Science Skills Guide

Skill FOCUS 1

SAFETY SYMBOLS

The following safety symbols are used in the *SCIENCEFOCUS™ 8* program to alert you to possible dangers. Be sure you understand each symbol used in an activity or investigation before you begin.

Disposal Alert This symbol appears when care must be taken to dispose of materials properly.
Thermal Safety This symbol appears as a reminder to use caution when handling hot objects.
Sharp Object Safety This symbol appears when a danger of cuts or punctures caused by the use of sharp objects exists.
Electrical Safety This symbol appears when care should be taken when using electrical equipment.
Skin Protection Safety This symbol appears when use of caustic chemicals might irritate the skin or when contact with micro-organisms might transmit infection.
Clothing Protection Safety A lab apron should be worn when this symbol appears.
Fire Safety This symbol appears when care should be taken around open flames.
Eye Safety This symbol appears when a danger to the eyes exists. Safety goggles should be worn when this symbol appears.

Instant Practice

Find four of the *SCIENCEFOCUS™ 8* safety symbols in activities or investigations in this textbook. Record the page number and the title of the investigation or activity in which you found the symbol. What are the possible dangers in the activity or investigation you have identified that relate to each symbol?

WHMIS Symbols

Look carefully at the WHMIS (Workplace Hazardous Materials Information System) safety symbols shown here. The WHMIS symbols are used throughout Canada to identify dangerous materials used in all workplaces, including schools. Make certain you understand what these symbols mean. When you see these symbols on containers in your classroom, at home, or in a workplace, use safety precautions.

Compressed Gas	Flammable and Combustible Material
Oxidizing Material	Corrosive Material
Poisonous and Infectious Material Causing Immediate and Serious Toxic Effects	Poisonous and Infectious Material Causing Other Toxic Effects
Biohazardous Infectious	Dangerously Reactive

Instant Practice

Find any two WHMIS symbols on containers in your school, or ask your parent or guardian to look for WHMIS symbols in a workplace. Record the name of the substance on which the symbols are used, and where you or your parent or guardian saw the containers stored. What dangers are associated with the substance in each container?

USING YOUR TEXTBOOK AS A STUDY TOOL

SCIENCEFOCUS*™ *8 contains a great deal of useful information. How can you read your textbook effectively in order to add information to your existing store of knowledge, and to identify areas of inquiry that you might like to pursue? This *Skill Focus* will give you some ideas for remembering what you read.

Organizing the Information in Your Textbook

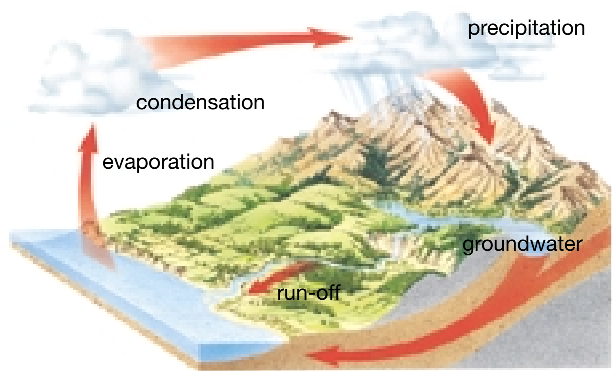
Look at all of the suggestions presented here. Use the learning strategies that work for you, but try others as well. Doing something in a different way often helps you see ideas more clearly and understand them better.

1. When you are starting a new unit, read the *Unit Contents*, the *Focussing Questions*, and the Topic cluster descriptions beside each photograph on the Unit Preview page. They will help you to focus on what each Topic cluster presents. Think about how the ideas fit into the "big picture" or main theme of the unit. Try to predict some ideas you might learn about in each Topic cluster. Write some of your own questions about each Topic.
2. Try rewriting the Topic headings and subheadings as questions. Then look for the answer to each question as you read.
3. Think about what you are reading, and write brief notes to help you remember the information in each paragraph.

Using Your Textbook Visuals

As you read each page, look at any photographs, illustrations, or graphs that appear on the page. Read the captions and labels that accompany the photographs, as well as the titles of graphs. Think about the information each visual provides, and note how it helps you to understand the ideas presented in the text. For example, look closely at the illustration on this page. What information does it convey to you?

Look, as well, at any terms that are in bold (dark, heavy) type. These terms will provide important definitions that you will need in order to understand and write about the information in each Topic. Make sure that you understand these terms and how they are used. Each boldfaced term appears in the *Glossary* at the back of this book.



Water on Earth moves in an endless water cycle.

Making Sure You Understand

At the end of every section and every Topic cluster, you will find review questions. If you are unable to answer them, reread the material to find the answers.

Instant Practice

1. Go to the unit your teacher has told you that you will be studying, and try strategy number 1 (under "Organizing the Information in Your Textbook").
2. In the first Topic of the unit, try out strategy number 2.
3. Find any terms that are in bold in the introduction and in the first section of the first Topic of the unit. Record the terms and their meanings.

Graphic Organizers

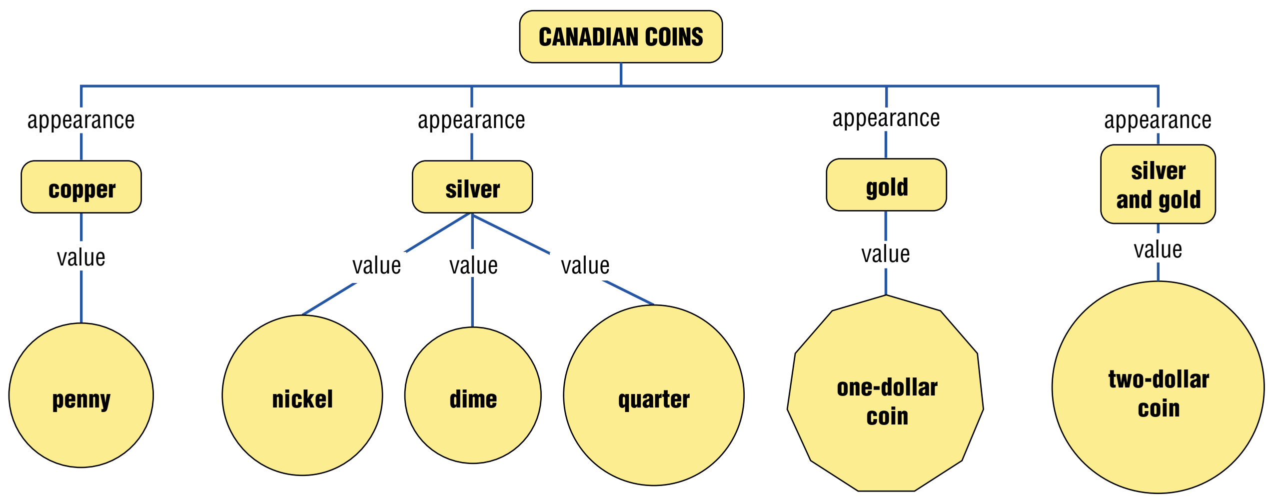
A good way to organize information you are learning is to use a **graphic organizer**. One kind of graphic organizer you will find useful is a **concept map**.

A concept map is a diagram that represents visually how ideas are related. Because the concept map shows the relationships among concepts, it can clarify the meaning of the ideas and terms and help you to understand what you are studying.

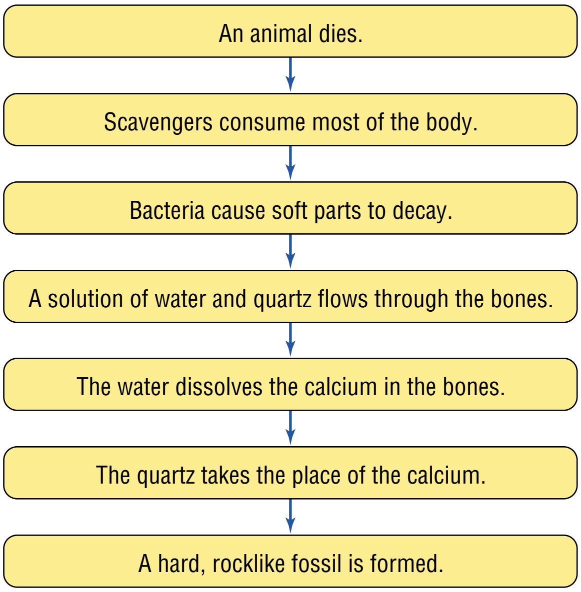
Study the construction of the concept map below called a **network tree**. Notice how some words are enclosed while others are written on connecting lines. The enclosed words are ideas or terms called concepts. The lines in the map show related concepts, and the words written on them describe relationships between the concepts.

As you learn more about the Topic, your concept map will grow and change. Concept maps are just another tool for you to use. There is no single "correct" concept map, only the connections that make sense to you. Make your map as neat and clear as possible and make sure you have good reasons for suggesting the connections between its parts.

When you have completed the concept map, you may have dozens of interesting ideas. Your map is a record of your thinking. Although it may contain many of the same concepts as other students' maps, your ideas may be recorded and linked differently. You can use your map for study and review. You can refer to it to help you recall concepts and relationships. At a later date, you can use your map to see what you have learned and how your ideas have changed.

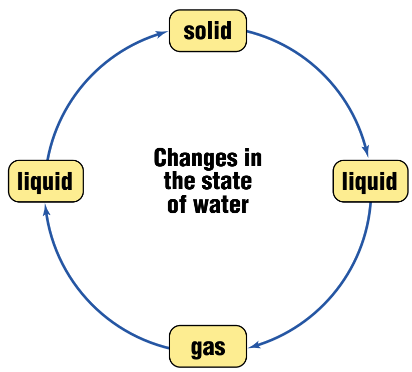


An **events chain map** describes ideas in order. In science, an events chain can be used to describe a sequence of events, the steps in a procedure, or the stages of a process. When making an events chain, you must first find out the one event that starts the chain. This event is called the initiating event. You then find the next event in the chain and continue until you reach an outcome. Here is an events chain concept map showing how an animal fossil may be formed.

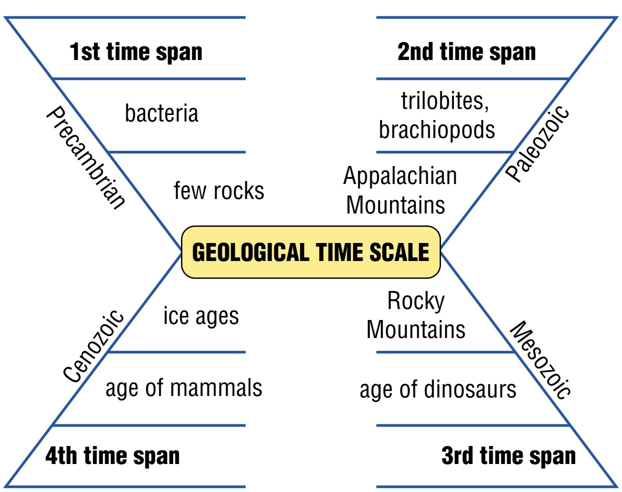


A **cycle concept map** is a special type of events chain map. In a cycle concept map, the series of events do not produce a final outcome. This type of concept map has no beginning and no end.

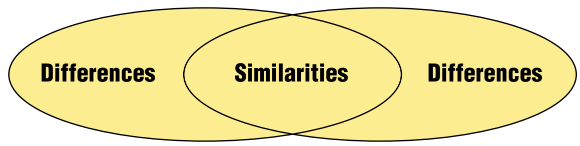
To construct a cycle concept map, you first decide on a starting point and then list each important event in order. Since there is no outcome and the last event relates back to the first event, the cycle repeats itself. Look at the cycle concept map below showing changes in the state of water.



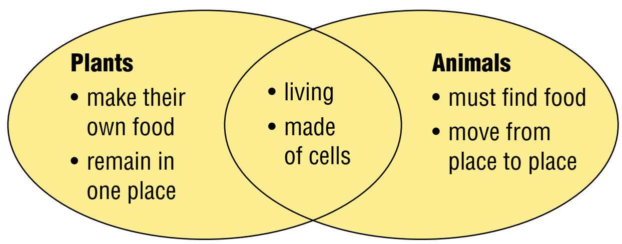
A **spider map** is a concept map that you may find useful for brainstorming. You may, for example, have a central idea and a jumble of associated concepts, but they may not necessarily be related to each other. By placing these associated ideas outside the main concept, you can begin to group these ideas so that their relationships become easier to understand. Examine the following spider map of the geological time scale to see how various concepts related to this time scale may be grouped to provide clearer understanding.



Comparing and contrasting is another way to help solidify your learning. When you compare, you look for similarities between two concepts or objects. When you contrast, you look for differences. You can do this by listing ways in which two things are similar and ways in which they are different. You can also use a graphic organizer called a **Venn diagram** to do this, using two circles.



Example



Testing Your Skills

Another way to make sure you understand what you have learned is to practise and use the special skills you learned at the beginning of this textbook and all through it. These are the skills of inquiry, problem solving, and decision making.

Instant Practice

1. Use the following words to produce a network tree concept map: music for listening, music for dancing, rap, classical, rhythm and blues, favourite CDs, rock, folk.
2. Make a Venn diagram to compare and contrast chocolate chip cookies with oatmeal cookies.
3. Produce an events chain concept map that starts with the buzzing of your clock radio and ends with your sitting at your desk as school begins.
4. Design a spider map to represent different means of transportation.

HOW TO USE A SCIENCE LOG/SCIENCE JOURNAL

Scientists keep logs — detailed records — of their observations, new data, and new ideas. You can keep a *Science Log* (or *Science Journal*) to help you organize your thinking.

In it, you can record what you already know about a Topic and add to that information as you learn more. Your teacher might ask you to keep a *Science Log* or *Science Journal* as a special booklet or as a marked-off section of your science notebook. Whichever approach your teacher takes, you will find that writing about new ideas you have learned will help you to solidify them in your own mind.

Stopping to reflect and then writing about what you already know may also help you to better understand a new subject area. You may discover that you know more than you realized. On the other hand, you might discover that you need to study new material especially carefully because you do not know very much about it. The value in keeping a *Science Log* or *Science Journal* is that you find out for yourself how clear your understanding is. You do not have to wait until your teacher assesses your knowledge through a formal test or examination.

SCIENCEFOCUS™ 8 has some special features to make sure you can add to your *Science Log* effectively. Each unit begins with a set of *Focussing Questions*.

Focussing Questions

- What do living organisms have in common?
- How are cells organized to carry out different functions?
- How do systems work together to keep organisms healthy?

Are you able to answer any of these questions from your previous studies? You can write the answers, draw a sketch, or use whatever means you find best to explain what you know. Also, feel free to record that you know very little about any of these questions if that is the case.

Pause & Reflect

Here are some situations in which diffusion occurs: A sugar cube is left in a beaker of water for a while. Fumes of perfume rise from the bottle when the top is removed. Give some other examples of diffusion. Can solids diffuse? Why or why not? Write your responses in your Science Log.

Throughout each unit, *Pause & Reflect* features help you keep thinking about what you already know. These features are designed to help you make connections between ideas and organize your thoughts. Your teacher may have you use these features all the time to record your new learnings, or your teacher may ask you to decide for yourself how often to answer the *Pause & Reflect* questions.

As the final question in each Unit Review, a *Pause & Reflect* item asks you to look back at your original answers to the *Focussing Questions* at the beginning of the unit, and to compose new answers to those questions. You may be amazed at how much your answers have changed, based on the new knowledge you have gained by studying the unit.

Other information you might want to add to your *Science Log/Science Journal* could include:

- questions that occur to you that you would like to be able to answer
- sketches and notes about models and processes in science
- graphic organizers (see examples in *Skill Focus 2*)
- thoughts on what is difficult for you and ideas on how you might overcome the barriers to learning new material
- notes about interesting items in the news that involve a Topic and that spark more questions or answers to some existing questions
- profiles of leading Canadian scientists or technologists that you learn about in the media, plus profiles of careers related to science and technology that you find interesting
- connections between science and other subject areas that occur to you in the course of your learning

Your *Science Log/Science Journal* will help you become a better learner, so take the time to make entries on a regular basis.

Instant Practice

1. What do you know about science? What do you know about technology? What do you know about how both science and technology can help answer questions about societal issues? Formulate your own questions about science, technology, and societal issues to produce a set of *Getting Ready* questions. Then exchange your questions with a classmate so each of you can start your own *Science Log/Science Journal* using these questions.
2. Think of something that you consider to be an example of a simple technology. It can be any tool or device that you may have used. Do you necessarily have to be a scientist to produce such technological devices? What is an example of a complex technology? How do you think scientific knowledge might help to produce such technology? Write responses to these questions in your *Science Log/Science Journal*.

Skill FOCUS 4

UNITS OF MEASUREMENT AND SCIENTIFIC NOTATION

Throughout history, people have developed systems of numbering and measurement. In time, when different groups of people began to communicate with each other, they discovered that their systems and units of measurement were different. Groups within societies 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 ten. 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 ten has its own prefix (a word joined to the beginning of another word). For example, *kilo-* means multiplied by 1000. Thus, one kilometre is one thousand metres.

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

The prefix *milli-* means divided by one thousand. Thus, one millimetre is one 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 measure, such as mass, weight, area, and energy. A table of the most common metric prefixes is given on page 489.

Example 1

The distance from Halifax to Winnipeg is 3538 km Express this distance in metres.

Solution

$$3538 \text{ km} = ? \text{ m}$$
$$1 \text{ km} = 1000 \text{ m}$$
$$3538 \text{ km} = 3538 \times 1000 \text{ m}$$
$$= 3\ 538\ 000 \text{ m}$$

Example 2

There are 250 g of cereal in a package. Express this mass in kilograms.

Solution

$$1000 \text{ g} = 1 \text{ kg}$$
$$250 \text{ g} \times 4 = 1000 \text{ g}$$
$$\frac{1000}{4} \text{ g} = 250 \text{ g}$$
$$\frac{1}{4} \text{ kg} = 0.25 \text{ kg}$$

The following table lists most of the frequently used metric quantities you will encounter in your science classes.

Frequently Used Scientific Quantities, Units, and Symbols

Quantity	Unit	Symbol
length	nanometre micrometre millimetre centimetre metre kilometre	nm μm mm cm m km
mass	gram kilogram tonne	g kg t
area	square centimetre square metre hectare	cm^2 m^2 ha
volume	cubic centimetre cubic metre millilitre litre	cm^3 m^3 mL L
time	second	s
temperature	degree Celsius	°C
force	newton	N
energy	joule kilojoule	J kJ
pressure	pascal kilopascal	Pa kPa
electric current	ampere	A
quantity of electric charge	coulomb	C
frequency	hertz	Hz
power	watt	W

Instant Practice

1. A box is 35 cm wide. Express the width in metres.
2. You ride your bicycle 1.4 km to school. Express the distance in metres.
3. A teaspoon of water has a mass of 5.0 g. Express the mass in milligrams.
4. There are 600 mL of soft drink in a bottle. Express the volume in litres.
5. A glass of water contains 32 μg of sulfur. Express the mass in grams.
6. A student added 0.0055 L of cleaning solution to some water. Express the volume in mL.

SI Units

In science classes, you will often be instructed to report your measurements and answers in **SI** units. The term SI is taken from the French name *Le Système international d'unités*. In SI, the unit of mass is the kilogram, the unit of length is the metre, the unit of time is the second, the unit of temperature is the Kelvin (see "Skill Focus 5: Estimating and Measuring," for an explanation of the Kelvin), and the unit of electric current is the ampere. Nearly all other units are defined as combinations of these units.

Example 1

Convert 527 cm to SI units.

Solution

The SI unit of length is the metre.
1 m = 100 cm

$$527\ \cancel{\text{cm}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}} = 5.27\ \text{m}$$

Example 2

Convert 3.2 h to SI units.

Solution

The SI unit of time is the second.
1 min = 60 s; 1 h = 60 min

$$\frac{3.2\ \cancel{\text{h}} \times 60\ \cancel{\text{min}}}{\cancel{\text{h}}} \times \frac{60\ \text{s}}{1\ \cancel{\text{min}}} = 11\ 520\ \text{s}$$

Instant Practice

Convert the following quantities to SI units.

1. 52 km
2. 43 min
3. 8.63 g
4. 45 973 mm
5. 537 891 cm
6. 1.75 h
7. 16 Mg (megagrams)
8. 100 km/h

Scientific Notation

Some common values in SI units can be very large or very small. The distance from Earth to the Sun is 149 600 000 000 m. The mass of an electron is 0.000 000 000 000 000 000 000 000 000 000 91 kg. The speed of light is 299 792 500 m/s. These numbers are difficult to read and tedious to write.

To solve the problem, scientists use **scientific notation** to express a number in exponents of ten. An **exponent**, or power, tells you how many times the number is multiplied by itself. For example, 10^3 means $10 \times 10 \times 10$ or 1000. Notice that the exponent of ten is the number of zeros after the 1 in 1000. The following table shows some powers of 10 written in standard form (no exponents) and in exponential form.

In scientific notation, all numbers are written in the form, $X.Y \times 10^n$, where X and Y are numbers and n is the exponent of 10. The decimal point is always placed after the first digit. Examine the following examples to learn how to convert numbers from standard form to scientific notation.

	Standard form	Exponential form
ten thousands	10 000	10^4
thousands	1000	10^3
hundreds	100	10^2
tens	10	10^1
ones	1	10^0
tenths	0.1	$\frac{1}{10^1} = 10^{-1}$
hundredths	0.01	$\frac{1}{10^2} = 10^{-2}$
thousandths	0.001	$\frac{1}{10^3} = 10^{-3}$
ten thousandths	0.0001	$\frac{1}{10^4} = 10^{-4}$

Example 1

The circumference of Earth at the equator is about 127 500 000 000 000 m. Write this distance in scientific notation.

Solution

First, count the number of places you have to move the decimal point to leave only one digit to the left of it.

127 500 000 000 000. m ⟵ The decimal point starts here. Move the decimal 14 places to the left.

$= 1.275 \times 100\ 000\ 000\ 000\ 000$ m

$= 1.275 \times 10^{14}$ m

Remember that the number of zeros after the 1 is the exponent of 10. This number is also the number of places that you moved the decimal point.

Example 2

The length of a bacterium is about 0.000 001 25 m. Write this distance in scientific notation.

Solution

First, count the number of places you have to move the decimal point to leave only one digit to the left of it.

The decimal point starts here. Move the decimal 6 places to the right. ⟶ 0.000 001 25 m

$= 1.25 \times 0.000\ 001$ m

$= 1.25 \times 10^{-6}$ m

Because you moved the decimal point 6 places, you might think that the exponent of 10 is 6. However, this time you moved the decimal point to the right. Therefore, the exponent of ten is negative, in this case –6. Use the following table to determine the sign of exponent of 10.

Direction decimal moved	Sign of exponent	Size of quantity
left	positive (+)	large
right	negative (–)	small

Instant Practice

1. Express the following measurements in scientific notation.

(a) The distance from the north pole to the south pole, directly through Earth, is about 12 700 000 m.

(b) Light travels at a speed of approximately 300 000 km/s.

(c) The thickness of a cell membrane is about 0.000 000 008 m.

(d) The mass of a blue whale is approximately 140 000 kg.

2. Convert the following measurements to standard form.

(a) 5.82×10^{9} m

(b) 1.773×10^{-5} kg

(c) 3.15×10^{7} s

(d) 8.3×10^{-4} L

Commonly Used Metric Prefixes

Prefixes	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 = 1 000
hecto-	h	10^2 = 100
deca-	da	10^1 = 10
–	–	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

ESTIMATING AND MEASURING

Estimating

How long will it take you to read this page? How heavy is this textbook? What is the height of your desk? You could probably answer all of these questions fairly quickly by estimating — making an informed judgment about a measurement. You recognize that the estimate gives you an idea of the measure but an estimate is not totally accurate.

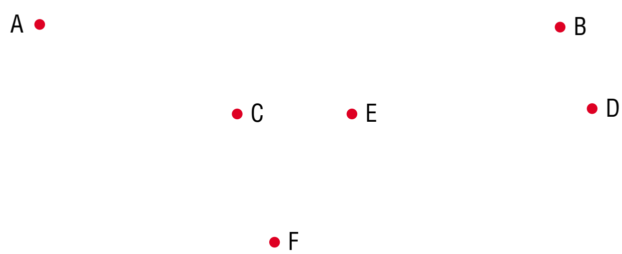
Scientists often make estimates, as well, when exact numbers are not essential. You will find it useful to be able to estimate as accurately as possible, too. For example, suppose you wanted to know how many ants live in a local park. Counting every ant would be very time-consuming — and the ants would be most unlikely to stay in one spot for your convenience! What you can do is count the number of ants in a typical square-metre area. Multiply the number of ants by the number of square metres in the total area you are investigating. This will give you an estimate of the total population of ants in that area.

Instant Practice

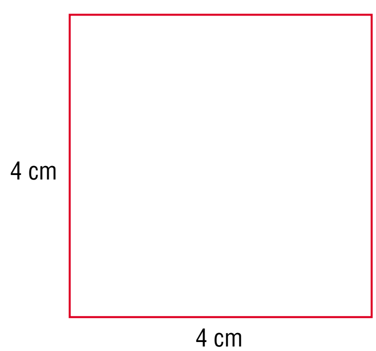
1. A blue whale has a mass of about 140 000 kg. Students in your class have an average mass of about 60 kg. Estimate the number of students it would take to equal the whale in mass. Calculate the exact number to see how close your estimate was.
2. The arctic tern is a bird that nests in the Canadian Arctic and migrates 17 500 km to the Antarctic to spend the winter. It makes the trip in about 16 weeks. Estimate how far the tern flies in one week. Calculate the exact distance to see how close your estimate was.
3. A 1 L (1000 mL) jar is filled with popcorn kernels. How can you make a good estimate of the number of popcorn kernels in the jar?
   - **(a)** Decide how you can use a 100 mL container and a small number of popcorn kernels to estimate the number in the 1 L jar.
   - **(b)** Carry out your plan.
   - **(c)** Compare your results with those of two or three classmates.
   - **(d)** About how many popcorn kernels will a 1 L jar hold?

Measuring Length and Area

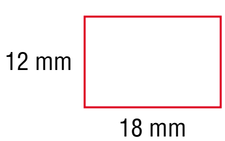
You can use a metre stick or a ruler to measure short distances. These are usually marked off in centimetres and/or millimetres. Use a ruler to measure the length in millimetres between points A and F, C and E, F and B, and A and D. Convert your measurements to centimetres and then to metres.



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.



Area of square is 4 cm × 4 cm = 16 cm^2.



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

Instant Practice

1. What is the area of a rectangle with a width of 3 cm and a length of 4.5 cm?
   - **(a)** Convert your measurements to millimetres.
   - **(b)** Convert your measurements to metres.
2. Imagine you are in charge of tiling the floor of your classroom. How many 10 cm × 10 cm tiles would you need to cover it?
   - **(a)** First, decide what unit would be most practical for the floor area — mm^2, cm^2, or m^2.
   - **(b)** Measure the length and width of your classroom.
   - **(c)** Calculate the floor area in the unit you have selected.
   - **(d)** Calculate how many tiles you would need to fill 1 unit of area.
   - **(e)** Multiply that number by the number of these units in the floor area.

Make sure you always use the same units — if you mix up centimetres and millimetres, your calculations will be wrong. Remember to ask yourself if your answer is reasonable (you could make an estimate to consider this).

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. A cubic metre is the space occupied by a 1 m × 1 m × 1 m cube. This unit of volume is used to measure large quantities, such as the volume of concrete in a building. In this course, you are more likely to use cubic centimetres (cm^3) or cubic millimetres (mm^3) to record the volume of an object. You can calculate the volume of a cube by multiplying its sides. For example, volume = 1 cm × 1 cm × 1 cm = 1 cm^3.

You can calculate the volume of a rectangular solid if you know its length, width, and height.

Volume = Length × Width × Height

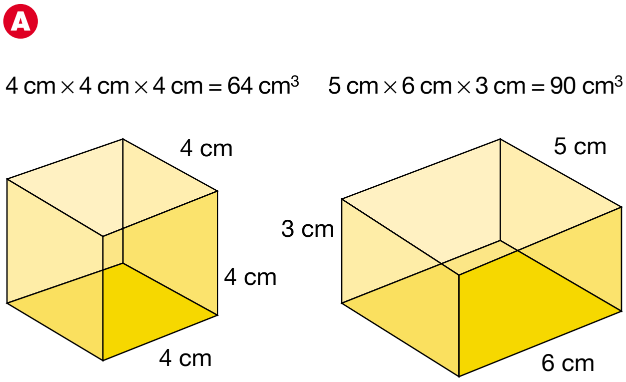
If all the sides are measured in millimetres (mm), the volume will be in cubic millimetres (mm^3). If all the sides are measured in centimetres (cm), the volume will be in cubic centimetres (cm^3). The units for measuring the volume of a solid are called **cubic units**.

The units used to measure the volume of liquids are called **capacity units**. The basic unit of volume for liquids is the litre (L). In this course, you also measure volume using millilitres (mL). Recall that 1 L = 1000 mL. You have probably seen capacity in litres and millilitres printed on juice, milk, and soft drink containers.

Cubic units and capacity units are interchangeable, for example:

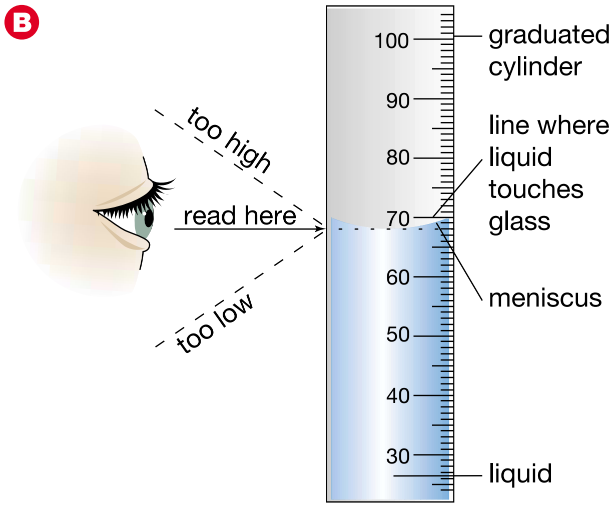
$1\ cm^3 = 1\ mL$
$1\ dm^3 = 1\ L$
$1\ m^3 = 1\ kL$

As you can see in Diagram A, the volume of a regularly shaped solid object can be measured directly.



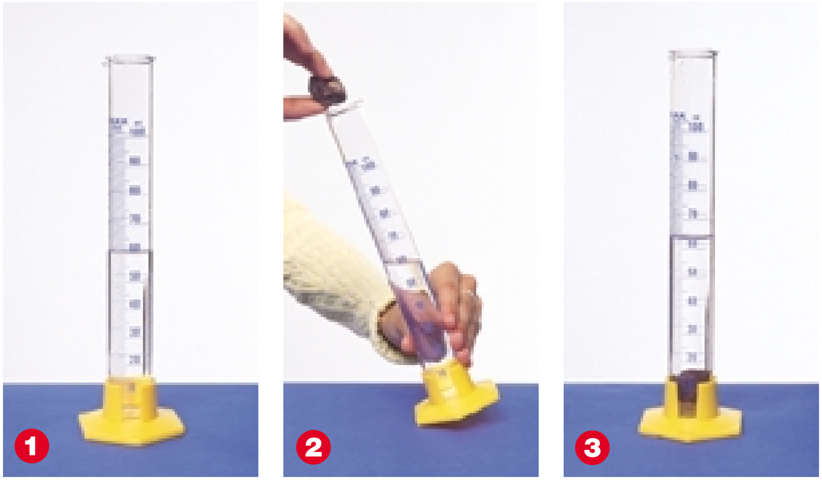
Measuring the volume of a regularly shaped solid

Similarly, 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

The volume of an irregularly shaped solid object, however, must be measured indirectly. This is done by determining the volume of a liquid it will displace, as shown in the photographs below.



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, e.g.:

   Volume of object = Volume of water with object – Original volume of water
   = 85 mL – 60 mL
   = 25 mL

Measuring the volume of an irregularly shaped solid

Instant Practice

1. Imagine you are cooking potatoes for dinner. You decide to measure the volume of a potato so that you can figure out how much water to use.

What You Need

water
500 mL beaker
large potato
wax pencil
graduated cylinder

   (a) Add water to the beaker (your "saucepan"). How much do you think you can add and still leave room for the potatoes?

   (b) Carefully add the potato. What is its volume? (If your beaker does not have millilitre markings, use a wax pencil to mark the water levels before and after the potato is added. Pour out the water and use a graduated cylinder to measure and record the number of millilitres between the two wax pencil marks.)

   (c) Could you add a second potato of the same size without spilling water, or would you need to pour off some of the water?

2. Now that you know the volume of a potato in millilitres, what is its volume in cubic centimetres?

Measuring Mass

Is your backpack heavier than your friend's backpack? It can be difficult to check by holding a backpack in each hand. At such times, you need a way to measure mass accurately. The **mass** of an object is the measure of the amount of material that makes up the object. Mass is measured in milligrams, grams, kilograms, and tonnes. You need a balance for measuring mass. A triple beam balance is one commonly used type.

Following are the steps involved in measuring the mass of a solid object.

1. Set the balance to zero. Do this by sliding all three riders back to their zero points. Using the adjusting screw, make sure the pointer swings an equal amount above and below the zero point at the far end of the balance.
2. Place the object on the pan. Observe what happens to the pointer.
3. Slide the largest rider along until the pointer is just below zero. Then move it back one notch.
4. Repeat with the middle rider and then with the smallest rider. Adjust the last rider until the pointer swings equally above and below zero again.
5. Add the readings on the three scales to find the 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.

The mass of the beaker is 160 g.

The mass of the table salt and beaker together is 230 g. Therefore, the mass of the salt is 70 g.

Instant Practice

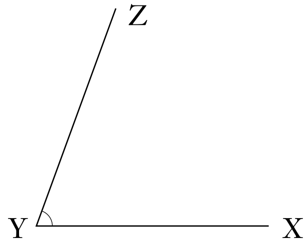
1. Which takes more "muscle" to carry: your favourite paperback book or your favourite portable electronic game? Find out by using a balance to compare their masses.
2. Write the steps you would take to find the mass of the contents of a container of juice.

Measuring Angles

In Unit 3, Light and Optical Systems, you need to be able to measure angles using a protractor. 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. YX crosses 0° on the outer scale. YZ crosses 70° on the outer scale. So ∠XYZ = 70°.

Example 2

Draw ∠ABC = 155°.

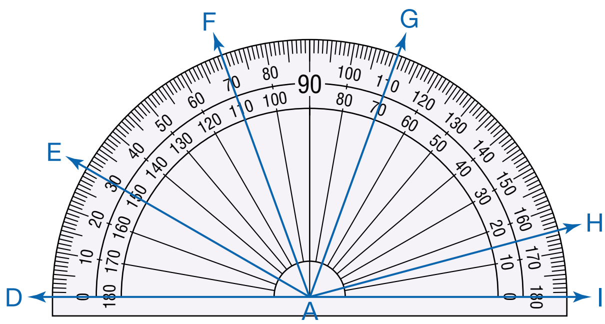
Solution

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

Instant Practice

1. State the measure of each of the following angles using the following diagram.

(a) ∠DAE **(b)** ∠HAG **(c)** ∠EAH
(d) ∠DAG **(e)** ∠GAE **(f)** ∠EAF
(g) ∠IAH **(h)** ∠DAH **(i)** ∠FAI



2. Use a protractor to draw angles with the following measures. Label each angle.

(a) ABC 60° **(b)** XYZ 10° **(c)** HAL 45°
(d) QRS 90° **(e)** JKL 32°

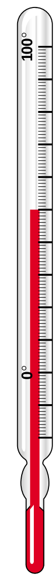
Measuring Temperature

"Temperature" is a measure of the thermal 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 one hundred degrees (100°C). Between these points, the scale is divided into 100 equal divisions. Each division represents 1 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.

The SI unit of temperature is 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 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. Thus, 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.

Skill FOCUS 6

SCIENTIFIC INQUIRY

"What happened to that puddle of water that was here a while ago?" You could probably quickly answer that question, but for an early scientist, it might have been more difficult. If you were that early scientist, how might you go about answering that question?

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

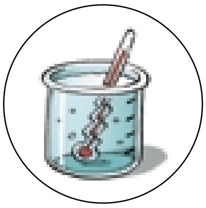
One observation you might make is, "The puddle is almost all gone." If you did, you would be making a **qualitative observation**, an observation in which numbers are not used. A little later, you might also say, "It took five hours for the puddle to disappear completely." You have made a **quantitative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

Instant Practice

In your notebook, copy the observations below. Beside each, write "Qual" if you think it's a qualitative observation and "Quan" if you think it's a quantitative observation.

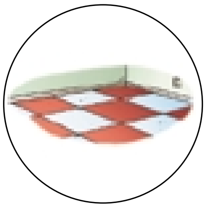
(a) We mixed water and food colouring.

We mixed 15 mL of food colouring in 250 mL of water.



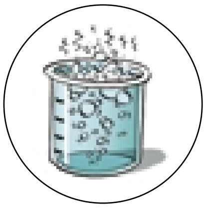
(b) We heated the water to 100°C.

We heated the water to boiling point.



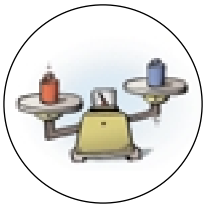
(c) We needed just over a dozen floor tiles for our model room.

We needed 14 floor tiles for our model room.



(d) The liquid boiled in 5 min.

The liquid took only a few minutes to boil.



(e) The mass of this solid is 5 g more than that one.

This solid is heavier than that one.

(f) He drinks 8 glasses of water each day.

He drinks 2 L of water each day.

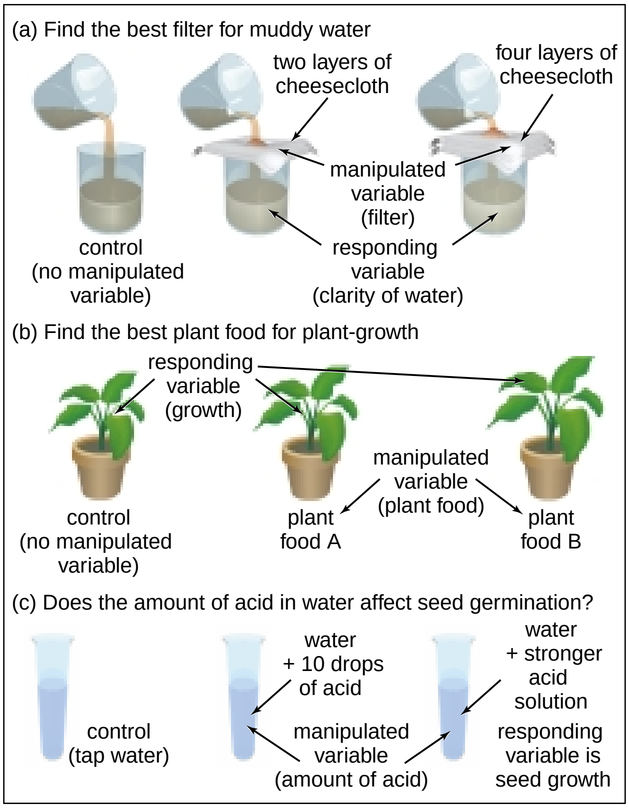
As you made your observations, you might have noticed something interesting about the disappearance of the two puddles. (As a twenty-first century science student, you already know that evaporation is the reason that the puddles are disappearing, but there are still lots of questions you can ask about evaporation.) Although the two puddles were the same size, one 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 Sun. The one that evaporated more slowly was in the shade. You make the same observations about another pair of puddles. You now have a question to ask: Does water always evaporate more quickly in the Sun than in the shade? Now you are ready to make a **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 thermal energy, so you might use that knowledge to make this hypothesis: Evaporation from natural pools of water is faster for pools in sunlight than for pools in shade. (You will be comparing the effect of Sun and shade.)

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 pools A, B, and C will dry up more quickly than pools X, Y, and Z.

"But wait a minute," you think, as you look again at your recorded observations. "There was a strong breeze blowing today. What effect might that have had?" This could become confusing, couldn't it? 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 always important to test only one variable at a time. 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 won't tell you anything useful. You won't know whether the breeze or the Sun made the water evaporate.

So, you need to control your variables. This means that you change only one at a time. The variable that you change is called the **manipulated variable**. In this case, the manipulated variable is the condition under which you observe the puddle (one variable would be adding thermal energy; another would be moving air across it).

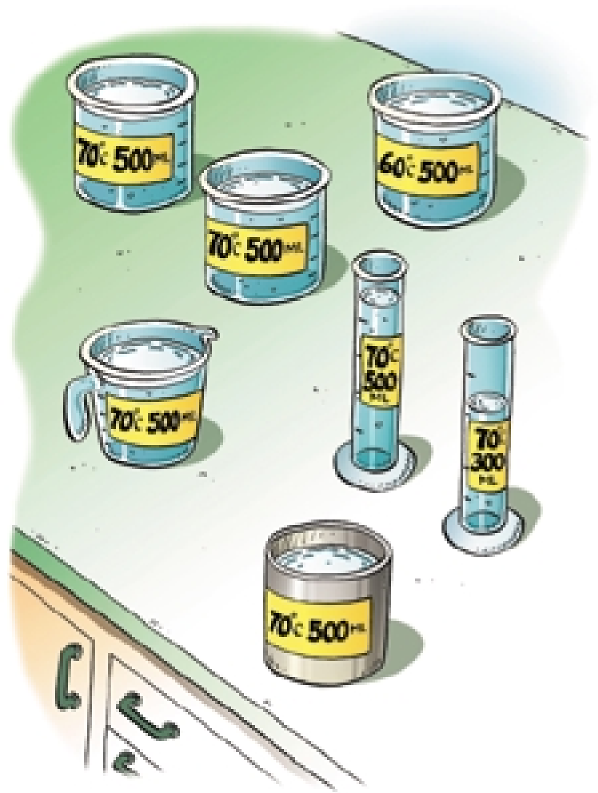
According to your hypothesis, adding thermal energy will change the time it takes for the puddle to evaporate. The time in this case is called the **responding variable**. Often, experiments have a **control**. This is a test that you carry out with no variables, so that you can observe whether your manipulated variable does indeed cause a change. Look at the illustration at the top of page 498 to see some examples of variables.



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 these, 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.

Instant Practice

With a partner, examine the following illustration. In your notebook, write the letters of the "puddles" you would *not* use to set up a fair test. Explain why you would not use them.



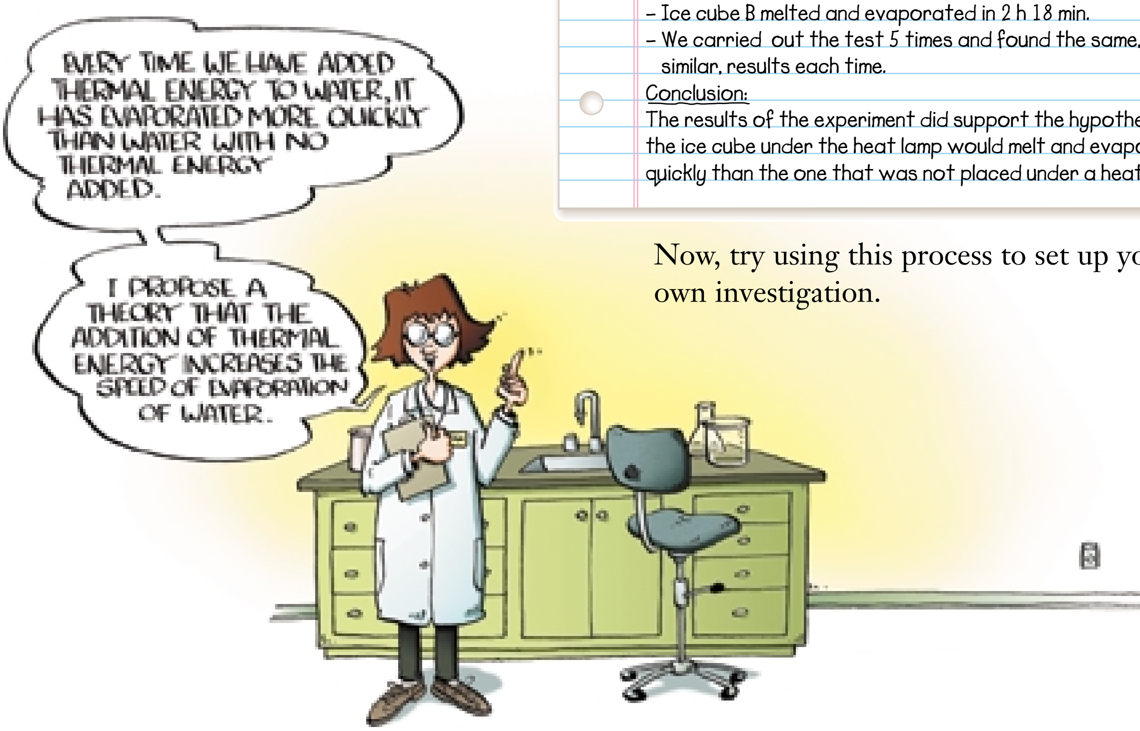
Now, you can carry out your experiment. How many times will you do it, in order to be sure that you have truly tested your hypothesis? The test you are conducting is a fairly simple one, but you still need to carry it out more than once.

Instant Practice

What kinds of errors can creep into a test such as the one described above? Use your sense of humour, and work with a partner to draw some sketches that illustrate some errors (make sure they are errors that could actually occur!)

Many investigations are much more complex than the one described here, and there are many more possibilities for error. That's why it's so important to keep careful qualitative and quantitative observations. After you have collected all your data, you are ready to analyze it and draw a **conclusion**. A conclusion is a statement that indicates whether your results support or do not support your hypothesis. If you had hypothesized that the addition of thermal energy would have no effect on the evaporation of water, your results would not support your hypothesis. A 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 prove that something will *not* happen.

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



Whenever you have a task to do, it always helps if you can follow a process. If you look back over the boldface terms in these pages, you will see that you now have a process for designing investigations to try to find answers to scientific questions. Imagine comparing the speed at which two ice cubes melt and evaporate under different conditions. The process you might follow can be seen in the student notes shown here:

Title:
Investigation 1 Rate of evaporation
Question:
Does an ice cube under a heat lamp melt and evaporate more quickly than an ice cube that receives no thermal energy?
Manipulated Variable: thermal energy (heat lamp)
Responding Variable: time
Hypothesis:
Melting and evaporation of an ice cube occur more quickly for an ice cube under a heat lamp than for an ice cube that is not under a heat lamp.
Prediction:
Ice cube A will melt and evaporate more quickly than ice cube B.
Results:
Qualitative observations:
– We made ice cubes that were the same size.
– We placed one ice cube near a heat source (heat lamp).
– The ice cube under the heat lamp melted and evaporated more quickly than the ice cube that wasn't under the heat lamp.
Quantitative observations:
– We made ice cubes that were 2.5 cm3 in size.
– We placed one ice cube (ice cube A) 25 cm from a heat source.
– Ice cube A melted and evaporated in 20 min.
– Ice cube B melted and evaporated in 2 h 18 min.
– We carried out the test 5 times and found the same, or very similar, results each time.
Conclusion:
The results of the experiment did support the hypothesis that the ice cube under the heat lamp would melt and evaporate more quickly than the one that was not placed under a heat lamp.

Now, try using this process to set up your own investigation.

INQUIRY

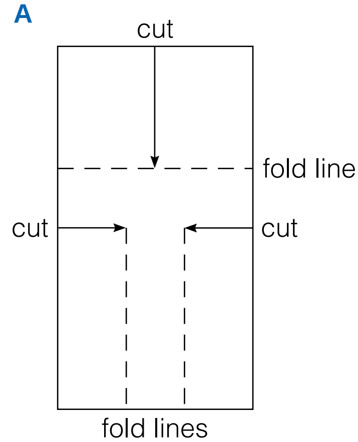
INVESTIGATION I-A

Observing Falling Motion

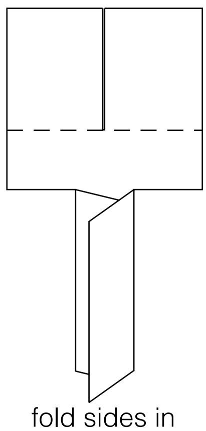
In this investigation, you will put your knowledge of science inquiry to work. You will look for variables that affect the falling motion of a structure called a rotocopter. The directions for making a rotocopter are given in the diagrams on the right.

Some features of the rotocopter that might affect its falling motion are the length of the blades, the length of the stem, the width of the blades, the weight (number of paper clips attached), and the stiffness of the paper. These are **manipulated variables** because they do not depend on the design you have chosen. The features of the rotocopter will influence the rate at which the rotocopter falls or the rate at which it rotates while falling. These motions are **responding variables** because they respond to any changes in the manipulated variables.

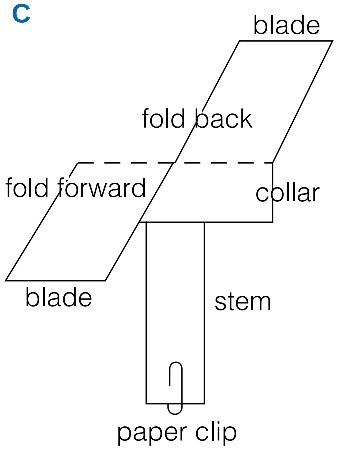
A



B



C



Question

Find at least two relationships between a feature of the rotocopter (a manipulated variable) and motion while falling (a responding variable).

Safety Precautions

Be careful when using sharp objects such as scissors.

Apparatus

ruler
pencil
scissors
paper clips

Materials

paper (several different types with varying thickness and stiffness)

Procedure

1. Each member of the group will choose the type of paper and the dimensions of his or her own rotocopter and then build it.
2. Make observations about the falling motion of rotocopters. The group as a whole will observe the motion of each rotocopter in order to collect general information about the falling motion. When dropping the rotocopters, hold them by the tips of their blades, about 2 m above the floor, and let them fall freely.
3. As a group, choose at least two different, manipulated variables to test. For each of the variables that the group chooses, formulate a hypothesis that predicts how the variable will affect the falling motion.

4. Choose a basic design and decide exactly how you will vary each feature of the rotocopter you have decided to test. For example, if you choose to test the effect of the stiffness of the paper, all of the rotocopters must be identical in size and shape. If you choose to test the width of the blade, then the type of paper and the length of the blade and the stem must remain the same for each rotocopter. Only one feature can be varied at a time.

5. For each of the variables that you have chosen to test, build at least three rotocopters with variations in that feature only.

6. Test your rotocopters, as shown in the photograph. Test only one variable at a time. To make good comparisons, have different members of the group hold the rotocopters at the same height and drop them at the same time. As they fall, observe the rate of rotation and observe the order in which they reach the floor. Carry out at least five trials on each of the variations you are testing.

Analyze

1. Was there a relationship between either one of your manipulated variables and the rate of rotation? If so, state the relationship.
2. Was there a relationship between either one of your manipulated variables and the rate of fall? If so, state the relationship.

Conclude and Apply

3. Did your results support your hypotheses or not? Explain.
4. Write a statement describing any relationship between a manipulated variable and a responding variable that you observed.

SCIENTIFIC PROBLEM SOLVING

"Technology" — what does that word make you think of? Do you think of complicated electronic equipment? Do you think of the latest-model cars? Do you think of space exploration? Well, all of those have to do with technology, but think about this: Have you ever used a pencil to flip something out of a tight spot where your fingers couldn't reach? Have you ever used a stone to hammer "bases" or "goal posts" into the ground?

These, too, are examples of technology. **Technology** is the use of scientific knowledge, as well as everyday experience, to solve practical problems. 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. Often, science has a part in technology, but not always.

When you used that pencil to move the small item you couldn't 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 isn't always quite so simple.

Your 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 isn't an option, because the hamster will eat it all at once. What kinds of 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 has no opportunity to overeat.

Now, how will you be able to assess how well your device works? You can't 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. Device must feed and water the hamster.
2. Hamster must be thriving at the end of the three-day period.
3. 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.

You'll probably come up with something great! Like all other scientists, though, you will want to make use of 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 they work? What materials would they require? How difficult would they be to build? How many parts are there that could stop working during the 16-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.

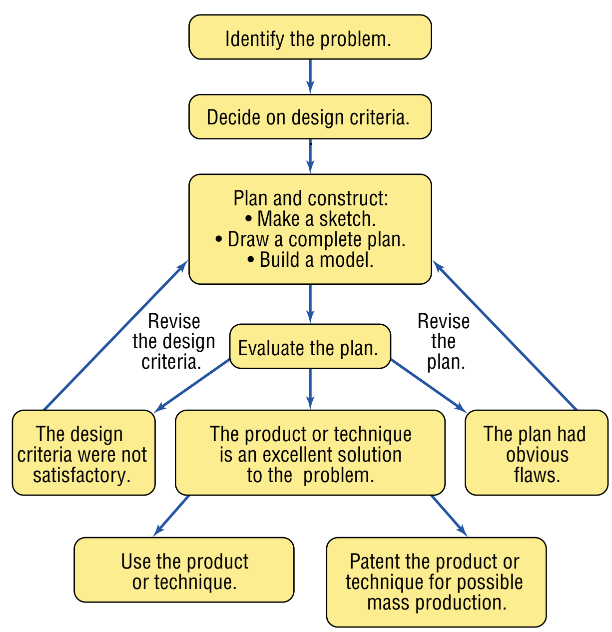
Get your teacher's approval of the drawing of the design your group wants to build. Then gather your materials and build a **prototype** (a model) of your design. Experiment with your design to answer some questions you might have about it. For example, should the food and water be provided at the same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

You might find, too, that your invention always seems to fail 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.

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

Now, look at what you have accomplished. Not only have you made a successful (if only imaginary) model; you have also used a process for solving problems. The problem-solving model you have just used is shown here.

Solving a Technological Problem



This is the kind of step-by-step model that engineers, architects, technologists, and designers use to help them solve problems.

In your investigation of the rotocopter, you observed relationships between the rotocopter's design and its falling motion. Now see if you can use the problem-solving process discussed here to solve a technological problem involving rotocopters.

How to Make a 'Copter Fall As Slowly As Possible

You work for an airplane manufacturer early in the 1900s. Airplanes have been invented recently and are flying successfully. You and some of your colleagues have an idea. Is it possible to build a flying machine that has a rotor at the top of it so it will lift straight up and also land upright? Think of some of the places you could travel to in such a vehicle. You start your thinking and planning with paper, cardboard, and paper clips in your company's office. By the way, this is not so different from how ideas for many inventions were first conceived!

Challenge

Design and construct a rotocopter that will take the longest time to fall to the ground from a height of 2 m and that will remain intact for three trials.

Materials

construction paper or poster board, pencil, ruler, paper clips, scissors, stopwatch or watch with a second hand

Safety Precaution

Be careful when using sharp objects such as scissors.

Design Criteria

A. Your rotocopter must be designed and built by a team of students in no more than 20 min.

B. Your rotocopter must withstand three drops.

C. It must be no more than 30 cm long and no more than 10 cm wide.

D. The stabilizer of your rotocopter must be no more than 30 cm long.

E. You must use at least one paper clip.

F. You must draw a clearly labelled sketch before you begin to construct your rotocopter.

Plan and Construct

1. Brainstorm as many ideas as you can about how rotocopters behave when they are dropped. Consider what you learned in the previous investigation about the characteristics of rotocopters. How could you modify the design to meet the design criteria of this challenge, based on what you learned in the first investigation?

2. **(a)** Consider a few possible designs and make rough sketches of them.

   (b) Select the design that you think will work best. Check once more to ensure it meets all the design criteria.

3. Make a detailed sketch of your selected design. Label the rotor, the stabilizer, and their dimensions (measurements), as well as the position and number of paper clips you will use. Show your design to your teacher.

4. Use the materials provided to build your rotocopter design.

5. **(a)** Each model is allowed three trials.

   (b) Drop the rotocopter from a height of 2 m, and time how long it takes to reach the ground. Record the results in a table like this one.

6. Calculate the average time for each group's rotocopter to fall to the ground. Which design had the slowest falling time?

Group	Dimensions used	Materials used	Time in trial # 1	Time in trial # 2	Time in trial # 3	Average time

Evaluate

1. Evaluate your design. Consider the dimensions and materials of the slowest falling rotocopter. If your design was not the slowest (or did not withstand three drops), how would you revise it? What was the same and what was different between your model and the slowest one?

2. If you have enough time and the appropriate materials, make a revised model. Test your new rotocopter against the one that fell most slowly. How does your rotocopter's falling time compare now?

SOCIETAL DECISION-MAKING

Suppose you are part of an enthusiastic mixed hockey team that practises at an arena belonging to a town a few kilometres away. The town council is in the middle of budget discussions, and one of the items under discussion is the salting of roads. The council is prepared to expand the salting program so that roads in your area will be salted in winter. You and your teammates are delighted. This will make your trip to the arena easier — and always possible. There are days now when you just can't get there because the roads are too icy.

Soon after hearing the news about the road-salting, you go to your friend's house. You find your friend sitting in front of the computer, composing a letter to the town council. In it, your friend is asking that the salting program not be expanded to your area. You can't believe your eyes, but as you begin discussing the letter, you start to see your friend's point of view.

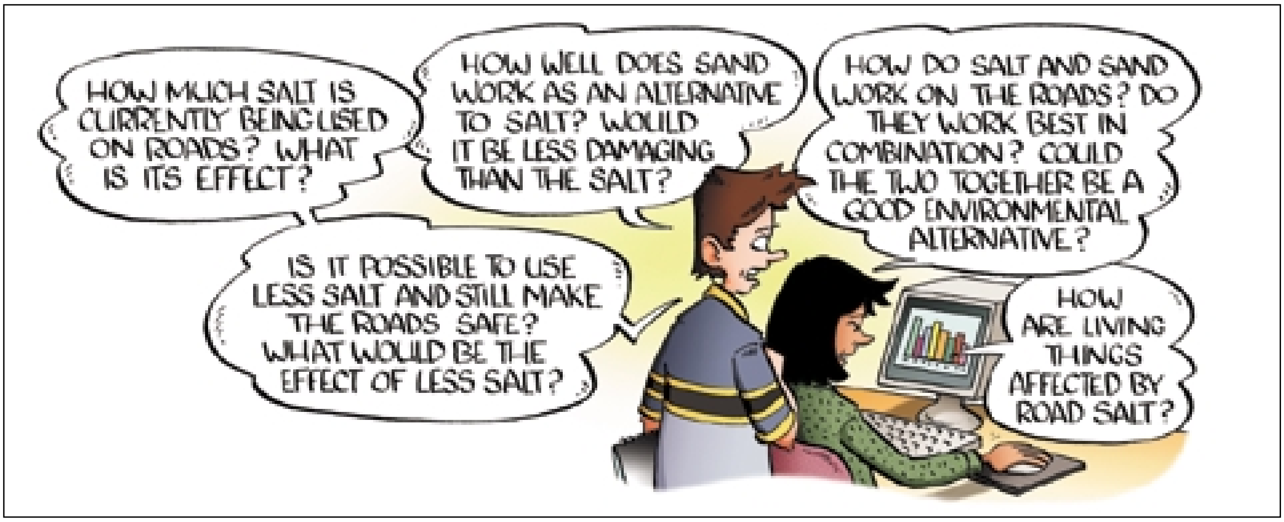
"What do you mean, damage the environment?" you ask. "Surely it's important that it makes our roads safer."

"It is," answers your friend, "but is there some way we can make the roads safer without doing so much harm to the plants at roadsides and to the drinking water in springs and wells? I was going to check the Internet to find information about these questions I've written down."

"Whew," you say. "There's an awful lot to think about here. Let's see what we can find out from the Internet."

"Well, we found a lot of information, but I'm still not completely convinced that salting the roads could cause a problem with our water," you say. "What sorts of things do we need to find out in order to answer that question?"

"We could do an investigation," your friend suggests. "Then I could use the results in my letter to the town council."



Title:
Investigation STS 1 Effect of Road Salt on Water Systems
Question:
Does the addition of salt to soil affect the surrounding water?
Manipulated Variable:
– salt
Responding Variable:
– amount of salt in water
Hypothesis:
– Water near soils that contain salt will also contain salt.
Prediction:
– If we add salt to soil, any water that drains through that soil will contain salt.
Procedure
1.

"I guess road salt does get into the water system," you admit after completing your investigation. "But we added quite a lot of salt. I wonder if any salt stays in the soil — maybe we could add less salt so that much less would get into the water, and our roads would still be safe for driving. Let's do some more research in the library and on the Internet, and see if we can find out how salt leaches through soil. Maybe we can also see what kinds of alternatives there are. We could look for something about using less salt on the roads — or even no salt."

Instant Practice

How would you go about finding the above information on the Internet? Work with a partner to come up with some ideas. You have probably done research on the Internet. You may have looked for something that you thought would be easy to find. Instead, you became lost in a lengthy list of highly technical sites that you couldn't understand. How creative can you be in coming up with terms that you could use to find the information you want? If you can, try your terms out to see how successful you are.

In some cases, the information you want might not yet exist. Think about what you might do then.

When you have all of the data that your scientific studies can provide, your decision will still involve some very human and personal elements. People have strong feelings about the social and environmental issues that affect them. Something that seems obvious to you might not be so obvious to another person. Even your scientific data might not change that person's mind. 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.

Instant Practice

Think of something that's "good for you" that you dislike doing. Develop a series of arguments, a cartoon, a poster, a video — whatever you feel would persuade someone to do that "good for you" thing.

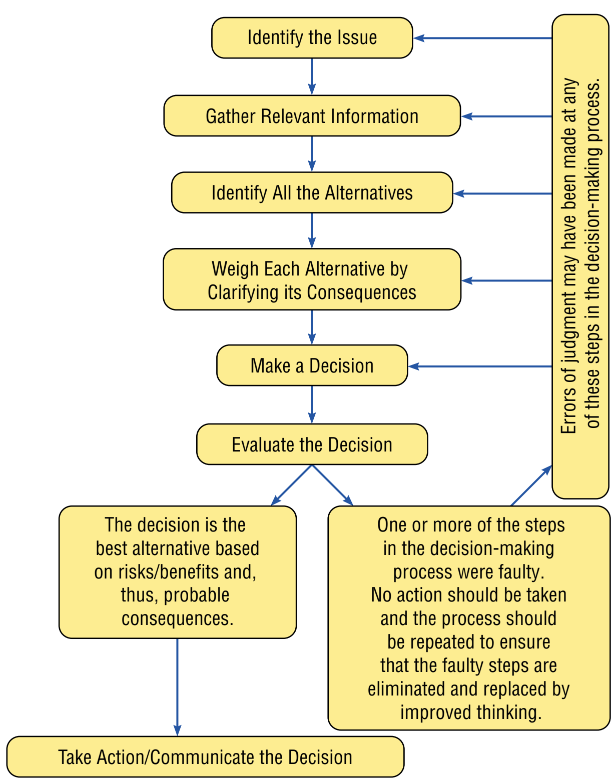
After all the data are in, and after all the persuading is done, it's time to take some action. The seemingly small actions done by you and your friends can have a snowball effect. You are very keen to show your sense of responsibility and community spirit by getting your ideas across to town council when one of your friends makes you stop and think. "I've noticed you putting a lot of salt out on your sidewalk," says your friend. "You could use a bit of time and muscle power to chip away the ice, but that isn't the choice you make." You realize your friend is right — it isn't up to the town council or any other group to act responsibly; it's up to you and your friends. How easy is it for you to give up an undemanding way of doing a task in order to make an environmentally responsible decision?

Issues rarely have easy answers. Those 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 town council. As a compromise, you might suggest a combination of salt and sand on the roads. Your scientific study 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 on the salted/sanded roads? Does less salt end up in the water than when more salt alone is used?

As you reached your decision, you went through various stages. Now you can think about how well each stage worked and how well you feel you completed each stage. If you look back over these pages, you will see that we have indeed developed a process that can be used for decision making. Examine the flow chart below.

Developing Decision-Making Skills



You can see that you used every step in this process. As with science inquiry and problem solving, having a process to use helps you to focus your thinking and stay on track.

Instant Practice

1. Describe two ways in which each of the following technological developments has affected society positively:
   (a) dam building
   (b) production of supertankers
   (c) mass production of the automobile
   (d) mass production of computers
   (e) harnessing nuclear reactions
2. Now describe two ways in which each of the above technologies has affected or might affect society negatively.
3. How would you evaluate whether each of the technologies in question 1 is "good" or "bad" for society?
4. For each of the technologies in question 1, record ideas you have on the kinds of scientific knowledge that were necessary for its development.
5. An issue has two or more possible solutions, and a decision must be made in favour of one solution over the others. In weighing the advantages and disadvantages of the solutions, is it important to take into account:
   (a) Who benefits from the solution?
   (b) Who is affected by the costs or disadvantages?
   (c) Should we be careful in selecting a solution based on who proposes it? Why or why not?
6. As a class, discuss the possible shortage of fresh water. Identify possible solutions and consider the benefits and risks of each solution. Do the solutions involve the use of technology? Do we have enough scientific knowledge to assess the risks attached to each solution? Is there a simple answer? Is there a solution that does not interfere with the environment at all? If so, is it a realistic solution?

Skill FOCUS 9

USING TECHNOLOGY IN SCIENCE

Technology includes the designing and use of devices, processes, and materials to solve practical problems.

The computer is an important technological advance. In your science lab you may also be able to use other advances in technology, such as electronic balances, scientific calculators, electronic probes, and other electronic tools. Your teacher can explain their use to you.

Technology tools can be used to make more accurate measurements, collect and store information, and display the data in a colourful and exciting manner.

These tools can also make the sharing of data easier between partners. However, the advances in technology can be expensive, can reduce the need for human input, and can destroy natural resources. Science and technology must work together to create a balance between human needs and the needs of a sustainable environment.

Using a Word Processor

Word processing software allows you to write, change, store, and print information. You may already be familiar with editing functions, such as cut and paste, find and replace, and copy. Formatting features let you change the font, style, size, and alignment of print. The word processor can also be used to create tables and columns, insert art, add page numbers, and check spelling and grammar. Remember that the spell check does not catch those words that are spelled correctly but are the wrong words (such as "date" instead of "data"). If you are uncertain about how to use certain features, check the Help menu for instructions.

Instant Practice

Using a Word Processor

1. Using a word processor, write an answer to the following question: How many students in your class are male and how many are female?
2. Add a picture to the answer you wrote for question 1 by inserting a graphic.
3. Add a chart that shows the data you used to answer question 1. Use the chart to make a graph.
4. Number the pages in your document and complete a spell check. Proofread the document for grammatical errors and then print.

Using a Database

How do you keep track of all the information you gather for a project? A good tool to use is the database. You can think of a database as a file cabinet within your computer that can sort information into a variety of categories. If you use shortcuts, such as tabbing between entry fields and using your software's automatic formatting, the task becomes even faster. When you search for information within your database, use "and," "or," and "not" to narrow your search.

Instant Practice

Using a Database

1. Collect information from five books. Include the title, publisher, publication date, and number of pages.
2. Enter the information you collected on the books into a database and sort, based on publication date.

Using Graphics Software

Have you discovered your computer's graphics software? You can use it to arrange clip-art, change scanned images, create illustrations, and integrate text into your diagrams. You might find it easier to start by studying and manipulating existing drawings. The more you practise using graphics software, the easier it will be to make your own illustrations. Keep in mind that your final product should effectively represent your message. Consider the balance of text and visuals, and the use of colour, style, and font. Avoid cluttering your final product with too many elements.

Instant Practice

Using Graphics Software

1. Import an image into a graphics software. Play with the image (resize, crop, etc.), and add text to relay a message.
2. Use a scanner or pieces of clip art to create a message. Add text to the graphic you created to improve the message.

Developing Multimedia Presentations

A multimedia presentation can make your information come alive for your audience. You might integrate visuals, such as posters, charts, slides, or photographs, with sound. Or you might produce a video and represent information from an Internet site. Software programs, such as PowerPoint™ and HyperStudio™ can help you create your multimedia presentation. Consider what medium will best communicate the information you want to share. Whatever your choices, make sure you know how to use the equipment. Practise your presentation several times and ask for feedback from friends or family.

Instant Practice

Developing Multimedia Presentations

Use multimedia software such as Powerpoint™ or Hyperstudio™ to create a short presentation about yourself. Include graphics and text in your presentation. Make a section about your personal information (age, where you live, etc.) and a section about your interests.

Using E-mail

If you want to correspond with a scientist, contact a relative who might be able to help you with your project, or send your homework to your teacher, an electronic mail system can quickly get your message on its way. Before sending an e-mail message, remember to check it carefully for both spelling and grammar. Make sure you have correctly entered the e-mail address. If you receive frequent e-mail messages, keep them organized. Delete messages you no longer need, and save others in folders.

Instant Practice

Using E-mail

Find a short, interesting article in the newspaper, in a magazine, or an interesting portion of a book you are reading. Key the information into your computer, and e-mail it to friends, relatives, and/or teachers you think might be interested. Ask for their comments.

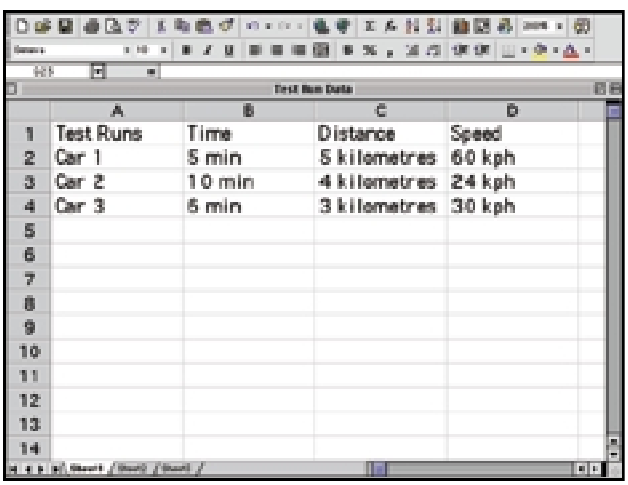
Using an Electronic Spreadsheet

Electronic spreadsheets can be used to keep track of, and make calculations with, scientific data. Information is entered in both rows and columns. Calculations can be made with any combination of numbers. For instance, you might enter the time and distance various fluids travelled in an investigation. To calculate the speed of each, you could enter the formula *speed = distance ÷ time*. Once the calculations are complete, the results can be graphed.

Instant Practice

Using an Electronic Spreadsheet

1. Gather information on the number of boys and the number of girls in your school at each grade level. Using spreadsheet software, create a spreadsheet that displays this information.
2. Use calculations in the spreadsheet to determine the total number of students in each grade level at your school.
3. Create a graph from the information in the spreadsheet you created.



	A	B	C	D
1	Test Runs	Time	Distance	Speed
2	Car 1	5 min	5 kilometres	60 kph
3	Car 2	10 min	4 kilometres	24 kph
4	Car 3	6 min	3 kilometres	30 kph

Using a CD-ROM

When you are researching information for a science project or just wanting to know more about a topic, consider using a CD-ROM. A CD-ROM is a form of compact disc that stores information as well as sounds and videos. Encyclopedias, atlases, and other valuable references are available as CD-ROMs. Some science CD-ROMs include interactive tutorials so that you can learn about volcanoes by watching them explode, or discover deep sea vents by viewing them in action. Be sure to include a reference to the CD-ROM in your bibliography if you are preparing a research project.

Instant Practice

Using a CD-ROM

Use an encyclopedia CD-ROM to find out information about mammals. Find out how many mammal species there are.

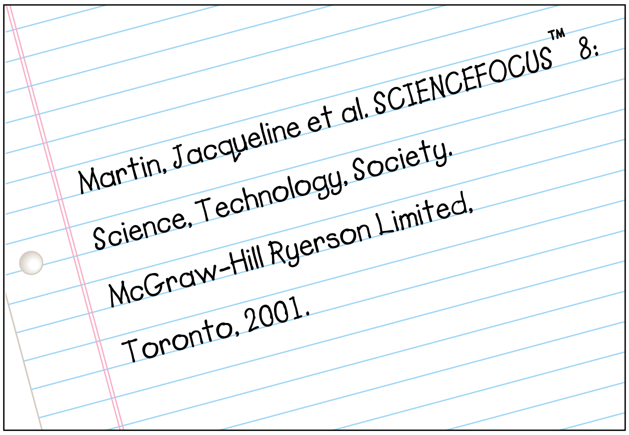
Using the Internet

The Internet can be an invaluable research tool for homework, investigations, and research projects. You can find sites that offer virtual tours of museums and the very latest information about a subject — sometimes just a few hours old! However, you can also find incorrect and outdated information. Always be sure to verify the origin of the site and check your facts with several sources. Take a few minutes to think about key words before you begin your search. Make a list of several possibilities for key words. Limit your search with terms such as "and," "or," and "not." If you place an "and" between two words in your search, the database will look for any entries that have both the words. If you place an "or" between the two words, the database will show entries that have at least one of the words. If you place a "not" between two words, the database will look for entries that have the first word but do not have the second word.

Always record the information that identifies any material you use. You will need to let your audience know where you obtained your information, and you may need to go back to it. Make sure that you record

- the author's name (or the name of the group that provided the information)
- the name of the resource
- the name of the publisher or information source
- the city where the resource was published
- the publishing date

• the URL, if the information is from an Internet site



At the end of every research project, record each source of information you used. Here is an example of the proper way to list a source in a bibliography. List your sources by author's last name, in alphabetical order.

Most of this information can be found on the copyright page at the beginning of a book. The URL can be found in the address bar at the top of an Internet page. (Some URLs are very long and complex. Get a partner's help to make sure that you have copied the URL correctly.)

Above is an example of how to cite your source. (NOTE: et al. means "and others.")

Instant Practice

Using the Internet

1. Use an Internet search engine to locate information on the population of Alberta.
2. Narrow your search to determine the population for your city or town.

Using Probeware

Some scientific investigations involve taking measurements over a long period of time. The task of collecting and storing the data is made easier by using probeware. In many cases, the probeware provides more accurate quantitative measurements than non-electronic methods. Measurements such as temperature, pressure, motion, and pH can be taken by a probe hooked to the computer. Once all the measurements have been collected, the probeware can be used to graph and analyze the data. When using probes, be sure all cables are solidly connected. Consider doing many trials in your investigation so that your data are strengthened.

Instant Practice

Using Probeware

1. Fill a glass with cold tap water. Use probeware to determine the temperature of the water over a 1 h period.
2. Use probeware to determine the pH of the water.

INTERNET CONNECT

www.school.mcgrawhill.ca/resources/

You have looked at animal adaptations, and the photographs here show some plant adaptations. Find out about the special adaptations of cacti for their dry environments by going to the web site above. Go to **Science Resources**, then to **SCIENCEFOCUS 8** to know where to go next. Write and sketch your findings.

This recurring feature in *SCIENCEFOCUS™ 8* will take you to interesting web sites.

ORGANIZING AND COMMUNICATING SCIENTIFIC RESULTS

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 the data. You may choose to organize the data in the form of a table, line graph, bar graph, or circle graph.

Making a Table

A data table is usually a good way to start organizing information. The table may be the final form in which you present the data or you may use it to help construct a graph or a diagram.

Example

Read the article below, then examine Table 1. What information do the article and table present? Which one makes the data easier to analyze?

You may have heard of the "wind chill factor." When the wind is blowing on a cold day, the body of a living organism loses more thermal energy than normal. The heat that surrounds the body is blown away, and the organism has to keep warming the cold air that replaces it. It is important to know about wind chill because you need to know how to dress in order to be safe in very cold temperatures. If you bundle up in several layers of clothing, the extra layers will help to keep heated air close to your body. Exposed skin can freeze at certain temperatures and at different rates, so you need to take care to cover areas, such as your nose and ears, that can freeze quickly.

A wind chill index that has been in use for many years was developed by researchers in the Arctic in the 1940s. They studied how long it takes water to freeze at different temperatures and wind speeds. However, the containers of water were placed on top of 10 m poles. Most people are not constantly exposed to winds at a 10 m height, so the measure is not very practical. People don't take wind chill as seriously as they should because the figures are not accurate.

Randall Osczevski, a Canadian scientist who grew up in Saskatchewan, has researched this problem. He carried out tests in a wind tunnel, using a mannequin head. He covered the head with a "skin" containing temperature sensors. His model correctly predicted when frostbite would occur.

Osczevski and other scientists in Canada and elsewhere have been working to develop more accurate ways of measuring wind chill. Depending on wind speed and temperature, there can be small or large differences between the old wind chill index and a proposed new one. For example, at a wind speed of 8 kph, the current wind chill is 14°C. According to the proposed index, it will be 12°C. There isn't a lot of difference between those two numbers, but at 40 kph, the current wind chill is –34°C, while the new index is –28°C. In the past, people have used the wind chill index to remark on how cold the weather is. As new, more accurate models are developed, we will be able to use it for our own safety.

Table 1 Current and Proposed Wind Chill Figures

current wind chill estimate when the air temperature is 12°C, and a proposed revision:		
Wind Speed (kph)	**Current wind chill**	**Proposed wind chill**
8	14	12
12	–23	–18
24	–28	–22
32	–31	–26
40	–34	–28
48	–36	–31
56	–37	–32
64	–38	–34

Source: Maurice Bluestein and Jack Zecher, Indiana University-Purdue University at Indianapolis

Look through your textbook to find some examples of data tables. Note why you think the information is presented in a table.

Instant Practice

In some areas of science, researchers use probability, or the likelihood that certain things will happen, to help analyze their data. In this activity, you will make a data table of the outcomes of three different types of experiments in probability.

1. Prepare a table with two main headings: "Experiment" and "Outcomes." Divide the Outcomes column into four columns with the following headings: (A = 3, B = 0), (A = 2, B = 1), (A = 1, B = 2), (A = 0, B = 3) as shown here.

Table 2 Probability Data

Experiment	Outcomes			
	(A = 3, B = 0)	(A = 2, B = 1)	(A = 1, B = 2)	(A = 0, B = 3)
Coin tossing A - heads B - tails				
Drawing cards A - black B - red				
Paper picking				

2. Obtain three identical coins. Toss all three coins and write down the number of heads (A) and tails (B). Repeat the process nine more times. Count the number of times you tossed three heads and no tails and record that number in the column (A = 3, B = 0), in the row for "Coin tossing." Under the heading (A = 2, B = 1), record the number of times you tossed two heads and one tail. In the third column, record the number of times you tossed one head and two tails; and in the fourth column, record the number of times you tossed three tails.
3. Obtain a deck of playing cards and shuffle the cards. Draw three cards and write down the number of black cards and the number of red cards. Replace the three cards, shuffle the deck, and draw three more cards. Record the outcome. Repeat the process until you have drawn three cards, a total of ten times. Record the card data in your table in the same way that you recorded the coin-toss data. Note that "A" represents the number of black cards and "B" represents the number of red cards.
4. Cut paper or cardboard into twelve 1 cm squares. On six of the squares, write "A." On the other six, write "B." Put the squares of paper in a bag and shake them up. Ask a friend to reach in and, without looking, draw three squares of paper. Record the number of A's and B's your friend drew. Replace the pieces of paper in the bag and shake it. Ask another friend to draw three squares of paper. Record the outcome. Repeat the process until friends have drawn three squares of paper, ten times. Record your outcomes in your table.
5. Analyze the outcomes in your table. Compare the data from the different experiments. Describe any pattern you observe. How does the table help you to analyze your data?

Graphing

A graph is the most 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 it. Throughout the year, you will be using line graphs, bar graphs, and circle graphs (pie charts).

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

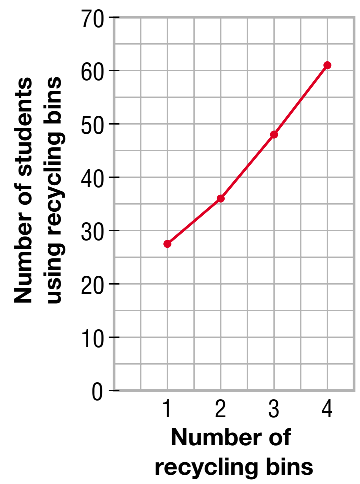
Suppose you have conducted a survey to find out how many students in your school are recycling drink containers. Out of 65 students that you surveyed, 28 are recycling. To find out if more recycling bins would encourage students to recycle cans and bottles, you place temporary recycling bins at three other locations in the school. Assume that, in a follow-up survey, you obtained the data shown in the table below.

Compare the steps in the procedure with the graph on the right to learn how to make a line graph to display your findings.

Table 3 Students Using Recycling Bins

Number of bins	Number of students using recycling bins
1	28
2	36
3	48
4	62

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. 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 right.
4. On the *x*-axis, you want to make sure you will be able to read your graph when it is complete, so make sure your intervals 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 until you have plotted all of the data for the four bins. Now, draw a line from one dot to the next.
6. If it is possible, draw a line that connects all of the points on your graph. This might not be possible. Scientific investigations most often involve quantities that change smoothly. 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**. Such a "best fit" line often passes through many of the points, but sometimes it goes between them. 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?



Instant Practice

Make a line graph using the following data on the development of a fetus. The first column represents the time since conception, in months. Plot these values along the *x*-axis. The second column is the average length of a fetus at that stage of development. Plot these values along the *y*-axis. Be sure to include units. Give your graph a title.

Table 4 Development of a Fetus

Time since conception (months)	Average length (cm)
1	0.6
2	3.0
3	7.5
4	18.0
5	27.0
6	31.0
7	37.0
8	43.0
9	50.0

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.

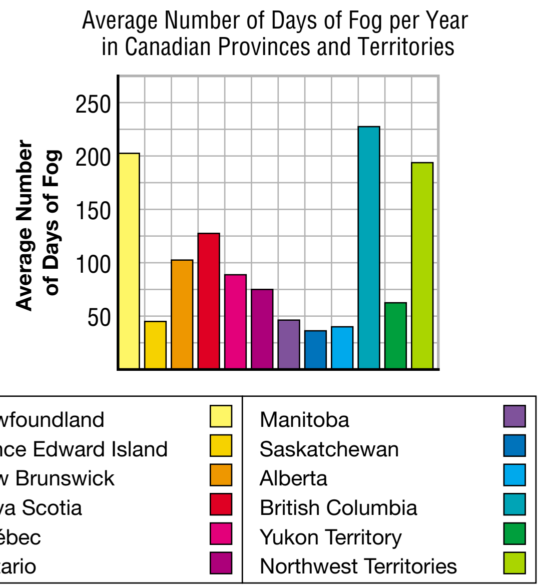
Example

To learn how to make a bar graph to display the data in Table 5, examine the corresponding graph in the next column as you read the steps below. The data show the number of days of fog recorded during one year, at one weather station in each of the provinces and territories.

Table 5 Average Number of Days of Fog per Year in Canadian Provinces and Territories (prior to April 1, 1999)

Province	Number of days of fog
Newfoundland	206
Prince Edward Island	47
New Brunswick	106
Nova Scotia	127
Québec	85
Ontario	76
Manitoba	48
Saskatchewan	37
Alberta	39
British Columbia	226
Yukon Territory	61
Northwest Territories	196

1. Draw your *x*-axis and *y*-axis on a sheet of graph paper. Label the *x*-axis with the names of the provinces and the *y*-axis with the average number of days of fog.
2. Look at the data carefully in order to select an appropriate scale. Write the scale of your *y*-axis on the lines.
3. Decide on a width for the bars that will be large enough to make the graph easy to read. Leave the same amount of space between each bar.
4. Using Newfoundland and 206 as the first pair of data, move along the *x*-axis the width of your first bar, then go up the *y*-axis to 206. Use a pencil and ruler to draw in the first bar lightly. Repeat this process for the other pairs of data.
5. When you have drawn all of the bars, you might want to colour them so that each one stands out. If you have no colours, you could use cross-hatching, dots, or diagonal lines to distinguish one bar from another. If you are comparing two or more manipulated variables that you have plotted on the *x*-axis, you will need to make a legend or key to explain the meaning of the colours. Write a title for your graph.



Instant Practice

Construct a bar graph to display the data in Table 6 showing the average heart rates of adult animals in several different species.

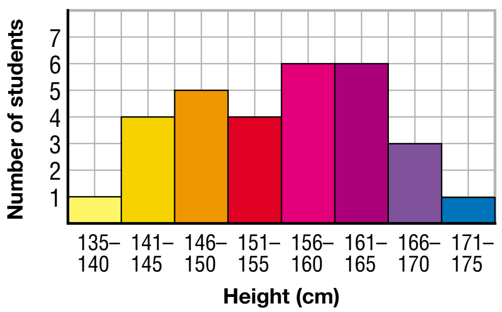
Table 6 Heart Rate and Species

Species	Heart rate (beats per min)
codfish (in water at 18°C)	30
iguana (in hot sun)	90
duck (resting)	240
dog (resting)	100
human (resting)	70
elephant (resting)	30
white rat (resting)	350

Constructing a Histogram

How does a histogram differ from a bar graph? The *x*-axis on a histogram represents continuous data such as time, mass, distance, or height. The histogram shown below displays the age distribution of 30 students in a grade 8 classroom. The *x*-axis is divided into eight height ranges. The size of each bar represents the number of students in that height range.

Histogram of 30 Students' Heights



To learn how to make a histogram, examine the raw data given below, as well as the frequency table, as you read the procedure.

Students' heights (in cm): 148, 165, 152, 156, 149, 160, 164, 169, 157, 170, 150, 159, 141, 173, 144, 150, 152, 158, 161, 137, 142, 145, 162, 165, 170, 147, 154, 157, 164, 157

1. Make a frequency table like Table 7, to tally the data.

Table 7 Frequency Table

Height range (in cm)	Tally	Frequency
135–140	/	1
141–145	////	4
146–150	~~////~~	5
151–155	////	4
156–160	~~////~~ /	6
161–165	~~////~~ /	6
166–170	///	3
171–175	/	1

2. Start with the first number, 148, in the raw data. Because 148 is in the range 146–150, put a mark in the tally column beside this range. Go to the next number, find its range, and put a mark in the tally column. Continue until you have tallied all of the data.
3. Write the number of marks in the tally column in the "Frequency" column.
4. Make a histogram with height ranges on the *x*-axis and "Number of students" (frequency) on the *y*-axis. The size of the bar in each height range is the number of students that fell in that range, as shown in the frequency table.

Instant Practice

A battery manufacturer routinely tests batteries for the number of times the batteries can be recharged. The quality control officer for the company selected 30 batteries of a certain model, at random, and tested them. The following data represent the number of times the batteries could be recharged and still perform according to company standards. Make a histogram to display the results of the test. Use a range of 10 recharges for the bars along the *x*-axis. Make a frequency table to organize the data. Then choose an appropriate scale on the *y*-axis for the number of times the batteries could be recharged.

723, 756, 771, 758, 749, 754, 738, 766, 755, 747, 762, 751, 748, 761, 735, 755, 736, 754, 743, 751, 762, 742, 751, 778, 741, 756, 732, 769, 743, 768

Constructing a Circle Graph

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

Example

To learn how to make a circle graph from the data in Table 8, study the corresponding circle graph on the right as you read the following steps.

Table 8 Birds Breeding in Canada

Type of bird	Number of species	Percent of total	Degrees in "piece of pie"
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

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:

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

3. To determine the degrees in the "piece of pie" that represents each type of bird, use the following formula.

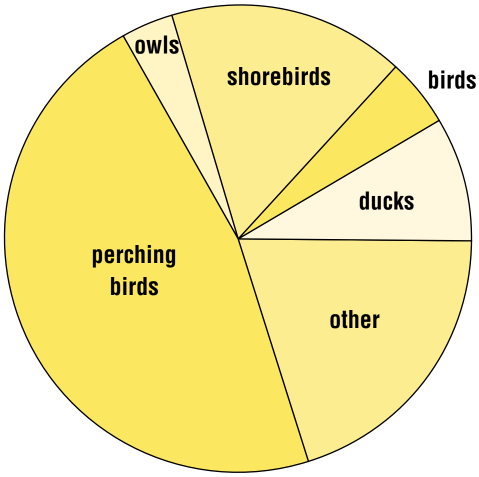
$$\text{Degrees in “piece of pie”} = \frac{\text{Percent for a type of bird}}{100\%} \times 360^\circ$$

Round your answer to the nearest whole number. For example, the "piece of pie" 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

Make a circle graph using the following data on the elements in Earth's crust. Notice that the data are given in percent.

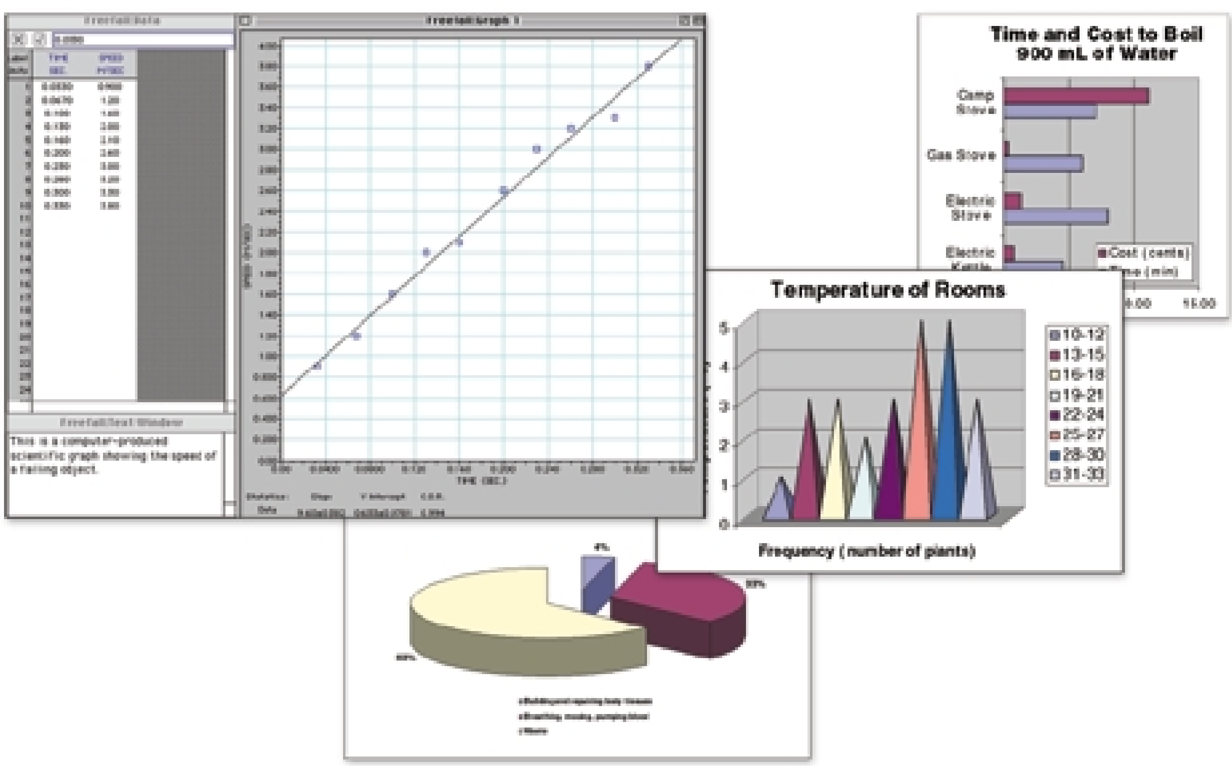
Table 9 Percent of Elements in Earth's Crust

Element	Percent of Earth's crust (%)
aluminum	8.0
calcium	2.4
iron	6.0
magnesium	4.0
oxygen	46.0
potassium	2.3
silicon	28.0
sodium	2.1
other	1.0

Graphing on a Computer

Computers are a great tool for graph preparation for the following reasons:

1. Data need only be entered once. As many graphs as you need can then be prepared without any more data entry.
2. Once the data are entered, you can get the computer to manipulate them. You can change the scale, zoom in on important parts of the graph, graph different parts of the data in different ways, and so on — all without doing any calculations!
3. Computers prepare graphs far more quickly than people working carefully.
4. Computers can be hooked up to sensors (thermometers, timers, and such) so you don't need to read instruments and enter data by hand, with all the resulting possibilities for error. The computer can display the readings on a graph as data are collected (in "real" time) so you can quickly get a picture of how your experiment is going.
5. Errors can be corrected much more easily when working with a computer. Just change the incorrect number and print again. Imagine the time and effort involved if you had to redo your graph by hand.
6. Computer graphs can be easily inserted into written lab reports, magazine articles, or Internet pages. It is possible to scan hand-drawn graphs into a computer, but it isn't easy to do it well, and the resulting files are very large.
7. Once data have been entered into a computer, the computer can determine a "best-fit" line *and* a mathematical equation that describes the line. This helps scientists to discover patterns in their data and make predictions to test their inferences in a very precise manner.



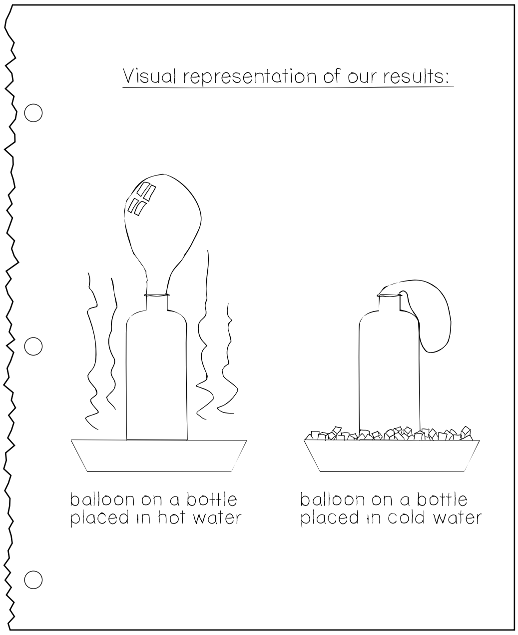
SCIENTIFIC AND TECHNOLOGICAL DRAWING

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.

In science, 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.

Example

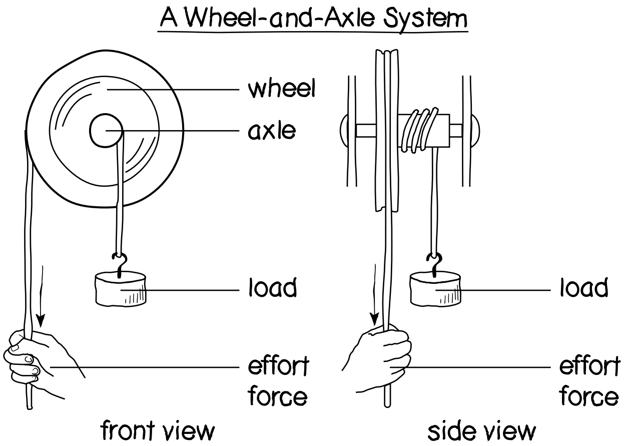
Examine the drawing shown below. It is taken from a Grade 8 student's lab report on an experiment to test the expansion of air in a balloon. The student's verbal description of results included an explanation of how the particle model can explain what happens to the balloon when the bottle is placed in hot water and in cold water. As you can see, the clear diagrams of the results can support or even replace many words of explanation. While your drawing itself is important, it is also important to label it clearly. If you are comparing and contrasting two objects, label each object and use labels to indicate the point of comparisons between them.



Making a Scientific Drawing

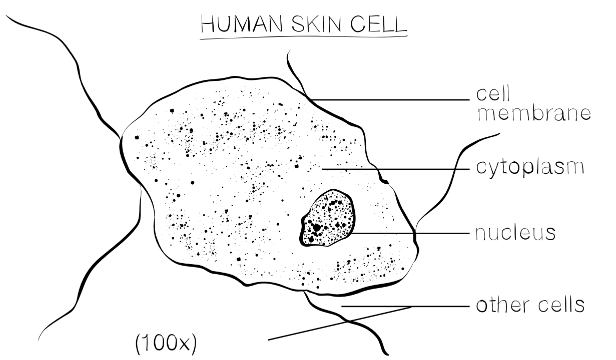
Follow these steps to make a good scientific drawing.

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 you observed. 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.



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 and 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. Pretend you know nothing about the object you have just observed, and think about what you would need to know if you were looking at it for the first time. 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. **Note:** The drawing of a human skin cell shown here is from a Grade 8 student's notebook. This student used stippling to show darker areas, horizontal label lines for the cell parts viewed, and a title — all elements of an excellent final drawing.

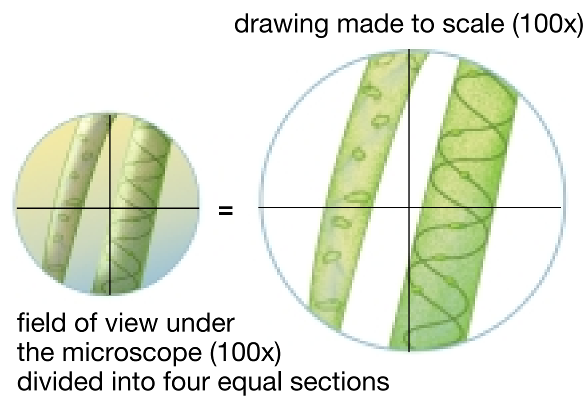


The stippling on this drawing of a human skin cell shows that some areas are darker than others.

Drawing to Scale

In Unit 2, you will be making drawings of objects that have been magnified using a microscope. When you draw objects seen through a microscope, the size of your drawing is important. Your drawing should be in proportion to the size of the object as the object appears when viewed through the microscope. This type of drawing is called a **scale drawing**. A scale drawing allows you to compare the sizes of different objects and to estimate the actual size of the object being viewed. Here are some steps to follow when making scale drawings.

1. Use a mathematical compass to draw an accurate circle in your notebook. The size of the circle does not matter. The circle represents the microscope's field of view.
2. Imagine the circle is divided into four equal sections (see the diagram). Use a pencil and a ruler to draw these sections in your circle, as shown here.
3. Using low or medium power, locate an object under the microscope. Imagine that the field of view is also divided into four equal sections.
4. Observe how much of the field of view is taken up by the object. Also note the location of the object in the field of view.
5. Draw the object in the circle. Position the object in about the same part of the circle as it appears in the field of view. Also, draw the object so that it takes up about the same amount of space within the circle as it takes up in the field of view, as shown in the diagram.



Tips on Technological Drawing

You will find that well laid-out drawings are a valuable learning tool. Also, ask the advice of specialist teachers or engineering or technology experts.

Instant Practice

1. How might you improve the student's drawing on page 520 to show the results of the balloon experiments visually?

2. **(a)** Choose an object in your classroom and use stippling as a way of giving it a three-dimensional appearance.
   (b) Exchange your drawing with that of a classmate to see if each of you can identify the other's "object." As well, give each other feedback on how you think the drawing could be improved for greater clarity.
3. Select any mechanical system in your classroom or at home; for example, a wall clock (with "hands") or bicycle gears. Show two different views of the system that would help someone else understand how the system "works."
4. Use your new knowledge to make a scale drawing of a unicellular organism that you observed in Inquiry Investigation 2-C on page 116.

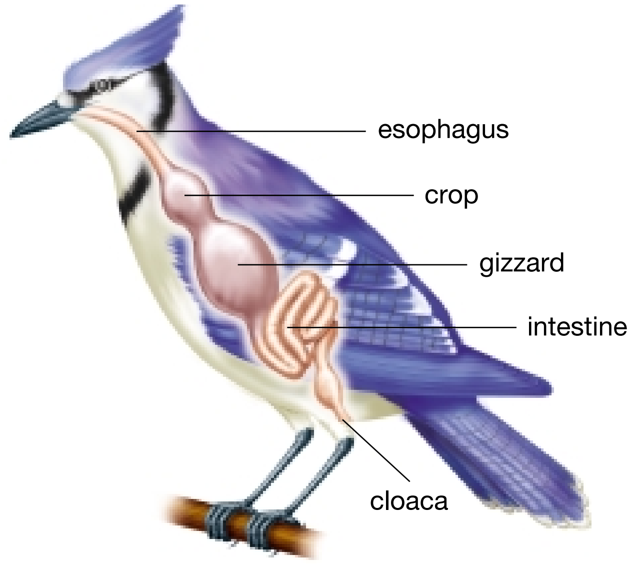
USING MODELS IN SCIENCE

When you think of a model, you probably 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 can also 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 previous studies, you learned about the particle theory of matter, for example, which is a model that suggests that all matter is made of tiny, invisible particles. On the other hand, sometimes a model is useful because some objects 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 shows you how to perform a calculation.

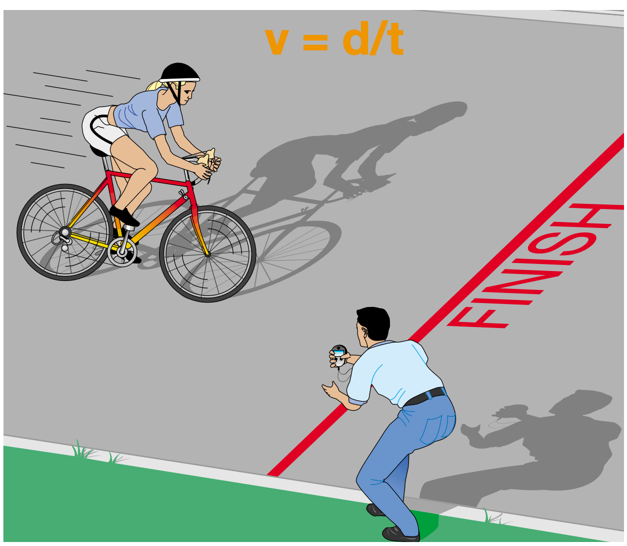
Scientists often use models to communicate their ideas to other scientists or to students. They also use models to test an idea and to find out if a hypothesis is supported. Models assist scientists in planning new experiments in order to learn more about the subject they are studying. Sometimes, scientists discover so much new information that they have to modify their models. Examine the models in the illustrations on this page. How can they 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.



bird

This model shows the digestive tract of a bird. You do not have a crop or a gizzard. Why do birds need these organs in their digestive systems?



The formula shown here is a mathematical model for speed. The symbol v represents speed (or velocity), d is distance, and t is time. The model shows you how to calculate speed if you know the time it took for a person or object to travel a certain distance. If the cyclist in the illustration travelled 25 m in 10 s, what was her speed?

Instant Practice

Build a model of the layers of Earth's crust as it would appear after millions of years of movements far below the surface.

You will need at least four colours of modelling clay, a pencil, a kitchen knife, and a plastic bag or plastic wrap. The following directions will help you build the model.

Safety Precaution

Be careful when using sharp objects such as a knife.

1. Flatten each of the four colours of clay into layers about 1 cm thick. Stack three of the layers of clay on a piece of plastic bag or wrap, as shown.

The clay represents layers of three different types of sediment deposited on an ocean floor many thousands of years ago.

2. Fold one side of the clay up and then lay the edge back down. Push the edges together gently.

Movements of the tectonic plates beneath the sea caused the sea floor to rise and become dry land. Further movements of the tectonic plates far beneath the surface caused the crust to fold.

3. About 2 or 3 cm from the fold, use the kitchen knife to cut the layers diagonally downwards. Lift one side of the cut slightly upward and push the pieces of modelling clay together gently.

Faults form when pressure and movement deep underground cause the layers on the upper crust of Earth to break and slide up or down on each other.

4. Using the kitchen knife, carefully cut off the top of the model.

Thousands of years of wind and water, or erosion, wear down hills and mountains that were formed from folds and faults.

5. Add the last slab of clay to the top of the stack, as shown.

Movements of Earth's crust, over thousands of years, can cause dry land to sink below sea level, causing it to become flooded. If the land remains below the ocean for thousands of years, another layer of sediment will form. Then this section of Earth's crust may rise up out of the sea and become dry land once again.

6. Make a hole directly downward through the clay with a pencil. Fill the hole with one colour of clay. Add more clay of the same colour above the hole and shape it like a volcano.

Deep cracks form in the layers of rock and allow molten rock to push upward, forming an intrusion. Heat and pressure force the molten rock upward through the crack, and a volcano erupts.

7. Using the knife, carefully cut the model in half. Cut perpendicular to both the fold and the fault.

Flowing water wears away land and even solid rock. Over thousands of years, a river may cut a deep canyon.

8. Move the halves apart. Examine your model. Can you see how a geologist might learn about the history of Earth's crust by studying the walls of a deep canyon? Write a summary paragraph to describe the movements of Earth's crust that might have created the formations you see in your model.