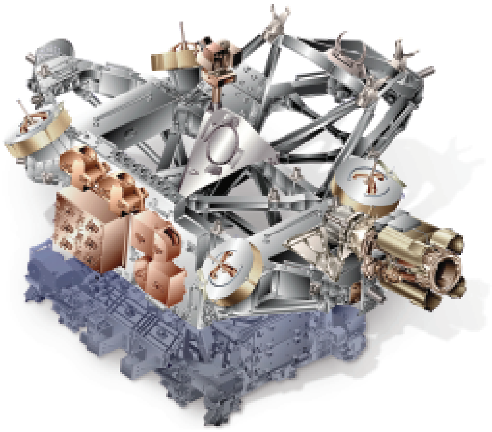
reactivity the degree to which a substance can change (2.2)

renewable energy source a source of energy, such as water, that can be replaced or restocked in a human lifetime (4.1)

resistance a measure of how much a load pushes against a current in an electrical circuit; measured in the unit ohms (4.4)

responding variable the factor that is observed; the experimenter in a test looks for changes in the responding variable in response to the manipulated variable (the one controlled by the experimenter); also called the dependent variable (SST2)

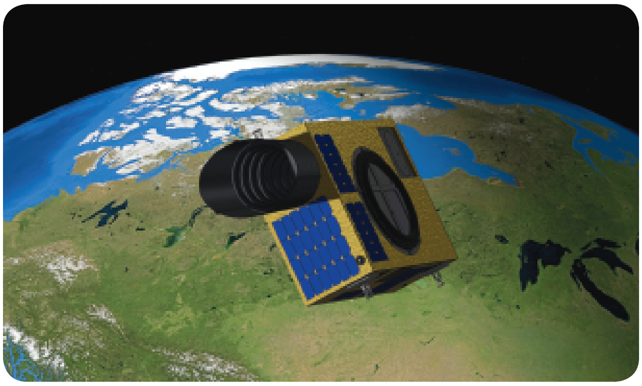
robotics using machines to replace human actions; robotics are very important to the space program; an illustration of the *Mobile Base System* from the International Space Station is shown (3.4) ▼



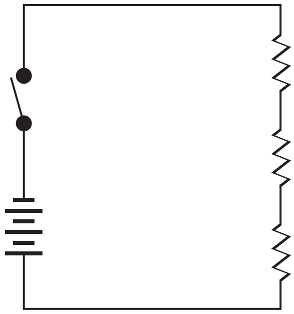
rotation the turning of an object around an imaginary axis running through it; Earth’s rotation around its axis takes 24 h (3.1, 3.2, 3.3) ▶

S

satellite human-made object or vehicle that orbits Earth, the Moon, or other celestial bodies; also, a celestial body that orbits another body of larger size; for example, the Moon is Earth's natural satellite; Canada's *NEOSSat,* shown in the illustration below, is used to monitor asteroids (3.2, 3.4) ▼



series circuit an electrical circuit that has only one path for the current to follow; in a series circuit, the current is the same at every point in the circuit (4.5) ▼

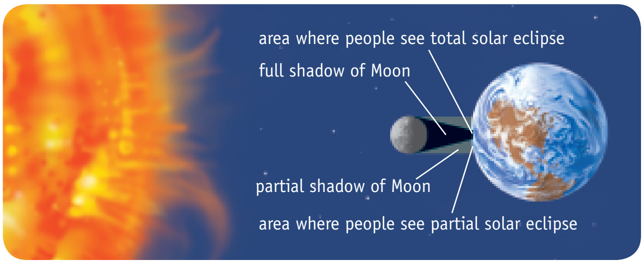


significant digits all the certain digits plus the first uncertain digit in a measurement; represent the amount of uncertainty in a measurement (NST1)

smart growth expansion of human communities by concentrating growth in the centre of a city, rather than in less populated areas; homes and businesses are found within the same areas, while parks and other natural areas are preserved (1.6)

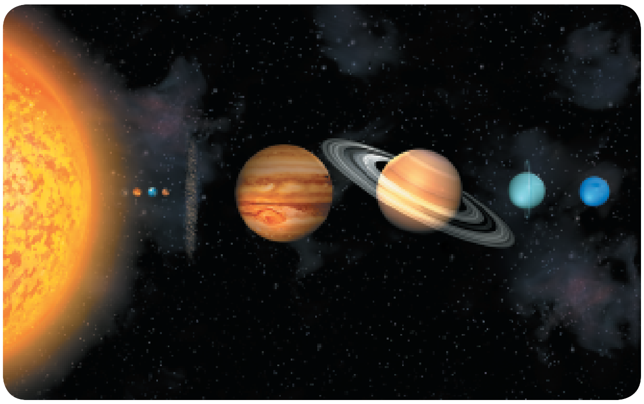
smart meter a meter that measures total electrical energy used every hour and sends this information to the utility company automatically (4.7) ▼

solar eclipse an event where the Moon moves directly between the Sun and Earth so that the Moon casts its shadow on part of Earth (3.2) ▼



solar energy energy that is directly converted from the energy of the Sun into electricity (4.1)

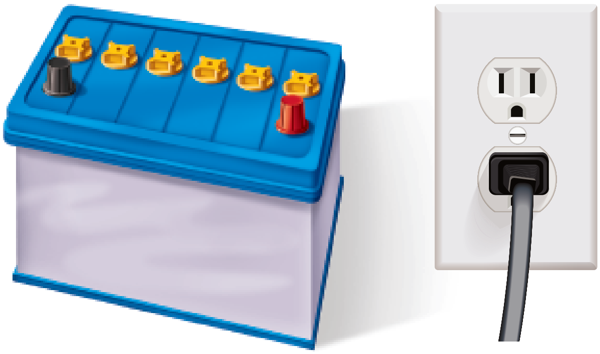
solar system the system of planets, including Earth, moons, and other objects that orbit the Sun; in the illustration shown here, the eight planets are drawn to scale, but the distance between the planets is not drawn to scale (3.1) ▼



solar wind a stream of fast-moving charged particles that the Sun sends into the solar system; solar wind is deadly to living things; Earth's magnetic field protects us from this extreme energy (3.2)

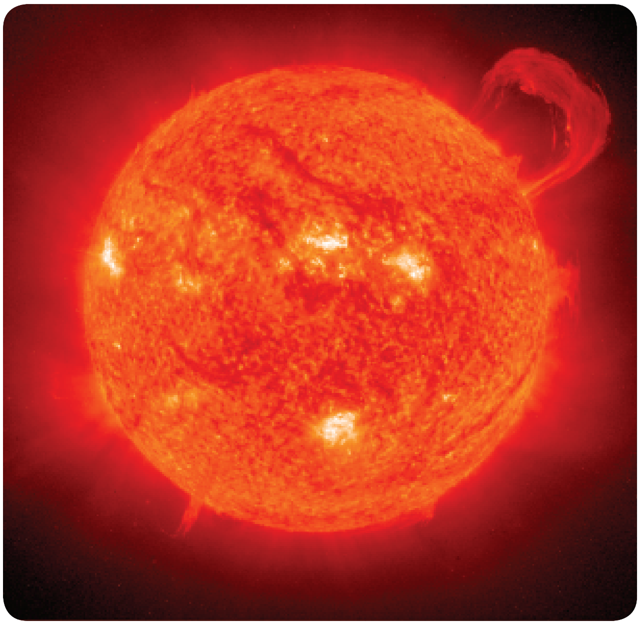
solubility describes how much of a substance dissolves in another substance (2.2)

source a material whose energy is used to create electricity; moving water, fossil fuels (coal, oil, natural gas), uranium, wind, and the Sun are all sources of electrical energy; also, the device that supplies electrical energy to operate any electrical device; for example, a battery or an outlet (4.1, 4.4) ▼



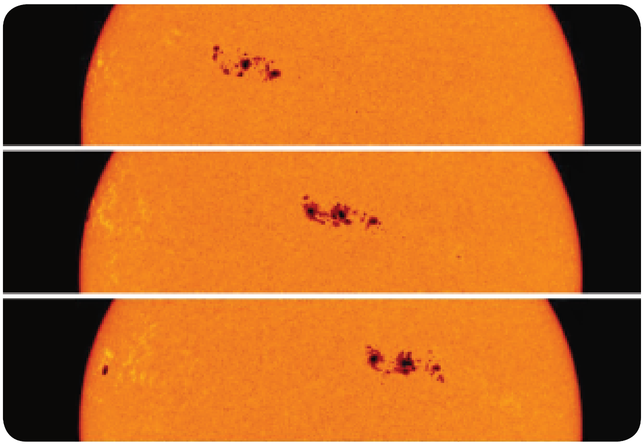
species diversity the number and variety of species of living things in an area (1.5)

star a huge celestial body made of superheated gases (3.1) ▼



static electricity the result when positive and negative charges are separated; creates an excess of charges that stay where they are (4.2) ▼

sunspot an area of strong magnetic fields on the surface layer of the sun (photosphere); as shown, sunspots move as the Sun rotates (3.2) ▼



sustain to continue; to support (1.1)

sustainability maintaining an ecosystem so that present populations can get the resources they need without risking the ability of future generations to get the resources that they need (1.6)

sustainable describes practices that do not lead to long-term exhaustion of a resource (1.6, 4.7)

sustainable ecosystem an ecosystem that can withstand pressure and support a variety of organisms now and for the future (1.6)

suffix an ending that changes the meaning of a base word; for example, in the word *fearless*, *-less* is a suffix (meaning *without*) that changes the meaning of the base word *fear*, to give the meaning *without fear* (LST4)

switch a control device connected to an electrical circuit that completes or breaks the circuit; opening the switch stops the current and turns the item off (4.4) ▼

T

technology the use of scientific knowledge, as well as everyday experience, to perform tasks or solve practical problems; for example, a computer is a form of technology that allows you to write reports, surf the Internet, play games, and perform many other tasks (SST3)

temperature a measure of the thermal (heat) energy of the particles of a substance; a measure of how hot or how cold something is (SST4)

terrestrial ecosystem an ecosystem that is based mostly or totally on land; forests are examples of terrestrial ecosystems (1.1) ▼

texture describes how the surface of a substance feels (its roughness, softness, or smoothness) (2.2)

theory a statement that explains why or how something happens; eventually, when an hypothesis has been thoroughly tested and nearly all scientists agree that the results support the hypothesis, it becomes a theory (SST2)

tidal energy energy captured from the movement of waves; for example the tidal energy from waves on the Atlantic Ocean is captured and converted to electrical energy at a generating station near the Bay of Fundy in Nova Scotia, Canada (4.1) ▼

U

universe all the celestial objects we see, and that can be seen, in the sky (3.1)

unsustainable a pattern of activity in an ecosystem that leads to the ecosystem not working well; in general terms, a pattern of activity or use that will lead to a shortage of resources in the future; for example, current use of fossil fuels will lead to these resources not being available to provide energy for future generations of people (1.6, 4.7)

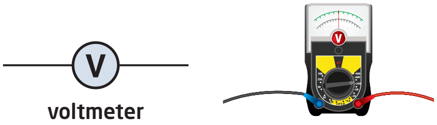
urban sprawl the growth of relatively low-density development on the edges of urban areas; the spread of housing and businesses into less populated areas, taking over areas that were once home to wildlife (1.6)

V

variable any possible factor that could affect a test (SST2)

volt the unit to measure potential difference; the potential difference of a AA battery is 1.5 volts; the potential difference of a typical electrical outlet in your home is 120 volts (4.4)

voltmeter a device that measures volts (4.3, SST9) ▼



volume the amount of space that a substance or object occupies (U2GR, 2.1, SST4)

W

watershed any area of land (natural, human-made, or both) that drains into a body of water, as shown below; for example, water in the Hudson Bay watershed drains into the Hudson Bay (1.5) ▼

watt a unit of electrical energy usage;
1 kilowatt = 1000 W (4.7)

wind farm many large wind turbines placed in one location to capture wind energy; wind farms capture wind energy and convert it into electrical energy (4.1) ▼

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Periodic Table of the Elements

🟦 metal

🟩 metalloid

🟨 non-metal

Atomic Number → 22
Symbol → Ti
Name → Titanium
Atomic Mass → 47.9
4+ 3+ ← Ion charge(s)

O natural

Db synthetic

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 1+ **H** Hydrogen 1.0																	2 0 **He** Helium 4.0
2	3 1+ **Li** Lithium 6.9	4 2+ **Be** Beryllium 9.0											5 **B** Boron 10.8	6 **C** Carbon 12.0	7 3– **N** Nitrogen 14.0	8 2– **O** Oxygen 16.0	9 1– **F** Fluorine 19.0	10 0 **Ne** Neon 20.2
3	11 1+ **Na** Sodium 23.0	12 2+ **Mg** Magnesium 24.3											13 3+ **Al** Aluminum 27.0	14 **Si** Silicon 28.1	15 3– **P** Phosphorus 31.0	16 2– **S** Sulfur 32.1	17 1– **Cl** Chlorine 35.5	18 0 **Ar** Argon 39.9
4	19 1+ **K** Potassium 39.1	20 2+ **Ca** Calcium 40.1	21 3+ **Sc** Scandium 45.0	22 4+ 3+ **Ti** Titanium 47.9	23 5+ 4+ **V** Vanadium 50.9	24 3+ 2+ **Cr** Chromium 52.0	25 2+ 3+ 4+ **Mn** Manganese 54.9	26 3+ 2+ **Fe** Iron 55.8	27 2+ 3+ **Co** Cobalt 58.9	28 2+ 3+ **Ni** Nickel 58.7	29 2+ 1+ **Cu** Copper 63.5	30 2+ **Zn** Zinc 65.4	31 3+ **Ga** Gallium 69.7	32 4+ **Ge** Germanium 72.6	33 3– **As** Arsenic 74.9	34 2– **Se** Selenium 79.0	35 1– **Br** Bromine 79.9	36 0 **Kr** Krypton 83.8
5	37 1+ **Rb** Rubidium 85.5	38 2+ **Sr** Strontium 87.6	39 3+ **Y** Yttrium 88.9	40 4+ **Zr** Zirconium 91.2	41 3+ 5+ **Nb** Niobium 92.9	42 2+ 3+ **Mo** Molybdenum 95.9	43 7+ **Tc** Technetium (98)	44 3+ 4+ **Ru** Ruthenium 101.1	45 3+ 4+ **Rh** Rhodium 102.9	46 2+ 4+ **Pd** Palladium 106.4	47 1+ **Ag** Silver 107.9	48 2+ **Cd** Cadmium 112.4	49 3+ **In** Indium 114.8	50 4+ 2+ **Sn** Tin 118.7	51 3+ 5+ **Sb** Antimony 121.8	52 2– **Te** Tellurium 127.6	53 1– **I** Iodine 126.9	54 0 **Xe** Xenon 131.3
6	55 1+ **Cs** Cesium 132.9	56 2+ **Ba** Barium 137.3	57 3+ **La** Lanthanum 138.9	72 4+ **Hf** Hafnium 178.5	73 5+ **Ta** Tantalum 180.9	74 6+ **W** Tungsten 183.8	75 4+ 7+ **Re** Rhenium 186.2	76 3+ 4+ **Os** Osmium 190.2	77 3+ 4+ **Ir** Iridium 192.2	78 4+ 2+ **Pt** Platinum 195.1	79 3+ 1+ **Au** Gold 197.0	80 2+ 1+ **Hg** Mercury 200.6	81 1+ 3+ **Tl** Thallium 204.4	82 2+ 4+ **Pb** Lead 207.2	83 3+ 5+ **Bi** Bismuth 209.0	84 2+ 4+ **Po** Polonium (209)	85 1– **At** Astatine (210)	86 0 **Rn** Radon (222)
7	87 1+ **Fr** Francium (223)	88 2+ **Ra** Radium (226)	89 3+ **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 **Ds** Darmstadtium (281)	111 **Rg** Roentgenium (272)	112 **Uub*** Ununbium (285)	113 **Uut*** Ununtrium (284)	114 **Uuq*** Ununquadium (289)	115 **Uup*** Ununpentium (288)	116 **Uuh*** Ununhexium (292)		118 **Uuo*** Ununoctium (294)

* Temporary names

58 3+ 4+ **Ce** Cerium 140.1	59 3+ 4+ **Pr** Praseodymium 140.9	60 3+ **Nd** Neodymium 144.2	61 3+ **Pm** Promethium (145)	62 3+ 4+ **Sm** Samarium 150.4	63 3+ 2+ **Eu** Europium 152.0	64 3+ **Gd** Gadolinium 157.3	65 3+ 4+ **Tb** Terbium 158.9	66 3+ **Dy** Dysprosium 162.5	67 3+ **Ho** Holmium 164.9	68 3+ **Er** Erbium 167.3	69 3+ 2+ **Tm** Thulium 168.9	70 3+ 2+ **Yb** Ytterbium 173.0	71 3+ **Lu** Lutetium 175.0
90 4+ **Th** Thorium 232.0	91 5+ 4+ **Pa** Protactinium 231.0	92 6+ 4+ 5+ **U** Uranium 238.0	93 5+ 3+ 4+ 6+ **Np** Neptunium (237)	94 4+ 6+ 3+ 5+ **Pu** Plutonium (244)	95 3+ 4+ 5+ 6+ **Am** Americium (243)	96 3+ **Cm** Curium (247)	97 3+ 4+ **Bk** Berkelium (247)	98 3+ **Cf** Californium (251)	99 3+ **Es** Einsteinium (252)	100 3+ **Fm** Fermium (257)	101 2+ 3+ **Md** Mendelevium (258)	102 2+ 3+ **No** Nobelium (259)	103 3+ **Lr** Lawrencium (262)

Based on mass of C-12 at 12.00.

Any value in parentheses is the mass of the most stable or best known isotope for elements that do not occur naturally.

SCIENCE LINKS 9

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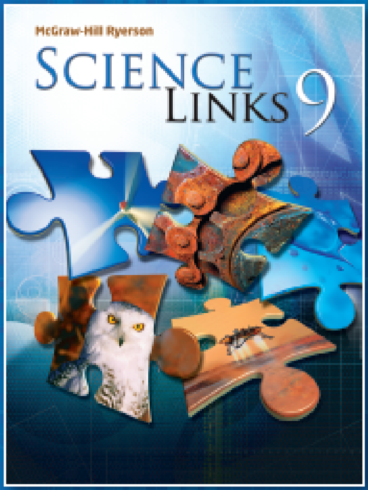

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