Science Skills Guide

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SAFETY SYMBOLS

The following safety symbols are used in the *SCIENCEFOCUS 9* 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.
Do Not	This familiar symbol appears when a particular action must *not* be taken.
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.
Fume Safety	This symbol appears when chemicals or chemical reactions could cause dangerous fumes.
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.
Poison Safety	This symbol appears when poisonous substances are used.
Chemical Safety	This symbol appears when chemicals used can cause burns or are poisonous if absorbed through the skin.

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 Material	Dangerously Reactive Material

Instant Practice

1. Find four of the ***SCIENCEFOCUS 9*** safety symbols in activities or investigations in this textbook. What are the possible dangers in the activity or investigation that relate to each symbol?
2. Using a word processsor program or hypertext editor, create a web page that you could use to instruct a student in grade 3 or 4 about the importance of one of the safety symbols.

USING YOUR TEXTBOOK AS A STUDY TOOL

SCIENCEFOCUS 9 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.

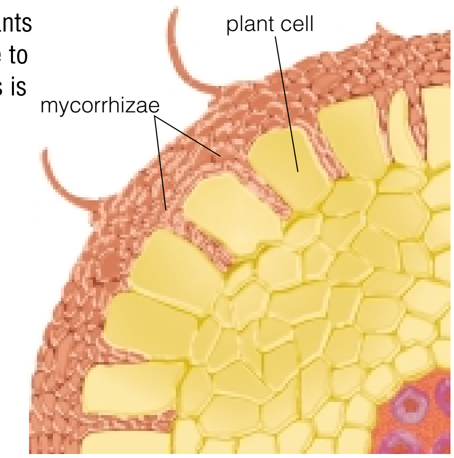
1. When you are starting a new unit, read the *Unit Contents*, the *Focussing Questions*, and the Topic cluster descriptions beside each photograph on the Unit Preview page. They will help you to focus on what each Topic cluster presents. Think about how the ideas fit into the "big picture" or main theme 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.

The ability of plants and mycorrhizae to live in symbiosis is an adaption.



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

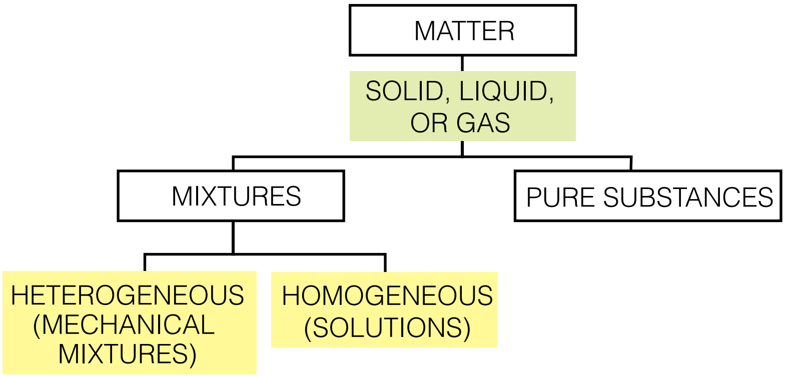
A good way to organize information you are learning is to use a **graphic organizer**. One kind of graphic organizer you will find useful is a **concept map**.

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.

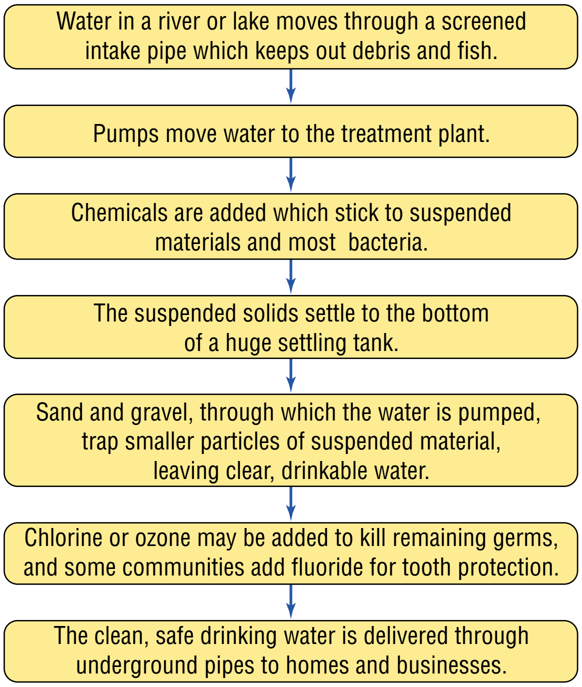
Study the construction of the concept map below called a **network tree**. Notice how some words are enclosed while others are written on connecting lines. The enclosed words are ideas or terms called concepts. The lines in the map show related concepts, and the words written on them describe relationships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

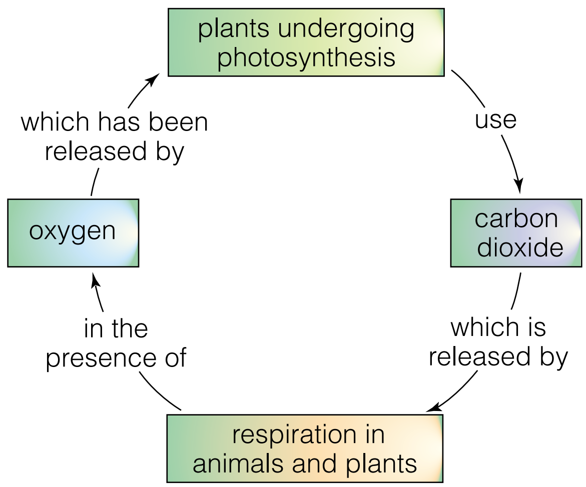


An **events chain map** describes ideas in order. In science, an events chain can be used to describe a sequence of events, the steps in a procedure, or the stages of a process. When making an events chain, you must first find out the one event that starts the chain. This event is called the initiating 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 the stages involved in the treatment of drinking water.

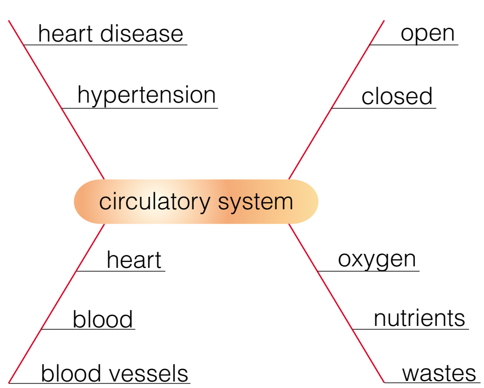


A **cycle concept map** is a special type of events chain map. In a cycle concept map, the series of events do not produce a final outcome. There is no beginning and no end to a cycle concept map.

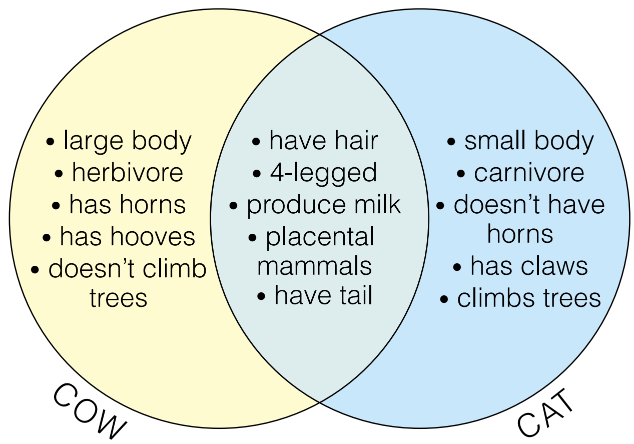
To construct a cycle map, you first decide on a starting point and then list each important event in order. Since there is no outcome and the last event relates back to the first event, the cycle repeats itself. Look at the cycle map below of the processes involved in photosynthesis.



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 related concepts, but they may not necessarily be related to each other. By placing these related ideas outside the main concept, you may begin to group these ideas so that their relationships become easier to understand. Examine the following spider map of the circulatory system to see how various concepts related to this organ system may be grouped to provide clearer understanding.



Another method to help you solidify your learning is comparing and contrasting. When you compare, you look for similarities between two things. When you contrast, you look for differences. This method can involve listing the ways in which two things are similar or ways in which they are different. You can also use a graphic organizer called a **Venn diagram** to do this, using two circles. The following Venn diagram can help you distinguish the similarities and differences between cows and cats.



Instant Practice

1. Use the following words to produce a network tree concept map (see Unit 1). Human characteristics, continuous variation, discrete variation, height, dermal ridge count, brown eyes, blue eyes.
2. Make a Venn diagram to compare and contrast solutions and mixtures (see Unit 2).
3. Produce an events chain to describe yourself setting up a garbology research project (i.e., a project in which students bring in garbage bags full of household refuse and go through it to sort out the recyclables). Add the word "fortunately" or "unfortunately" to alternating lines. Example: Unfortunately, I had to set up a garbology project. Fortunately, I knew my classmates would help. Unfortunately …
4. Produce a cycle concept map about recharging a rechargeable battery (see Unit 4).

Skill
FOCUS 3

SOLVING NUMERICAL PROBLEMS (GRASP)

Problem-solving skills are important in everyday life, in the workplace, and in school. Whether you realize it or not, you solve many problems every day. For example, one of the first problems you solve each day is deciding what to wear. The "given" information that you use to make your decision is a knowledge of what items of clothing you own and which ones are clean. Then you have to think about what is required of you on that day. If you are going to a job interview, you dress differently than you would if you were going to play soccer or softball. After you have analyzed all of the information, you make a decision, get dressed, and go out to start your the day.

Although solving numerical problems seems more difficult than deciding what to wear, you can use the same methods to solve both types of problems. Solving any problem is easier when you establish a logical, step-by-step procedure. One excellent method for solving numerical problems includes five basic steps called: Given, Required, Analysis, Solution, and Paraphrase. You can easily remember these steps because the first letter of each word spells the word **GRASP**. The following steps will help you get a "grasp" on quantitative or numerical problem solving.

The GRASP method

Given

The first step in solving a numerical problem is to organize the given data. Read the problem carefully and make a list of all of the numerical quantities given in the problem statement, as well as any other important, qualitative information. Include the symbols, numerical values, and units for each numerical quantity. For example, if you are told that the mass of a rock is 3.5 kg, you would list: Mass of rock, $m = 3.5$ kg.

Required

The second step in the GRASP method is to identify exactly what information the problem requires you to find. Write the name of the quantity, the symbol, and the units. For example, if you are asked to find the velocity of an object, write: Velocity, v (m/s).

Analysis

To carry out the third step, analyze the problem statement by breaking it down into individual phrases. A single phrase may contain important information. You can use the following strategies to help you analyze the problem:

- Look at the given data and the required value. Write down any relationships between these quantities. For example, if you are given values for area and pressure and you need to determine the force, write down: $P = F/A$.
- If possible, make a sketch or a diagram. A good diagram can often provide the key to solving a problem.
- Ensure that the units in the given data are consistent with each other and with the units you will use in your final answer. If the units are not consistent, make the necessary conversions.
- Analyze the problem statement to determine if you need any information that can be found in a table, appendix, or other reference. For example, the densities of many substances are listed in tables in science textbooks. The masses of many objects, from an electron to the Sun can be found in reference materials, both print, and electronic. Look up and record any numerical values that you will need.
- Write down any assumptions you will have to make in order to solve the problem.

Solution

In the fourth step, use all of the data and information you have accumulated to find the solution. Convert all units to the units required in your final answer. Then substitute the given values into the relationships you have written down and carry out the mathematical operations. Include units in every step.

Paraphrase

The purpose of the fifth and final step is to clarify the meaning of the calculations you have done. The word "paraphrase" means to restate in a different way. Paraphrase your solution, including the quantity, value, and units, in the form of a sentence.

Example of the GRASP Problem-Solving Method

A small, shiny, gold-coloured, metallic crown was uncovered at an excavation site. To determine whether the crown was made of either pure gold or copper, the excavators decided to calculate its density and compare it to the published densities of the two metals. They measured the mass of the crown and found it to be 2.00 kg. The measured volume was 225 cm^3. Was the crown made of copper or gold?

Given

Mass of crown, $m = 2.00$ kg

Volume of crown, $V = 225\ cm^3$

Required

Density, D (g/cm^3)

Analysis

Units are not consistent.

Convert mass in kilograms to grams.

Use the conversion factor 1 kg = 1000 g.

Write it in the form $\frac{1000\ g}{1\ kg} = 1$

$D = m/V$

Densities of copper and gold are needed for comparison. Published values are:

Density of copper, $D_{Cu} = 8.90\ g/cm^3$

Density of gold, $D_{Au} = 19.30\ g/cm^3$

Assume that any dirt was removed from the crown before its mass and volume were determined.

Solution

1. Convert units.

$$m = 2.00\ \cancel{kg}\ \frac{1000\ g}{1\ \cancel{kg}}$$
$$= 2000\ g$$

2. $$D = \frac{m}{V}$$
$$= \frac{2000\ g}{225\ cm^2}$$
$$= 8.89\ g/cm^3$$

The density of the crown is almost the same as the published density of copper.

Paraphrase

The density of the gold-coloured crown is 8.89 gm/cm^3, almost the same as the published density of copper. Since the published density of gold, 19.30 g/cm^3, is much larger than the calculated density of the crown, the crown could not be made of gold. The colour and the density of the crown are consistent with the colour and density of copper. However, more tests should be done to confirm this conclusion.

Instant Practice

Use the GRASP method to solve the following problems.

1. A cube of aluminum has a mass of 2.0 kg and a volume of 741 cm^3. What is the density of the aluminum in g/cm^3?
2. An armoured vehicle can carry a maximum mass of 10 000 kg. The security safe in the vehicle has an inside volume of 0.600 m^3. Can this safe hold 10 000 kg of gold? Explain your answer.
3. On March 24, 1989 an oil tanker called the Exxon Valdez ran aground on Blight Reef off Prince William Sound along the Alaskan Coastline. Breaks in the hull of this ship released an estimated 50 108 000 L of Alaska North Slope crude into the ocean. Use the GRASP method to solve the following problems.
   - **(a)** To describe this spill in terms that a younger grade might understand, how many classrooms full of oil is this equivalent to? (Typical classrooms are about 10 m wide, 10 m long and 3 m high, or you can measure your own classroom.)
   - **(b)** If the mass of the spill is 45 147 809 kg how many of thes ocean creatures could that equal?
     - blue whale 135000 kg
     - harbour seal 93 kg
     - sea otter (male) 45 kg
     - sea otter (female) 27 kg
     - silver salmon "coho" 5 kg
   - **(c)** The residue from oil forms a layer of about 1 mm in thickness. According to the Canadian Football League, the regulation size of a football field is 100.6 m by 59.4 m. What area of the surface of the ocean could this slick cover if ideal conditions resulted in uniform coverage? How many football fields would fit in that area?
4. This problem concerns Canadians, especially if an oil spill occurred in one of the Great Lakes. The Alaska North Slope oil floated in saltwater at a density of 1.025 g/cm^3, but could it float and be cleaned off fresh water that is at a density of 0.997 g/cm^3? (Recall that the mass of the spill was 45 147 809 kg, and $D = m/V$).

Skill
FOCUS 4

UNITS OF MEASUREMENT AND SCIENTIFIC NOTATION

Sometimes when you're working with numbers, you just need an approximate idea about a quantity. At other times, you need to be very precise. For example, what size shoes do you wear? Your answer is probably very precise. Imagine how uncomfortable you would be if you wore shoes only generally approximated to your size. Obviously you need shoes that are carefully measured to fit your foot.

The Metric System

When you take measurements in science, you use the **metric system**, which is a decimal system of measurement.

In the metric system, all units are multiples of 10. Therefore, if you need to express a quantity using a larger unit, you multiply by a multiple of 10. To express a quantity using a smaller unit, you divide by a multiple of ten. For example, the prefix *kilo*- means multiplied by 1000; thus, one kilogram equals one thousand grams.

$$1 \text{ kg} = 1000 \text{ g}$$

The prefix milli- means divided by 1000; thus, one milligram equals one one thousandth of a gram.

$$1 \text{ mg} = \frac{1}{1000} \text{ g}$$

The table on the right lists some frequently used units of measurement in the metric system.

Frequently Used Metric Quantities, Units, and Symbols

Quantity	Unit *SI	Symbol
length	nanometre	nm
	micrometre	µm
	millimetre	mm
	centimetre	cm
	*metre	m
	kilometre	km
mass	gram	g
	*kilogram	kg
	tonne	t
area	square metre	m^2
	square centimetre	cm^2
	hectare	ha (10 000 m^2)
volume	cubic centimetre	cm^3
	cubic metre	m^3
	millilitre	mL
	litre	L
time	*second	s
temperature	degree Celsius	°C
force	newton	N
energy	joule	J
	kilojoule	kJ
pressure	pascal	Pa
	kilopascal	kPa
electric current	ampere	A
quantity of electric charge	coulomb	C
frequency	hertz	Hz
power	watt	W

The following table shows the most commonly used metric prefixes. (Adding metric prefixes to a base unit is a way of expressing powers of ten.)

Metric Prefixes

Prefix	Symbol	Relationship to the base unit
giga-	G	10^9 = 1 000 000 000
mega-	M	10^6 = 1 000 000
kilo-	k	10^3 = 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

Example 1

The distance across Canada is 5514 km. How would you express this distance in metres?

Solution

5514 km = ? m

$$5514\ \cancel{\text{km}} \times \frac{1000\ \text{m}}{1\ \cancel{\text{km}}} = 5\ 514\ 000\ \text{m}$$

Example 2

You have 10.5 g of salt. To express this mass in kilograms, remember that 1000 g = 1 kg.

Solution

10.5 g = ? kg

$$10.5\ \cancel{\text{g}} \times \frac{1\ \text{kg}}{1000\ \cancel{\text{g}}} = 0.0105\ \text{kg}$$

Instant Practice

1. 35 cm = ? m

2. 20 m = ? mm

3. 55 g = ? mg

4. 0.5 kg = ? g

5. 6.5 L = ? mL

6. 1750 cm^3 = ? m^3

7. 750 mL = ? L

8. 1250 kg = ? t

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*. SI uses the metre as the basic unit of length, the kilogram as the basic unit of mass, and the second as the basic unit of time. Most other units are related to the basic units.

Example

Convert 42.5 $\frac{\text{cm}}{\text{s}}$ to SI Units.

Solution

$$42.5\ \frac{\cancel{\text{cm}}}{\text{s}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}} = 0.425\ \frac{\text{m}}{\text{s}}$$

Instant Practice

Convert the following to SI Units

1. 275 cm

2. 22 min

3. 21 $\frac{\text{km}}{\text{h}}$

4. 6937 g

Exponents of Scientific Notation

An exponent is the symbol or number denoting the power to which another number or symbol is to be raised. The exponent shows the number of repeated multiplications of the base. In 10^2, the exponent is 2 and the base is 10. The place table below shows the powers of 10 as numbers in standard form and in exponential form.

	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	$\frac{1}{10^1}$
hundredths	0.01	$\frac{1}{10^2}$
thousandths	0.001	$\frac{1}{10^3}$
ten thousandths	0.0001	$\frac{1}{10^4}$

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

Example 1

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

Solution

In scientific notation, a number has the form $x \times 10^n$, where x is greater than or equal to 1 but less than 10, and 10^n is a power of 10.

58 000 000. ← The decimal point starts here. Move the decimal point 7 places to the left.

$= 5.8 \times 10\ 000\ 000$

$= 5.8 \times 10^7$

Example 2

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

Solution

To write the number in the form $x \times 10^n$, move the decimal point to the right until there is one, non-zero number to the left of the decimal point.

The decimal point starts here. 0.000 000 000 053

Move the decimal point 11 places to the right.

$= 5.3 \times 0.000\ 000\ 000\ 01$

$= 5.3 \times 10^{-11}$

Notice that, when you move the decimal point to the left, the exponent of ten is positive. When you move the decimal point to the right, the exponent of ten is negative. The number of places you move the decimal point is the number in the exponent.

Instant Practice

1. Express each of the following in scientific notation.

(a) Our galaxy, the Milky Way, contains more than 400 000 000 000 stars.

(b) The distance of the Andromeda Galaxy from Earth is about: 23 000 000 000 000 000 000 km

(c) The distance across the universe has been estimated at: 800 000 000 000 000 000 000 000 km

(d) The mass of a proton is about: 0.000 000 000 000 000 000 000 0017 g

2. Change the following to standard notation.

(a) 9.8×10^5 m

(b) 2.3×10^9 kg

(c) 5.5×10^{-5} L

(d) 6.5×10^{-10} s

ESTIMATING AND MEASURING

The gathering of scientific data often involves the measurement of different quantities. Special tools and techniques have been developed to take accurate measurements. **Accuracy** refers to how close a measurement is to the true value of a particular quantity, such as the length or volume of an object. Some of the measurements scientists need to make are more complex than others. Whether complex or simple, measurements must be taken properly. In this *SkillFocus*, you will learn and practise some of these techniques so that you may gather your own data.

Estimating

In some cases, it may not be essential or possible to take exact measurements. In such cases, scientists make estimates. For example, suppose you were an ecologist and needed to know the number of individuals of a tree species in a large provincial park. It would not be practical to count every single tree of that species. It would take too much time and money, and you probably would not need to know the exact number. If you define a study area, say 100 m^2 and if you know the total area of the park, then you could obtain a good estimate by multiplying the number of trees in your study area by the number of 100 m^2 blocks in the total area of the park.

Instant Practice

1. You need to estimate the number of micro-organisms on a petri dish. It is impractical to examine the whole dish with a microscope, but you can easily count the micro-organisms in a 1 mm × 1 mm square. Suppose you count 15 micro-organisms in this area, and you know that the area of the dish is 20 cm^2. Estimate the number on the whole dish. Remember that you must use the same units in your estimate.
2. Suppose you are an ornithologist studying parental behaviour in American robins. You observe that in an 8 h period, a robin visits its nest 29 times. Estimate how many times per hour the robin visits the nest.
3. Examine the photograph (top right) How might you make a good estimate of the number of animals in this herd?

Measuring Area

As you know, length is the distance between two points. **Area** is the number of square units required to cover a surface. Area can be calculated easily for a square or rectangular shape: measure the lengths of two neighbouring sides (in other words, the length and width) and multiply them together. For example, the area of a rectangle with a length of 5 cm and a width of 4 cm is

$$5 \text{ cm} \times 4 \text{ cm} = 20 \text{ cm}^2$$

Notice that the values for area are expressed in square units.

The area of a right-angled triangle is obtained by multiplying the base and height (which are the neighbouring sides joined at the right angle) and dividing by 2. In other words:

$$\text{Area of triangle} = \frac{1}{2} \times \text{height} \times \text{base}$$

A special formula is required to calculate the area of a circle. Measure the radius, r — the distance between the centre of the circle and its circumference — (or halve the diameter instead), square this value, and multiply by the special number pi (3.14), which is symbolized by π.

$$\text{Area of a circle} = \pi r^2$$

Instant Practice

1. What is the area of a rectangle with a width of 2 cm and a length of 3.5 cm?
2. What is the area of a square with sides of 1 cm?
3. The area of a square or a rectangle is calculated by multiplying length by width. Why is a triangle's area half the area of a rectangle? To find out, draw a rectangle and create two triangles from it by drawing a line between two opposite corners.

4. You are responsible for supervising the renovation of your classroom into a laboratory. An end wall will serve as the sink area, and it needs to be tiled to a height of 1.5 m. Standard laboratory tiles, 10 cm in height and 20 cm in width, will be used. How many tiles will you need?
   - **(a)** First, decide what kind of measurement would be most practical for the area — mm^2, cm^2, or m^2.
   - **(b)** Measure the length of the wall.
   - **(c)** Calculate the area of the wall to be tiled.
   - **(d)** How many tiles would you need to cover 1 m^2?
   - **(e)** Multiply that number by the number of square metres of wall area.
   - **(f)** Remember to use the same units. Using centimetres and metres in the same calculation will lead to incorrect calculations.

Measuring Volume

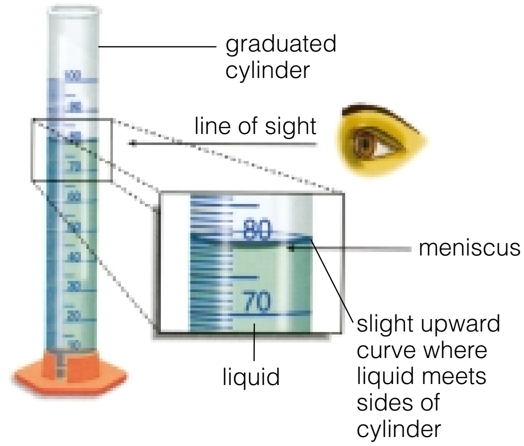
The volume of an object is the amount of space that the object occupies. Volume involves three dimensions: height, length, and width. The units for measuring the volume of a solid are called **cubic units** (for example, cm^3). The units used to measure the volume of liquids are called **capacity units**. The basic unit for liquids is the litre (L), but in this course, you will probably be working in millilitres (mL). Cubic units and capacity units are interchangeable, as indicated below:

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

To measure the volume of a liquid, you need a graduated cylinder. Once you have poured in the liquid sample, place the cylinder on a flat surface. Read the level at the top of the column of the liquid, but make sure that your eye is level with the top — do not measure from above or below. Finally, you need to consider the **meniscus**, the slight curve at the top of a liquid where the liquid meets the sides of the cylinder. For most liquids, such as water, the sides curve slightly upward, so measure at the lowest level of the meniscus, as shown in the diagram above.

In a mercury thermometer, the edges of the mercury curve slightly downward. In this case, read from the top of the meniscus.

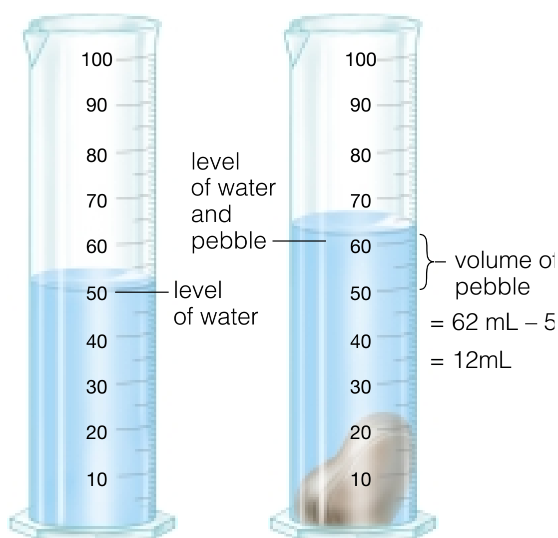
The volume of solids can be measured in several ways, depending on shape and form. A solid that pours, such as sugar, can be measured like a liquid, but the surface of the substance being measured must be as flat as possible.



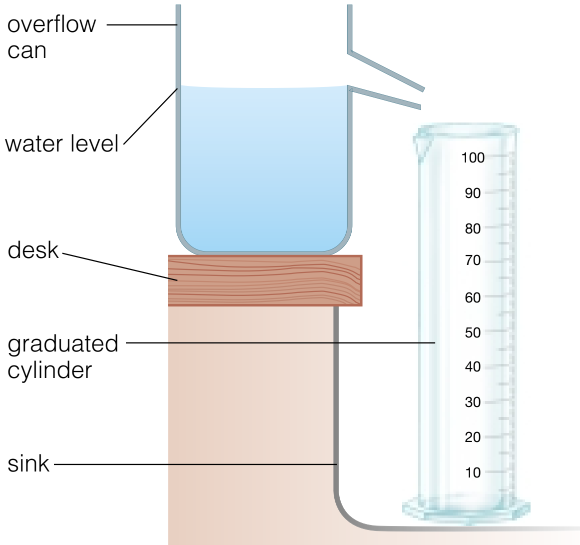
Take a reading from the bottom of the meniscus with your line of sight at the level of the meniscus.

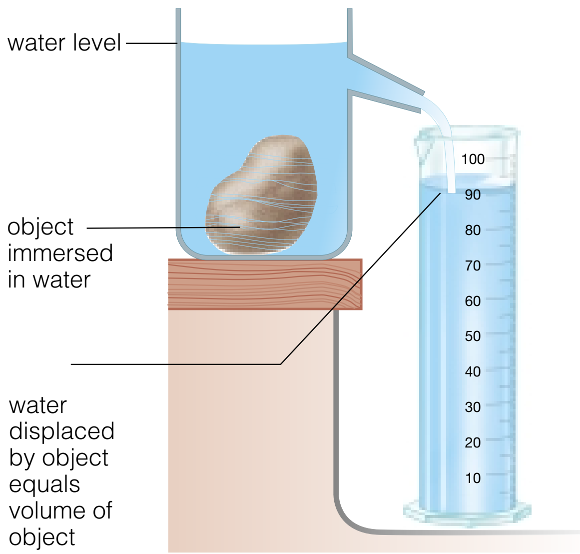
For a rectangular solid, measure the length, width, and height, then multiply the values together. You may also calculate the volume of a cylinder. Calculate the area of its circular base (see the formula on page 456) and multiply it by the height of the cylinder.

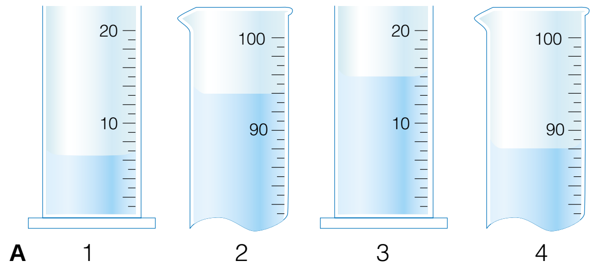
The volume of irregularly shaped objects may be determined by the amount of liquid they displace. The displacement for a small object, such as a coin or a pebble, may be determined with a graduated cylinder. The water displaced equals the volume of the object, as shown in the diagram below.

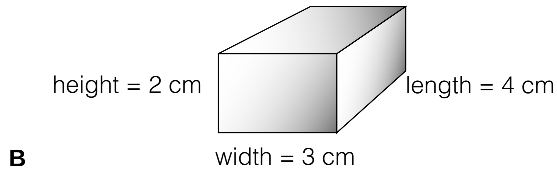


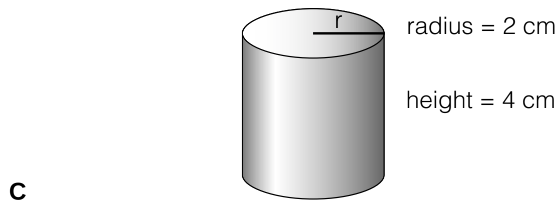
The volume of larger objects can be determined by displacement as well, by using an overflow can. The spout allows water displaced by an object to be caught and measured in a graduated cylinder, as shown in the two diagrams directly below.











Instant Practice

Refer to the diagrams on the top right.

1. What is the volume indicated by each of the graduated cylinders in diagram A?
2. Calculate the volume of the object in diagram B.
3. Calculate the volume of the cylinder in diagram C.
4. To measure the volume of an object, follow these steps:
   (a) Place a carefully measured amount of water, say 50 mL, into a 100 mL graduated cylinder. To do this, fill the cylinder to just under 50 mL and use a medicine dropper to bring the level to 50 mL.
   (b) Tilting the cylinder slightly, gently immerse an object. The object will displace the water by an amount equal to its volume, and the level of the water (50 mL) in the cylinder will rise by this amount.
   (c) Read the new volume level and subtract the original amount of water from this new value. This will give you the volume of the object.
5. You can use an overflow can and a graduated cylinder to measure the volume of an object.
   (a) Place your finger over the spout and fill the can above the level of the spout. Position the can on a level surface and remove your finger to allow the excess water to drain into a sink.
   (b) Place a graduated cylinder beneath the spout and carefully immerse the object in the water. Be careful that you do not immerse your fingers. The volume of the water displaced into the cylinder equals the volume of the object.

Measuring Mass

The mass of an object is the measure of the amount of material that makes up the object, but not the space occupied by the objects. For example, which has more mass: a cube of wood or a cube of lead of the same size? In this case, you know that the cube of lead has more mass because lead is much more dense than wood. What about a marble and a quarter? This comparison is not as easy to make. To measure the mass of each object accurately, you need to use a balance or a scale. You will probably use a triple beam balance similar to the one shown below.

The balance has a pan on one side and a set of three beams on the other. Each of the beams has a scale marked off and a rider or weight that can be moved along the beam. You can find the mass of an object by placing it directly on the pan. What if you needed to determine the mass of one cup of sugar? There is an easier way than dumping the sugar on the pan! Learn how to find mass by doing the following.

Instant Practice

1. Before you begin, set the balance to zero by sliding all three riders back to their zero points, at the left side of the beams. The pointer at the right side of the beams should swing slowly an equal amount above and below the zero. If it does not, turn the adjusting screw until it does so.
   - **(a)** Place your object on the pan. The pointer will rise above the zero mark.
   - **(b)** Slide the largest rider along until the pointer falls below zero. Then move it back one notch.
   - **(c)** Repeat with the next heaviest rider, and then with the lightest rider. Adjust the last rider until the pointer swings equally above and below zero.
   - **(d)** Add the readings of the three beams to find the mass.
2. What is the mass of half a cup of sugar?
   - **(a)** Place an empty beaker (or cup) on the pan of the balance. Determine the mass of the beaker and record it.
   - **(b)** Remove the beaker and half-fill it with sugar. Place the beaker on the pan of the balance and determine the mass of the sugar and the beaker together.
   - **(c)** Determine the mass of the sugar only.
3. You may use the balance "in reverse" to measure out a known quantity. Suppose you needed to measure out 100 g of sugar (see the diagrams below).
   - **(a)** Place an empty beaker on the pan and determine its mass.
   - **(b)** Now move the appropriate slider along and add 100 g to the right side of the scale. The pointer will fall below zero.
   - **(c)** Carefully pour sugar into the beaker until the pointer begins to move. You need to add exactly 100 g to balance the scales again.

A Determine the mass of the empty beaker.

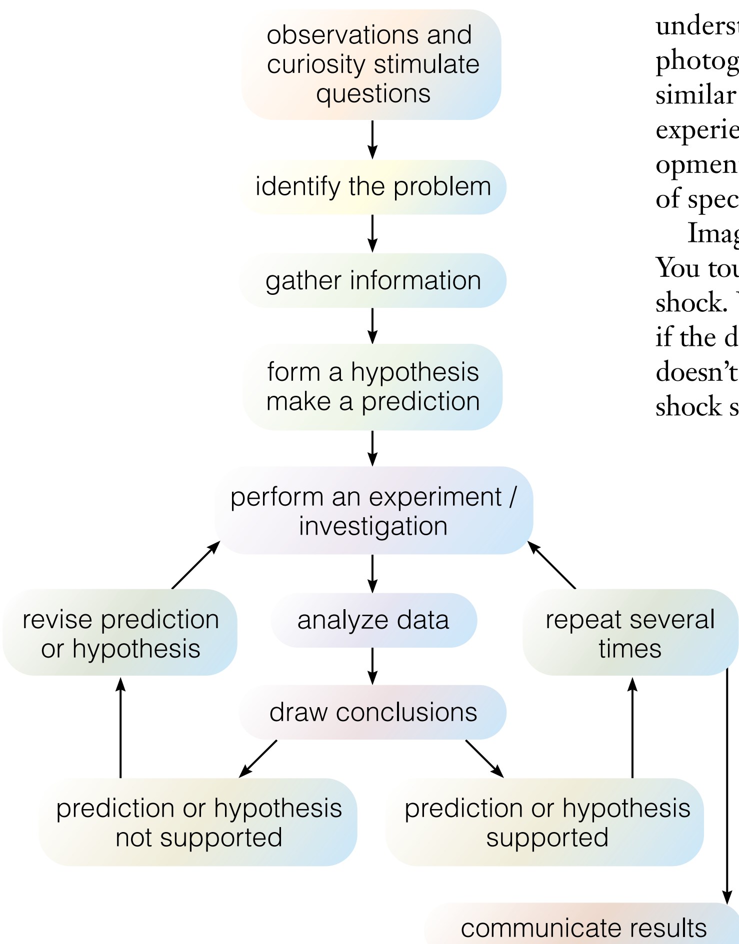
B Add 100 g to the mass measurement by moving the appropriate rider along the beam.

C Carefully add the solid to the beaker on the pan of the balance. The scales will be balanced again when 100 g of solid have been added to the beaker.

SCIENTIFIC INQUIRY

Science is a way of explaining the objects and events in the natural world. Scientists want to know how and why things happen. As you know from previous science studies, you too can answer these questions scientifically. The inquiry processes you have learned to use result in scientific knowledge that allows you to predict and explain such events as the lightning flash in this photograph.

A scientific inquiry involves several different processes. These are reviewed here to assist you in getting the most out of studying this textbook. As you know, some of these processes have to be followed in order. Scientific inquiry can be initiated, though, at any step in the idealized sequence shown in this diagram.



How might you proceed to develop scientific understanding about the lightning strike in the photograph? Here is an example of a phenomenon similar to lightning, one that you might have experienced in everyday life. Notice that the development of a **scientific law** has made use of the idea of specific "charges."

Imagine walking across a carpeted room in winter. You touch the metal door pull and zap! you get a shock. Why does it happen? Why doesn't it happen if the door pull is made of wood or plastic? Why doesn't it happen in summer? Is the cause of the shock still there in summer? Why don't you feel it?

Questions such as these have led scientists to conduct experiments that have resulted in their formulating the Laws of Charges which state:

1. Unlike charges attract.
2. Like charges repel.
3. Charged objects attract uncharged (neutral) objects.

> **law**: an action or condition that has been observed so consistently that scientists are convinced it will always happen. A law does not explain events, but summarizes their regularity. In previous studies, you probably learned about the two laws of reflection, for example.

By using the law of charges, you might begin to understand how the lightning strike occurs. Also, now that you know something about charges, you can formulate your own question about how you can identify like and unlike charges. In what substances can you observe like charges? To answer this question, you will need to state the problem clearly and narrow the investigation down to one, specific object that you can control. Even when you study one object, many characteristics of the object might influence its behaviour. These characteristics are called the **variables** of the investigation.

You must control all of the variables except one when you make observations. The one factor or variable that you change is called the **manipulated variable**. The factor or variable that changes as a result of the manipulated variable is called the **responding variable**. If you change two different variables at the same time, you will not know which one was responsible for the effect that you observed. If your investigation is to be valid and unbiased (a **fair test**), you must carry out the procedure in precisely the same way more than once, changing only the variable you are measuring. Many experiments have a **control** — a treatment or experiment that you can compare with the result of your test groups.

> **variable**: any factor that will influence the outcome of an experiment

In an investigation of like charges, the substance with which you test all other substances is a variable.

Next, review all of the information that you already have about the object. You have acquired this information through your **observations**.

> **Qualitative observations**: describe something using only words; for example, a yellow short-haired dog. **Quantitative observations**: use numbers as well as words to describe something; for example, a dog with a mass of 14 kg, a height of 46 cm, an ear length of 10 cm, and an age of 150 days.

Through careful observation, you may notice patterns in natural events, or you may suspect that a relationship exists between certain events and outcomes. Use the information obtained through your observations to formulate a **hypothesis**. Design an **experiment** to test your hypothesis. Carry out the investigation, then record your data and analyze the results. Did your results support or contradict the hypothesis? If the data you recorded during the investigation did not support your hypothesis, review the results and formulate a new hypothesis, then start the testing process again. Even if the data did support your hypothesis, you must repeat the experiment at least once more. Scientific evidence must be reproducible.

hypothesis: statement of a proposed relationship, based on background information or an observed pattern of events, and stated in a way that makes it testable. Example: An organism that is deprived of water will fail to thrive.

experiment: an activity or procedure designed to falsify a hypothesis. It may seem strange to attempt to prove something wrong. However, it is not possible to prove something to be absolutely true because there might always be one more experiment that would reveal a flaw. It takes only one experiment to falsify a hypothesis. If you do not falsify a hypothesis, then the results support it.

Experimental results and **conclusions** can contribute to the growing body of scientific knowledge only if they are communicated. Scientists communicate their findings by submitting articles to scientific journals, by presenting papers at conferences, and by discussing their work with colleagues. Before an article is published in a print resource, other scientists review it to ensure that the research and conclusions are based on proper methods of science inquiry.

conclusion: an interpretation of the results of an experiment as it applies to the hypothesis being tested. Example: Based on quantitative data for gasoline consumption, we found that regular gasoline is more efficient than premium gasoline.

As a final step in the science inquiry process, you write a report on your experiment, presenting the procedural results clearly so that someone else who reads your report could repeat the experiment. End your report with a discussion of your interpretation of the results and the conclusion.

This example of science inquiry is the first phase in a broader process. As various scientists replicate (copy) the investigations of others, they may find that their conclusions always support a specific hypothesis. The hypothesis may then be accepted in the scientific community as a **theory**.

A **model** helps you to explain an event or observation for yourself or others. For example, think about the electrical charges we discussed earlier. The model being used is that electricity behaves as if it comes in tiny bundles called charges. At one time, scientists worked with a model that electricity came in two kinds of fluids. As they worked with the model, they found that it didn't explain everything that they were learning about energy. The bundle-of-charge model has been found to be more satisfactory for explaining electricity.

model: a mental image, used as a building block that helps to explain an event. Often, for clarity scientists diagram, make physical representations, or treat mathematically the features of a model. A physical representation of the solar system can be constructed from balls of different sizes. Software is available for building models on a computer.

theory: an explanation of an observation or event that has been supported by consistent, repeated experimental results, and has therefore been accepted by a majority of scientists. An example in this textbook is Dalton's atomic theory.

Now that you have reviewed the key processes of science inquiry, you are ready to use the processes yourself as you do the following Instant Practice and carry out activities and investigations throughout this book.

Instant Practice

Suppose you wanted to find out if you could touch a metal door pull in winter without getting a shock. Reread the third law of charges. It describes what happens when an electrical charge moves from a charged object (you) to an uncharged object (the door pull).

1. With your group develop a question that you could investigate.
2. Write a hypothesis. Based on what your own experience and observations tell you, what general statement can you make based on your question?
3. Write a procedure. What will your variables be?
4. Check your procedure with your teacher, and then carry out the procedure.
5. Record your observations. Should they be recorded in sentence form, or would a chart be more efficient and easier to read?
6. Explain what happened during your experimental procedure, referring to your hypothesis. Write a conclusion, and be prepared to share it with the class.

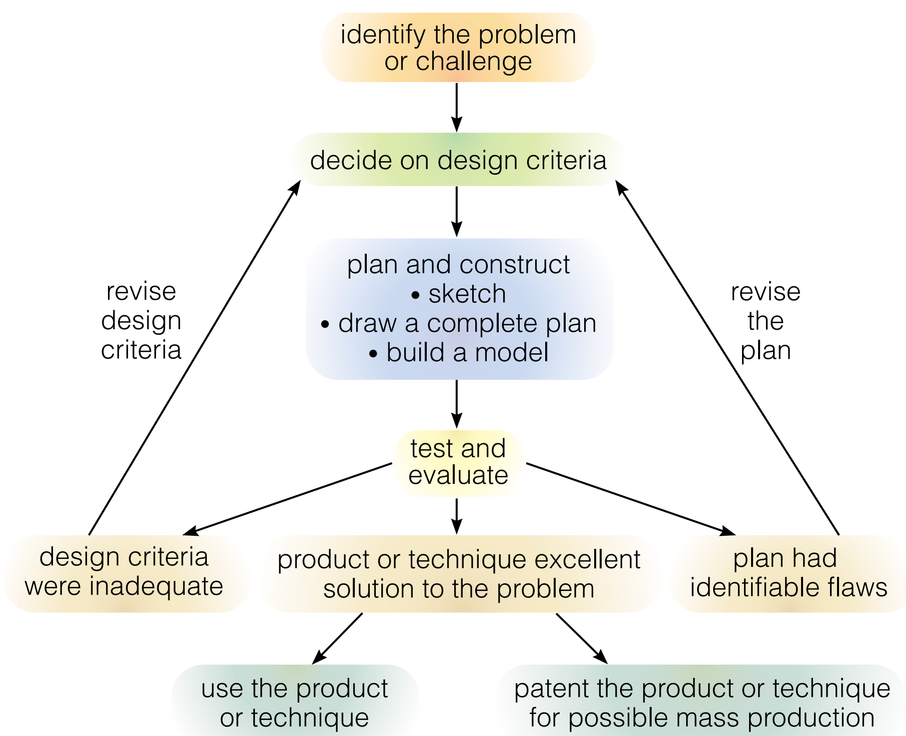
Skill
FOCUS 7

TECHNOLOGICAL PROBLEM SOLVING

Engineers, architects, computer specialists (information technologists), and designers are experts at using technological problem-solving skills to find solutions to practical problems. Everybody else uses these skills too, including you. You have learned about using these skills in earlier science studies, and they are reviewed here to assist you in getting the most out of studying this textbook.

Technological problem solvers are interested in such questions as, “Will it work?” and “How long will it last?” and “How efficient is it?” Often they develop devices that are used to solve the practical problem, or challenge, with which they are dealing. Technological devices can be simple or complex. For example, a shovel is a simple technological device that makes digging a hole easier. Precision lasers are complex devices that specially trained physicians can use to perform delicate brain or eye surgery. Sometimes technology is developed or improved by applying scientific knowledge. Sometimes successful technology comes first, though, and scientific knowledge advances as a result of trying to understand why the technology works.

The following flow chart diagrams the process as explained and used in this textbook to represent technological problem solving.



Technological Problem Solving in This Course

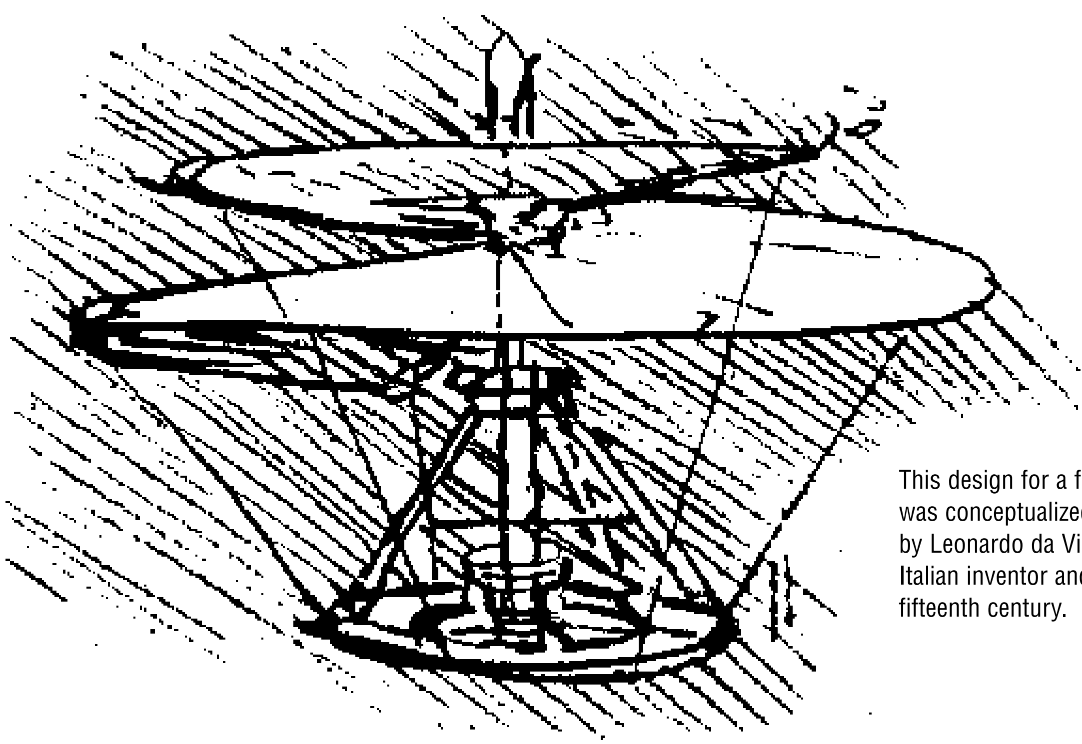
You will use technological problem-solving skills in this course in Problem-Solving Investigations. This kind of investigation asks you to develop strategies for meeting a challenge. You will be asked to develop and carry out a plan based on specific design criteria. You will also be asked to evaluate the plan, and to reflect on and communicate the results.

Instant Practice

1. In Unit 5 of this text, you will learn about telescopes (see pages 366-370) and you will also have an opportunity to construct a telescope. Suppose you were going to a parade and wanted to be able to see the parade from the back of the crowd. How could you construct a periscope that would help you see above the heads of the crowd?
   - **(a)** Work with your group to define the problem facing you and how you will solve it. What alternate solutions can you find?
   - **(b)** Suppose you have chosen to construct a periscope. Develop and design a prototype (you might want to read about telescopes on page 370, to get some ideas).
   - **(c)** List the materials you will need and the design criteria your periscope must meet.
   - **(d)** Have your design approved by your teacher, then build and test your periscope.
   - **(e)** Evaluate your design and discuss with your group how it might be improved.
2. Read the following excerpt from an article about Canadian scientist, Ursula Franklin. Do you agree or disagree with the thoughts expressed by Franklin? Discuss her comments with your group, using what you know about various modern technologies to agree or disagree with Franklin. What other universal laws might initially prevent people from fulfilling a dream? How does the idea expressed relate to the fact that technologies are sometimes developed without the scientific knowledge that underlies them?

People wanted to fly. And so in the beginning they strapped birds' feathers to their arms, jumped off cliffs, flapped mightily — and fell to the ground. "Because it doesn't work," Franklin said. "You can't opt out of the universal law of gravity."

"But it doesn't mean an end to the dream of flying. It just means you study the problem. You put your resources into finding a solution. You discover, eventually, that while pigs can't fly, they can be flown. That while people can't fly, they can be flown."



This design for a flying machine was conceptualized and sketched by Leonardo da Vinci, the great Italian inventor and artist of the fifteenth century.

Skill FOCUS 8

SOCIETAL DECISION MAKING

In your science course this year, you will often be asked to think about interactions among science, technology, and society. In other words, you will be examining issues that arise because science and technology are part of a social and environmental context. Complex issues frequently arise as a result, requiring a good grasp of scientific principles and a careful approach to the decisions they demand. For example, the photograph above was taken by astronauts who were orbiting the Moon. At the time (1968), the use of technology for space travel seemed new and exciting. Seeing the world from space gave humans a whole new perspective on our planet. We saw it in a new way and began to form different opinions about it.

Our ability to orbit the Moon resulted from our use of technology to solve the problem of defying gravity and leaving Earth's atmosphere. That use of technology has in turn led to problems of its own: space junk. Older nonworking satellites may break apart and spiral to Earth, causing environmental damage and requiring costly cleanup efforts. This problem raises the question: should we continue with the space program? It costs huge amounts of money that could be used elsewhere. It causes environmental problems. On the other hand, if we end the space program, what new knowledge, discoveries, and possibilities might we deny ourselves? Clearly, we need to weigh the decision carefully. Whenever we have a choice of this sort, decision makers are facing an issue.

What is the best way to approach a complex issue such as this? What information do we need? How can we use our scientific knowledge and our understanding of the processes of science to fully comprehend the issue and to find ways to make the best choice? In this instance, we could carefully monitor the kinds of problems that occur. We could observe environmental changes over time to understand the full impact. We might start thinking about new technology to counteract the environmental problems. We could establish criteria that any resolution of the issue must meet. We could then suggest solutions and, if appropriate, build models that could be used to test future environmental impacts. We could use these models to evaluate alternatives, consider consequences, and to choose the best alternative. We might decide that none of our solutions meets all (or most) of our criteria and decide to come up with new solutions, using what we have learned throughout the process. You can see that such decision-making processes are cyclical.

Even when a seemingly ideal resolution to an issue is found, circumstances and technology change, and the issue may need to be revisited.

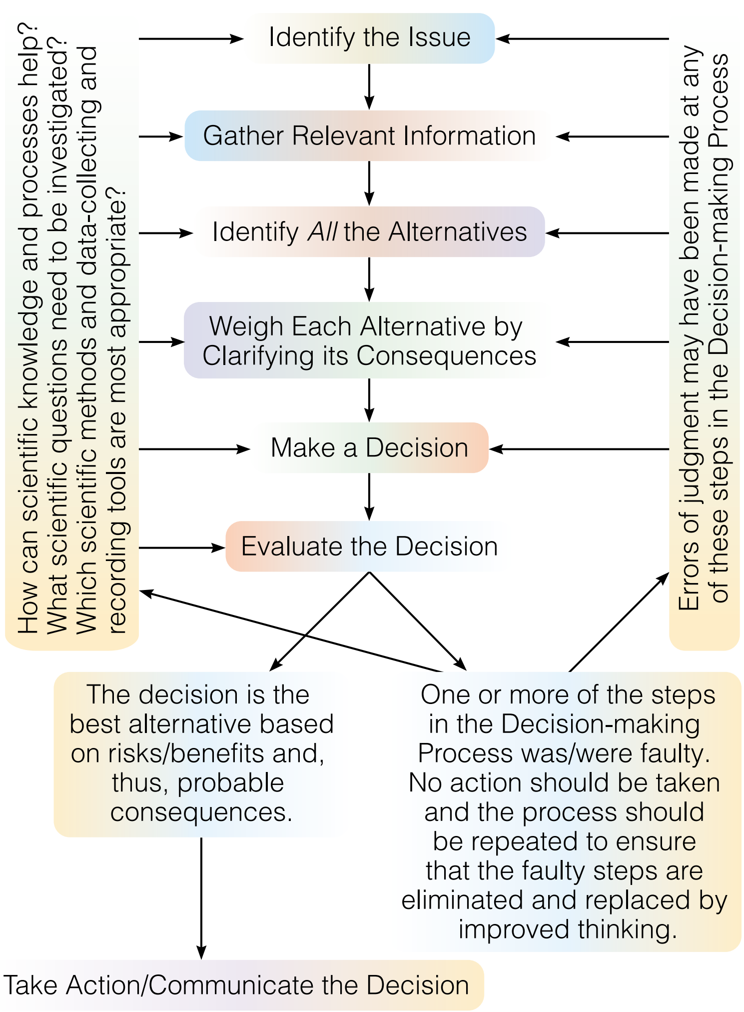
Issues like these can be addressed more effectively by societies made up of scientifically literate citizens: those able to sort information from misinformation and to evaluate whether claims made in the name of science are valid or invalid.

This textbook is designed to help you progress toward scientific literacy.

Science can provide basic information to help you evaluate risks. Indeed, how science helps us make decisions is a major focus of this book. But science alone is not enough to make final decisions about either public or personal issues. Throughout the decision-making process input is required from organizations, groups, and individuals, who can provide the social, aesthetic, evironmental, ethical, and economic background that the process requires. All viewpoints should be examined with respect. This textbook's content will help you to appreciate and understand the science underlying many societal issues that will arise in the future, and will also provide you with critical skills and concepts you need to succeed in future science courses.

Your ***SCIENCEFOCUS 9*** textbook, in general, promotes an understanding of issue analysis, but three special features will be especially useful in helping you to develop your decision-making skills.

Many of the *Think & Link Investigations* in this textbook examine issues. All of the *Decision-Making Investigations* and the *Unit Issue Analysis* activities provide issues to debate, simulations to role-play, or case studies giving you experience in developing your critical thinking and decision-making skills.



Instant Practice

In many of the experiments and investigations in this text, you need to use chemicals that are environmentally harmful if you are to learn your chemistry. How will you dispose of these chemicals? Should you be using them at all? What other questions does this issue raise, and how can you best answer them and find and evaluate useful alternatives?

1. With your group, examine the example of a decision-making flow chart shown on page 467.
2. Use it to reach a decision about the use of chemicals in your classroom.
3. Make sure you work with every step in the flowchart. Identify the issue clearly, and then identify as many sources as you can for your information-gathering.
4. Clearly identify how you can use your knowledge of science and its processes to obtain information that will help you to make your decision.
5. Consider who might be involved in the consequences of chemical disposal. What are the risks and benefits of this action? You might have to do some information-gathering outside your own school.
6. When you have reached the end of the process and are satisfied with the decision you have reached, share your thoughts and the process you followed with other groups.

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. Copy a scientific or factual quote (one sentence should do), out of the newspaper or an encyclopaedia. For example, a fact about adult African bull elephants is that they have a mass of 5 400 kg.
2. Write a sentence response to the quote stating why you chose it.
3. Box or highlight (using a different font) your main block of textual quote so that it is different in appearance form the response.
4. Add a questionnaire below this block. You can limit the questions to three or four requiring yes/no answers. In the case of the bull elephant above, you might ask if the person thinks this is the heaviest species of elephant on the planet (yes or no).
5. Spellcheck, proofread, and print out your questionnaire.

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

Using your questionnaire, from above:

1. Ask the questions of at least ten people (classmates or others).
2. Enter the information into a database and sort to determine the number of respondents who answered yes to the first question but not the remainder. Then sort to determine the number who answered yes to the first two, etc.

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.

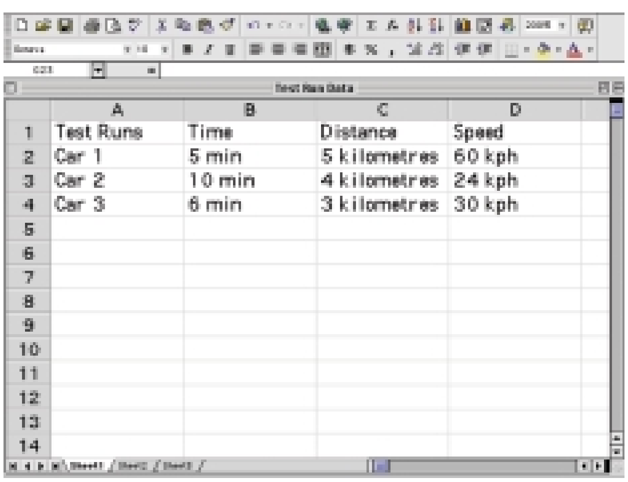
Using an Electronic Spreadsheet

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.

Spreadsheets speed calculations when the volume of numbers is large or when a calculation requires multiple steps. This form of entering data gives a quick way to modify a body of numbers and receive a calculation when time is a critical factor in finding a solution.

Instant Practice

Each astronaut is allotted a maximum mass of personal items that may be taken on a flight into outer space. The flight commander (your teacher) will be announcing at the last minute the limit for the flight on which you are booked. It will be up to you to select what you will take when the limit is announced. Using a scale, determine the mass of personal items that you and/or your classmates are carrying. List each item under columns that include the name, mass, quantity selected, and mass subtotal of the item. Then, under the mass subtotal column insert a function that will calculate the sum of all the masses selected.



	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

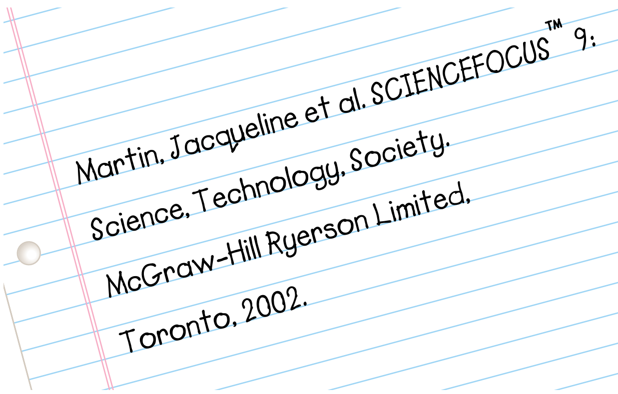
1. Use an encyclopaedia CD-ROM to find a map of North America, or a continent in which you are interested. Print a copy of the map.
2. Return to the CD-ROM and search for overlays that demonstrate the population density and average yearly precipitation for that continent. Use a different colour to sketch each on your map.
3. Investigate the range of an animal of your choosing that is native to that continent or a biome, and add that data to your map with cross-hatching or a third colour.

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. Use probeware to determine how long hot tap water takes to cool in a glass versus a metal container of equal volume.
2. Determine the pH of runoff water from soil or a potted plant.
3. Using photo gates, measure the time it takes for an object to fall one metre. For greater accuracy, repeat the experiment several times and average the times.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus9

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 the web site above, and click on Web Links to find out where to go next. Write and sketch your findings.

This recurring feature in *SCIENCEFOCUS*™ *9* 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?

Noooo!!! Kabooooom!!! Silence.

The above are the sounds of what did not happen on January 7, 2002 when a smallish asteroid passed near, in astronomical terms, to Earth.

For example, the nearness of Monday's near-miss was extremely relative. Part of what probably caught the attention of reporters was that Asteroid 2001 YB5 was described as missing Earth by an apparently minuscule 0.0056 Astronomical Units. But an AU is the average distance of Earth to the Sun, or 149 597 871 km.

Size has a huge effect when scientists try to compute what will happen to the surface of our planet when rogue rocks actually strike the Earth.

Anyone with access to the Internet can check the effect by using the Solar Systems Collisions Calculator — http://janus.astro.umd.edu/astro/impact.html — created by University of Maryland astronomer Doug Hamilton.

For example, if you enter the approximate size — up to 300 m — and speed — 108 000 km/h — of YB5, the calculator informs you that if the asteroid was largely rock, it would make a crater five kilometres across and half a kilometre deep. Upon impact, it would release the energy equivalent of 3 764 megatons of TNT, a figure roughly equal to the explosion of a third of all of the world's nuclear weapons at once.

If the impact's energy release was translated into an earthquake scale, it would be a Magnitude 8 — with the largest quake ever recorded measuring a 9.6. A collision that size would probably occur only once in every 28 000 years.

Surprisingly, lesser-sized asteroids can cause considerable damage as well. If you calculate the devastation from an asteroid that is less than a third of the size of YB5 it can create an impact crater almost two kilometres wide in an explosion equivalent to sixty megatonnes of TNT. That earth-shaking hit is similar to the San Francisco earthquake caused by movement of Earth's crust in 1906. The frequency of these lesser asteroids colliding is approximately one every 4 400 years.

Much smaller rocks from space, only about two metres in diameter, can make an impression about thirty five metres wide. The fact that they are striking the Earth at such great speeds allows such small pebbles to produce enough energy to match the use of 500 tonnes of TNT — not unlike the Canadian explosion of 1964 called "Snowball" that was the largest chemical explosion recorded. These very small asteroids are also very numerous; therefore we can expect one on average every 4 years.

All of which raises the larger question of how many collisions are likely to occur any time soon.

Source: The Globe and Mail, Saturday, January 12, 2002, page F7.

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

Table 1 Force of Space Debris Impact Craters on Earth compared to Historical Events

Projectile diameter	2 m	6 m	90 m	155 m	350 m
Crater diameter	35 m	120 m	1.8 km	3.1 km	6.9 km
Energy (= TNT)	500 t	20000 t	60 MT	310 MT	3600 MT
Average frequency	4 years	35 years	4400 years	12000 years	51000 years
Comparable terrestrial event	Minimum earthquake (M5), largest chemical explosion "Snowball," Canada, 1964.	Atomic bomb explosion Hiroshima Japan, 1945.	San Francisco earthquake, 1906 (M8.4), largest hydrogen bomb detonation.	Mount St. Helens, Washington eruption, 1981 (total energy including thermal).	Largest recorded earthquake, Chile, 1960 (M9.6).

Instant Practice

1. Organize the following data into a table. In the table, include a column that gives the greatest temperature range in each province and territory.

   The following temperatures are the warmest ever recorded in Canada to date: Newfoundland, 41.7°C; Prince Edward Island, 36.7°C; New Brunswick, 39.4°C; Nova Scotia, 38.3°C; Québec, 40.0°C; Ontario, 42.2°C; Manitoba, 44.4°C; Saskatchewan, 45.0°C; Alberta, 43.3°C; British Columbia, 44.4°C; Yukon Territory, 36.1°C; Northwest Territories, 39.4°C; Nunavut, 33.9°C.

   The following temperatures are the coldest ever recorded in Canada: Newfoundland, –51.1°C; Prince Edward Island, –37.2°C; New Brunswick, –47.2°C; Nova Scotia, –41.1°C; Québec, –54.4°C; Ontario, –58.3°C; Manitoba, –52.8°C; Saskatchewan, –56.7°C; Alberta, –61.1°C; British Columbia, –58.9°C; Yukon Territory, –63.0°C; Northwest Territories, –57.2°C; Nunavut, –57.8°C.

2. Why would some of the data in this table be different after February 5, 2002?

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

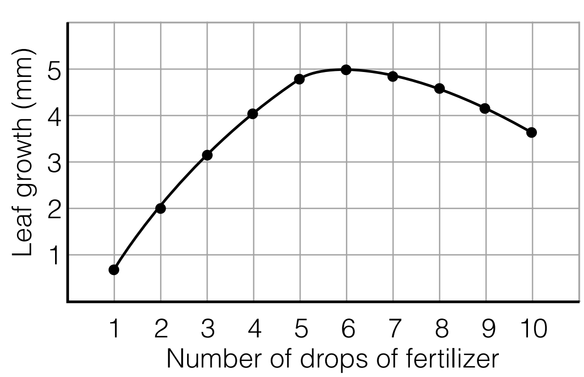
Suppose you are growing a large number of African violet tropical plants to sell for a local charity. This variety is new to you, so in order to determine the ideal amount of liquid fertilizer to use you decide to experiment on ten plants, adding a different amount of fertilizer to each and charting the width of leaf growth for a reasonable period of time. Assume that you obtained the data shown in the table below.

Table 2 Amount of Fertilizer Used to Promote Violet Growth

Number of drops of fertilizer	Width of leaf growth (mm)
1	0.7
2	2.0
3	3.1
4	4.0
5	4.7
6	5.0
7	4.9
8	4.6
9	4.2
10	3.5

Instant Practice

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 drops of fertilizer” along the *x*-axis and “Width of leaf growth” along the *y*-axis.
3. Now you have to decide what scale to use. You are working with two numbers (number of drops of fertilizer, and width of leaf growth). The scale on the *x*-axis will go from 0 to 10. You might anticipate that the greatest growth will be 5 mm. Mark the scale on the *y*-axis from 0 to 5. Use a “tick mark” at major intervals on your scale, as shown in the graph below.



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 0.7 (you are representing 0.7 mm of leaf growth). Now move along the line on the graph paper until you reach the vertical line that represents the first number of drops. Place a dot at this point (1 drop of fertilizer, 0.7 mm of leaf growth). Repeat this process until you have plotted all of the data for the various numbers of drops. 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 range in the number of drops of fertilizer that will produce leaf growth greater than 4.5 mm width?

Instant Practice

The data in Table 3 give the speed of a ball every second after it was thrown straight upward with an initial speed of 49 m/s. Make a graph of the speed of the ball with time. Use your graph to estimate the speed of the ball after 3.5 s.

Table 3 Speed of Ball Thrown Upward

Time (s)	Speed (m/s)
0.0	49.0
1.0	39.2
2.0	29.4
3.0	19.6
4.0	9.80
5.0	0.00

Constructing a Bar Graph

Bar graphs are most useful when you have numerical values associated with categories of places or things. In the following example, the categories are the world's continents.

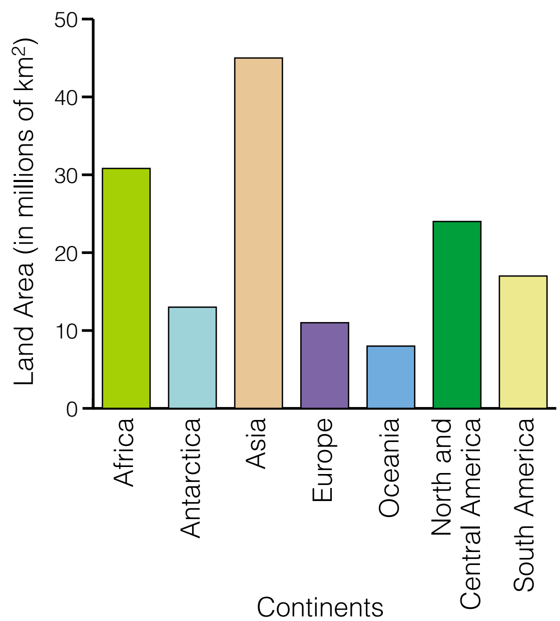
Example

Table 4 on page 476 provides the data for the bar graph shown on its right, showing the land areas of the world's continents. To learn how the bar graph was prepared, read the following steps and compare them to the graph.

1. Draw your *x*-axis and *y*-axis on a sheet of graph paper. Label the *x*-axis "Continents" and the *y*-axis "Land area." Remember to include units.
2. Select an appropriate scale. Write the numerical values to show the scale on your *y*-axis. For example, the number 10 represents: 10 000 000 km^2.
3. Decide on a width for the bars that will make the graph easy to read. Leave the same amount of space between each bar.
4. To draw the bar representing Africa, move along the *x*-axis the width of your first bar, then go up the *y*-axis just above 30 to represent 30.3. Use a pencil and a ruler to draw in the first bar lightly. Repeat the procedure for the other continents.

Table 4

Continent	Land area (millions of square kilometers)
Africa	30.3
Antarctica	13.2
Asia	44.5
Europe	10.5
Oceania	7.8
North and Central America	24.2
South America	17.8



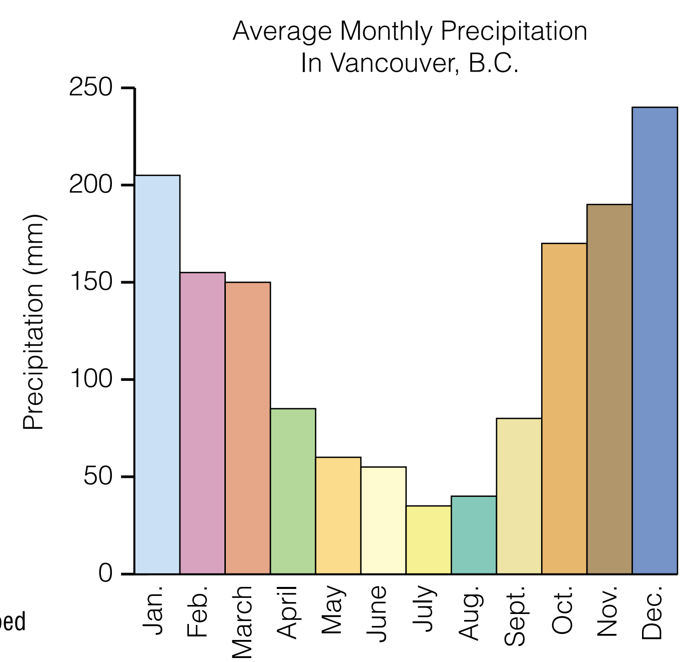
5. When you have drawn all the bars, you might wish to colour them so that each one stands out. If you do decide to use different colours, you may need to make a legend or a key to explain the meaning of the colours. Give your graph a title.

Instant Practice

Make a bar graph showing the greatest temperature range recorded for each province and territory. Use the data table that you prepared in the *Instant Practice* for making data tables (page 474).

Constructing a Histogram

How does a histogram, such as the one shown on the right, differ from a bar graph? You probably noticed that there is no space between the bars. The reason for placing the bars in contact with each other is that the *x*-axis represents a continuous quantity. In this histogram, the continuous quantity is time and each group is one month. The total of the data is represented by the height of a bar. In this case, the heights of the bars represent the total precipitation during each month. The procedure for constructing a histogram is the same as the procedure for making a bar graph.



The *x*-axis in this histogram represents time, which is a continuous variable. The precipitation data have been grouped by the month.

Instant Practice

The following data represent the masses, in grams, of 30 mature laboratory rats that have been fed a special test diet. Make a histogram to display the masses of the rats. Use mass groupings of 100 g for the bars along the *x*-axis. Choose an appropriate scale on the *y*-axis for the number of rats in each mass group.

756, 677, 811, 472, 591, 744, 714, 891, 903, 623, 767, 819, 922, 717, 858, 727, 512, 907, 537, 735, 681, 913, 836, 654, 789, 827, 638, 701, 873, 750

Constructing a Circle Graph

Circle graphs are an excellent way to communicate categories in terms of percentages of a whole.

Example

To learn how to construct a circle graph, follow the steps below while examining the circle graph showing the percentage of each blood type in the North American population.

Table 5 Blood Types in North America

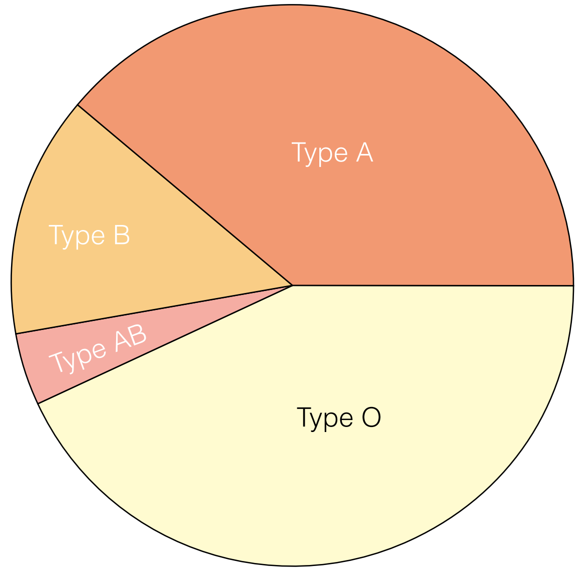
Blood type	Percentage of total	Degrees (°) in "piece of pie"
A	38	137
B	14	51
AB	4	14
O	44	158

1. Make a large circle on a piece of paper and put a dot in the centre.
2. To determine the number of degrees in each "piece of the pie" that represents each section, use the following formula:

$$\text{Degrees for ``piece of pie''} = \frac{\text{Percentage of total}}{100\%} \times 360°$$

Round your answer to the nearest whole number. For example, the degrees in the section representing blood type A are:

$$\text{Degrees for type A} = \frac{38\%}{100\%} \times 360° = 137°$$



3. Draw a straight line from the centre to the edge of the circle. Place a protractor on this line and use it to mark a point on the edge of the circle at 137°. Connect the point to the centre of the circle. This is the "piece" that represents the portion of the population having type A blood.
4. Repeat steps 2 and 3 for the remaining blood types.

Instant Practice

Make a circle graph using the following data on the elements in the human body: hydrogen (H), 63.1%; oxygen (O), 25.4%; carbon (C), 9.4%; nitrogen (N), 1.4%; calcium (Ca), 0.3%; phosphorus (P), 0.2%; other, 0.2%.

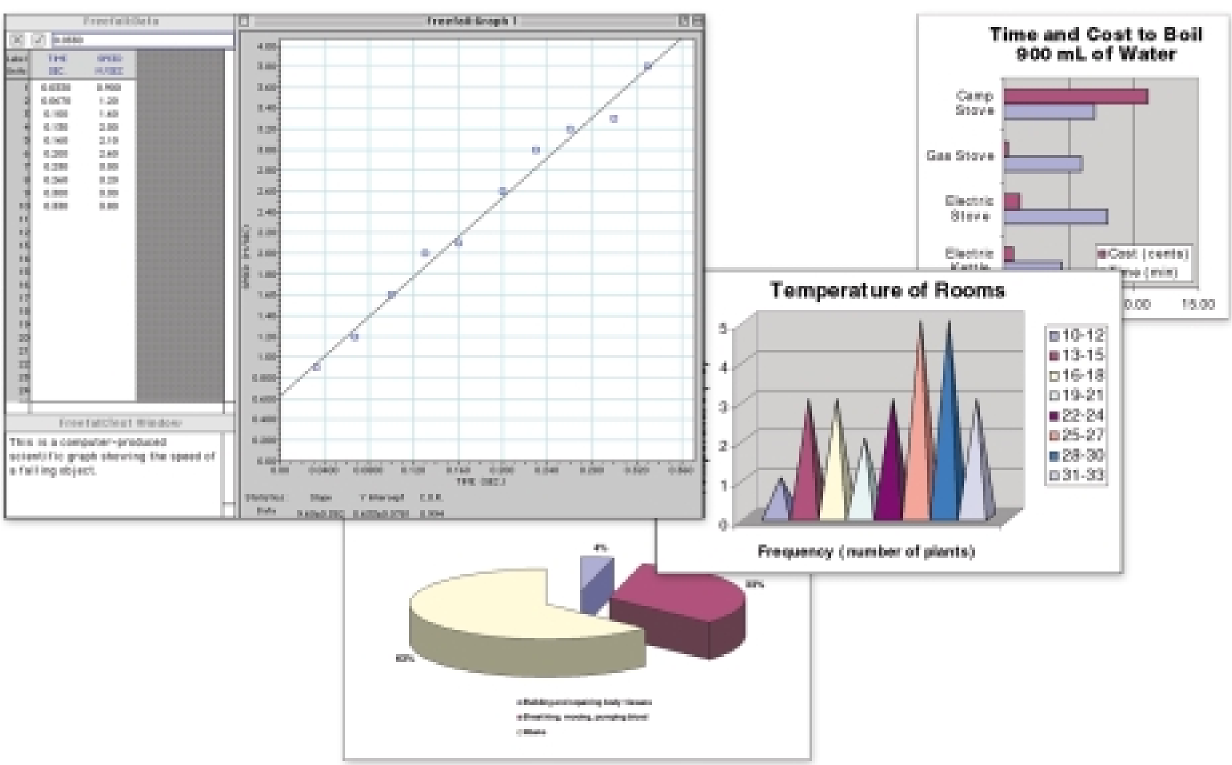
Graphing on a Computer

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.

Instant Practice

Using probeware, measure the change of temperature as 10 mL of crushed ice melts into water. Have the computer produce a table and line graph with a best fit curve. For best results, stir the mixture continuously from the start of the melting process.



SCIENTIFIC AND TECHNOLOGICAL DRAWING

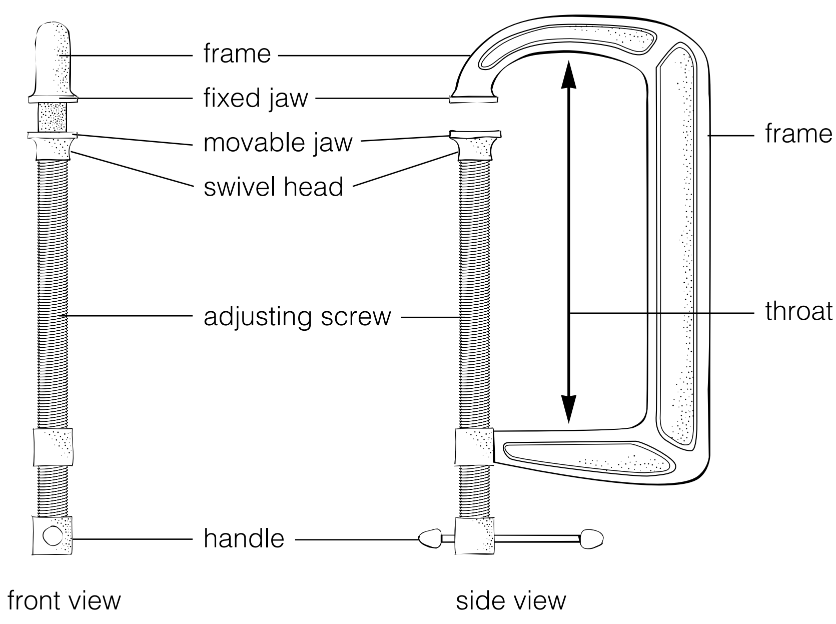
A clear, concise drawing can often illustrate or replace words in a scientific explanation. In science, drawings are especially important when you are trying to explain difficult concepts or describe something that contains a lot of detail. It is important to make scientific drawings clear, neat, and accurate.

Making a Scientific Drawing

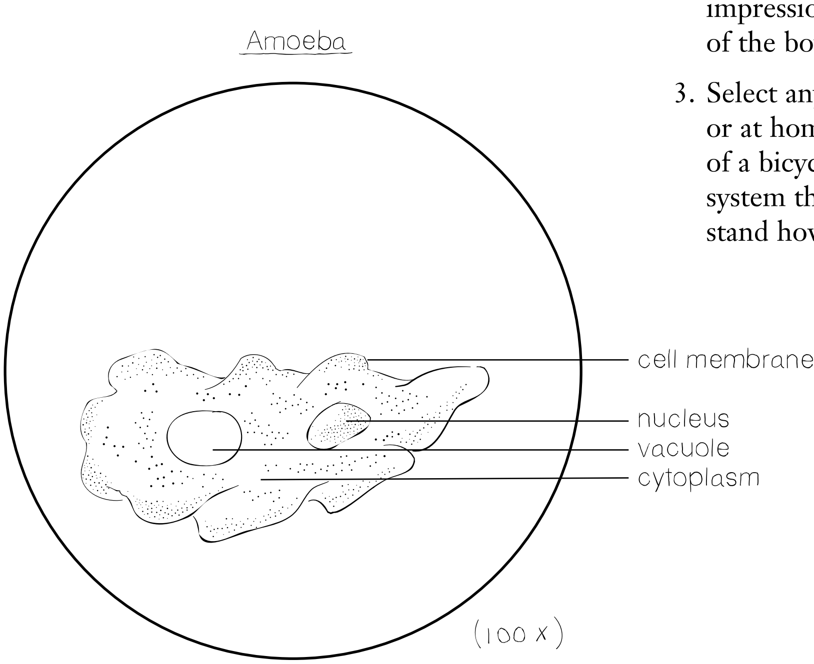
Follow these steps to make a good scientific drawing.

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 objects 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 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.

Front and side view of a "C" clamp



8. Give your drawing a title. **Note**: The drawing of an amoeba shown here is from a Grade 9 student's notebook. The student used stippling to show darker areas, horizontal labels for the cell parts viewed, and a title — all elements of an excellent final drawing.



The stippling on this drawing of an amoeba as observed under a microscope shows that some areas are darker than others.

Instant Practice

1. Make a drawing of an object in your classroom and use stippling as a way of indicating that it has three dimensions.
2. Draw a spoon in front view and back view. Show how you can use stippling to give the impression of the concave and convex surfaces of the bowl of the spoon.
3. Select any mechanical system in your classroom or at home; for example, the brakes or the gears of a bicycle. Show two different views of the system that would help someone else understand how the system works.

Skill
FOCUS 12

USING MODELS IN SCIENCE

In science, a model is anything that helps you to better understand a scientific concept. A model can be a picture, a mental image, a structure, or even a mathematical expression. Sometimes you need a model because the objects you are studying are too small to see or too large to envision. Sometimes they are hidden from view, like the interior of Earth or the inside of a living organism.

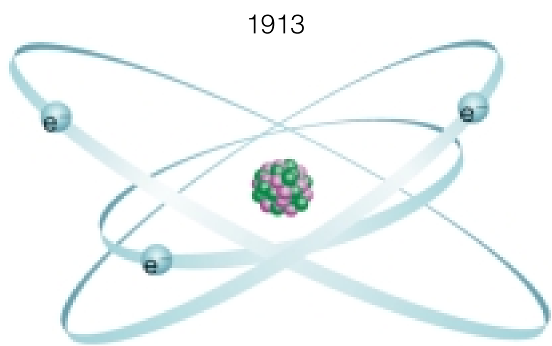
Scientists use models to help them communicate their ideas to other scientists and/or to students. They also use models to test an idea and to find out if it can work. Models help scientists plan new experiments in order to learn more about the subject they are studying. Sometimes, when scientists learn more, they have to modify their models.

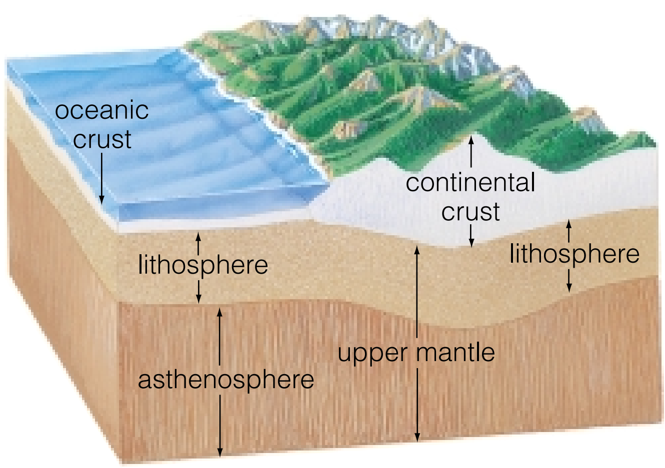
$$E = mc^2$$

This equation is one of the most famous mathematical models in all of science. It is part of Einstein's theory of relativity. The theory proposes that matter can be converted into energy. The equation allows you to calculate the amount of energy, E, that is produced when an amount of matter, m, is annihilated (made to disappear) and converted into energy. The c in the equation is the speed of light. Einstein's equation has been tested extensively and has never been shown to be incorrect.

Examples

An atom is too small to see, even with the most powerful microscope. Scientists have used a variety of techniques to learn about the atom. Bohr's atomic model, shown here, helped scientists describe what they had learned about the atom.





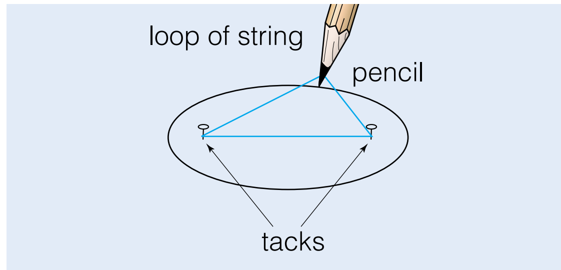
Scientists have used many techniques to probe Earth's internal structure. They have been able to create this model by combining results from many experiments and observations.

Instant Practice

Early astronomers believed that the paths, or orbits, travelled by planets were circles. However, many astronomical observations could not be explained by supposing that orbits were circular. In order to explain these observations, the famous astronomer Johannes Kepler reasoned that the orbits were ellipses. With this knowledge, you can construct a model that simulates the planetary orbits. Start by constructing a circle and then use a similar method to construct ellipses.

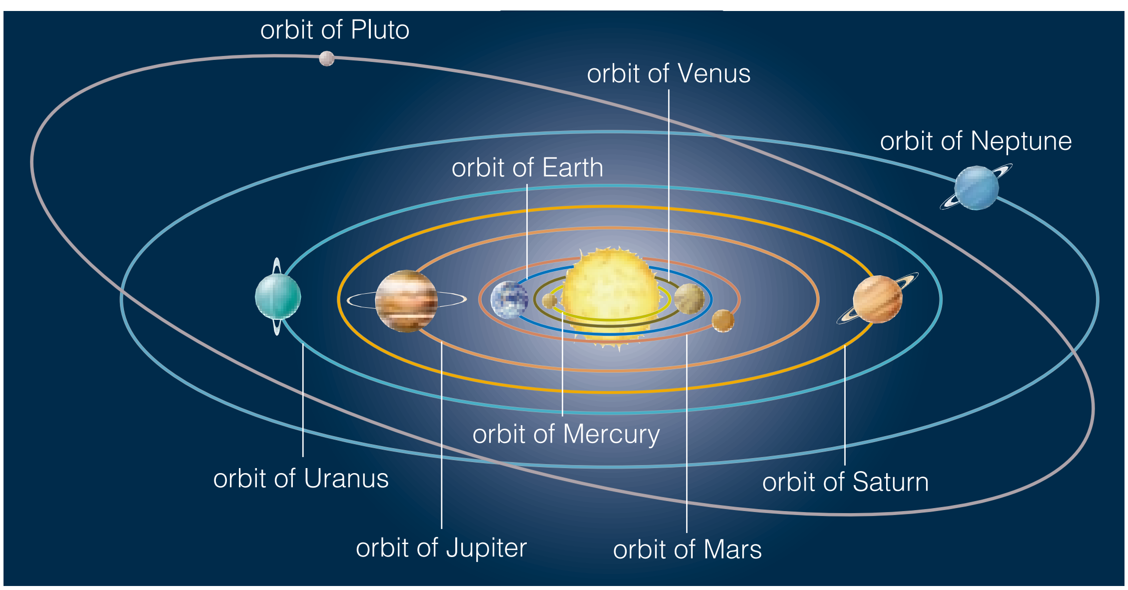
You will need two thumbtacks, a 25 cm length of string, pencil, paper, ruler, and cardboard. If possible, use a cork board under your cardboard. Carry out the following steps.

1. Tie the ends of the string together to form a loop.
2. Place a blank sheet of paper on the cardboard. Insert a thumbtack near the centre of the paper.
3. Loop the string around the thumbtack. If you have a cork board, push the thumbtack into the cork. If you do not have a cork board, have a partner hold the thumbtacks steady.
4. Put the tip of the pencil in the loop and pull it taut. Move the pencil around the thumbtack, keeping the string taut, until you have drawn a perfect circle.
5. Place a second thumbtack about 5 cm from the first one.
6. Loop the string around both thumbtacks.
7. Put the tip of the pencil in the loop and pull the string taut, as shown in the diagram.



8. Move the pencil all the way around the thumbtacks, keeping the string taut.

   You have just drawn an ellipse. Any closed, smooth curve drawn in this manner is an ellipse. To accurately model Earth's orbit, the two thumbtacks would have to be very close together. To model the orbit of a comet, the thumbtacks would have to be very far apart. (Earth's orbit is only slightly elliptical. The orbit of a comet is much more elliptical.)
9. Use what you have just learned to construct a model of Earth's orbit.
10. Use the information above to construct a model of a comet's orbit.



The orbits of the planets around the Sun are elliptical (drawing is not to scale).

USING A MICROSCOPE

Part 1 Parts of a Microscope

The **light microscope** is an optical instrument that greatly increases our powers of observation by magnifying objects that are usually too small to be seen with the unaided eye. The microscope you will use is called a compound light microscope because it uses a series of lenses (rather than only one as in a magnifying glass) and it uses light to view the object. A microscope is a delicate instrument, so proper procedure and care must be practised. This *Skillfocus* reviews the skills that you will need to use a microscope effectively. Before you use your microscope, you need to know the parts of a microscope and their functions. Do the *Instant Practice* below to familiarize yourself with your microscope.

Instant Practice

1. Study the photograph of the compound light microscope. Learn the names and functions of the parts of the microscope.
2. Before you go any further, close your book and draw and label as many parts of a microscope as you can.
3. Explain to a classmate the function of each part.

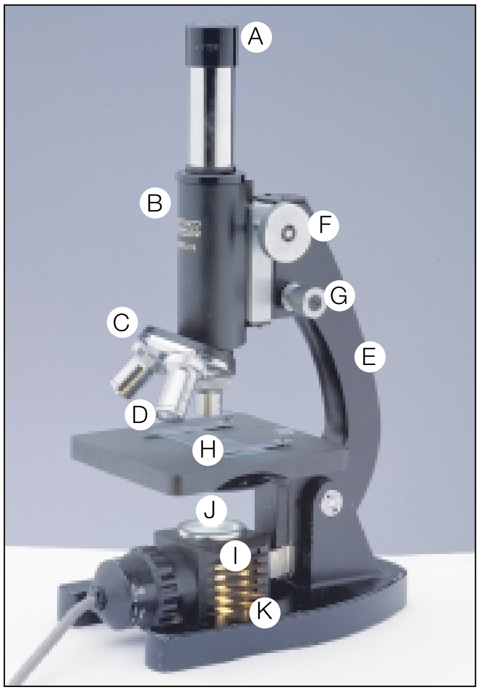
A. Eyepiece (or ocular lens)
You look through this part. It has a lens that magnifies the object, usually by 10 times (10×). The magnifying power is engraved on the side of the eyepiece.

B. Tube
Holds the eyepiece and the objective lenses at the proper working distance from each other.

C. Revolving nosepiece
Rotating disk holds two or more objective lenses. Turn it to change lenses. Each lens clicks into place.

D. Objective lenses
Magnify the object. Each lens has a different power of magnification, such as 4×, 10×, 40×. (Your microscope may instead have 10×, 40×, and 100× objective lenses). For convenience, the objective lenses are referred to as low, medium, and high power. The magnifying power is engraved on the side of each objective lens. Be sure you can identify each lens.

E. Arm
Connects the base and the tube. Use the arm for carrying the microscope.



K. Light source
Shining a light through the object being viewed makes it easier to see the details. Your microscope might have a mirror instead of a light. If it does, it must be adjusted to direct the light source through the lenses. CAUTION: Use an electric light, not sunlight, as the light source for focussing your mirror.

F. Coarse-adjustment knob
Moves the tube up and down to bring the object into focus. Use it only with the low-power objective lens.

G. Fine-adjustment knob
Use with medium- and high-power magnification to bring the object into sharper focus.

H. Stage
Supports the microscope slide. Stage clips hold the slide in position. An opening in the centre of the stage allows light from the light source to pass through the slide.

I. Condenser lens
Directs light to the object being viewed.

J. Diaphragm
Controls the amount of light reaching the object being viewed.

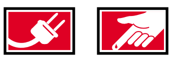
Part 2 Now, practise!

You are now ready to practise proper use of your microscope to view an object. In this activity, you will also practise calculating magnification and the **field of view** — the size of the area that can be seen using your microscope. By doing these calculations, you will be able to estimate the actual size of the objects you have magnified using the microscope.

What You Need

microscope, lens paper, prepared microscope slide, plastic ruler

Safety Precautions



- Be sure your hands are dry when you plug in or disconnect the cord of the microscope.
- Handle microscope slides carefully so that they do not break or cause cuts or scratches.

What to Do

1. Obtain a microscope and carry it to your work area. Use both hands to carry the microscope upright and support it properly. One hand should hold the arm of the microscope firmly and the other should support the base.
   - **(a)** Do not turn any knobs until you have read through the rest of this procedure.
   - **(b)** If the microscope has an electric cord for the light source, make sure the cord is properly connected and plugged in.
   - **(c)** Use lens paper to clean the lenses and the light source (or mirror). Do not touch the lenses with your fingers.
2. The microscope should always be left with the low-power objective lens in position. If it is not, rotate the revolving nosepiece until the low-power objective lens clicks into place, as shown in the photograph.
   - **(a)** Use the coarse-adjustment knob to lower the objective lens until the lens is about 1 cm above the stage.
   - **(b)** Look through the eyepiece (ocular lens) and adjust the diaphragm until the view is as bright as you can get it.

When you rotate the nosepiece on a microscope, watch from the side to make sure the objective lenses do not hit the slide. The medium- and high-power objective lenses are long enough to touch the slide if they are lowered too much. Therefore, *only* the fine-adjustment knob is used when observing specimens under these lenses.

3. Place a prepared slide on the stage. Make sure the object to be viewed is centred over the opening.
   - **(a)** Look through the eyepiece and slowly turn the coarse-adjustment knob until the object is in focus.
   - **(b)** Use the fine-adjustment knob to sharpen the focus.
4. View the object under higher magnification. **CAUTION**: Do not use the coarse-adjustment knob with the medium- or high-power objective lens.
   - **(a)** Watch from the side and rotate the revolving nosepiece to the medium-power objective lens. Do not change the focus first.
   - **(b)** After the medium-power objective lens has clicked into place, adjust the focus using only the fine-adjustment knob.
   - **(c)** Next, the object may be viewed under the high-power objective lens. Rotate the nosepiece (while watching from the side) until it clicks into place. Focus only with the fine-adjustment knob.

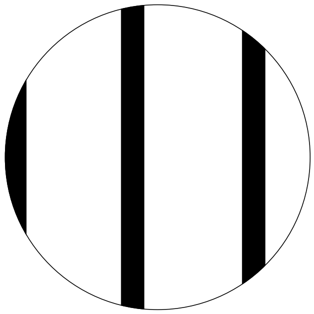
(d) When you have finished viewing the object, remove the slide and return it to the proper container before proceeding to step 5.

(e) If you do not continue to step 5, carefully unplug the microscope, click the low-power objective lens in place, and return the microscope to its storage area.

5. To calculate the total magnification of the object on your slide, multiply the number on the eyepiece by the number on the objective lens. For example, a 10× eyepiece and a 4× objective lens give a total magnification of 40×.

6. You are now ready to calculate the size of the field of view. Set your microscope to the low-power objective and place a clear plastic ruler on the stage.

7. Focus on the ruler and position it so that one of the centimetre markings is at the left edge of the field of view.



The diameter of the field of view under low power illustrated here is 2.5 mm.

8. Measure and record the diameter of the field of view in millimetres (mm). If the field of view is 2.5 mm in diameter, then an object that occupies about half the field of view would be about 1.25 mm in diameter.

9. Millimetre markings are too far apart to permit direct measurement of the field of view for lenses with magnifications higher than 10×. However, if you know the diameter of the field of view for the low-power lens, you can calculate the field of view for the other lenses. Before doing so, unplug the microscope by pulling out the plug. **CAUTION**: Never tug on the electrical cord to unplug it. Use the following formula to calculate the field of view for the medium-power objective lens:

$$\text{Medium-power field of view} = \text{Low-power field of view} \times \frac{\text{Magnification of low-power objective lens}}{\text{Magnification of medium-power objective lens}}$$

Troubleshooting

You may encounter difficulties when using your microscope. The following list details the more common problems and how you can deal with them.

- *You cannot see anything.* Make sure the microscope is plugged in and the light is on. If the microscope has no light, adjust your mirror.
- *Are you having trouble finding anything on the slide?* Be patient. Follow all of the steps outlined in this procedure from the beginning and make sure the object being viewed is in the middle of the stage opening. While watching from the side, lower the low-power objective as far as it will go. Then look through the ocular lens and slowly raise the objective lens using the coarse-adjustment knob.
- *Are you having trouble focussing, or is the image very faint?* Try closing the diaphragm slightly. Some objects that you will examine are almost transparent. If there is too much light, a specimen may be difficult to see or will appear "washed out."
- *Do you see lines and specks floating across the slide?* These are probably structures in the fluid of your eyeball that you see when you move your eyes. Do not worry; this is normal.
- *Do you see a double image?* Check that the objective lens is properly clicked into place.
- *Do you close one eye while you look through the microscope with the other eye?* You might try keeping both eyes open. This will help prevent eye fatigue. It also lets you sketch an object while you are looking at it.
- Always place the part of the slide you are interested in at the centre of the field of view before changing to a higher-power objective lens. When you turn to medium and high power, you otherwise may not see the object you were viewing under low power. Why not?

If, for example, your low-power objective lens is a 4× lens with a field of view of 4 mm, and your medium-power objective lens is a 10× lens, then the field of view for the medium-power lens would be:

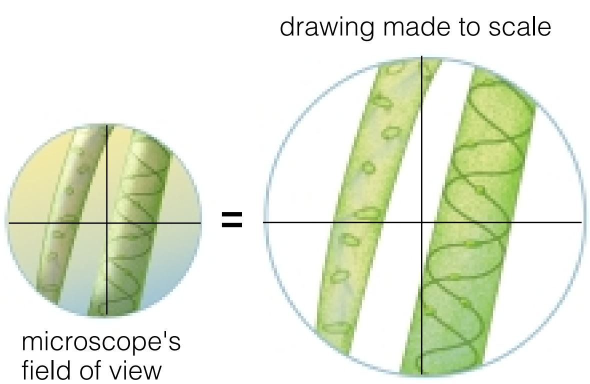
$$\text{Medium-power field of view} = 4\text{ mm} \times \frac{4}{10}$$
$$= 4\text{ mm} \times 0.4$$
$$= 1.6\text{ mm}$$

Do a similar calculation to determine your high-power field of view. Record the value.

Instant Practice

A scale drawing is a drawing in which you keep constant the proportions of what you see through the microscope. This is important because it allows you to compare the sizes of different objects and helps you form an idea of the actual size of an object. Also, a scale drawing makes it easier to explain what you see to someone else. Do the following to make a scale drawing.

1. Draw a circle (the size does not matter) in your notebook. The circle represents the microscope's field of view.
2. Imagine that the circle is divided into four equal sections (see the diagram below). Use a pencil and a ruler to draw these sections in your circle, as shown below.



3. Using low or medium power, locate a sample from the prepared slide that interests you. Imagine that the field of view is also divided into four equal sections.
4. Note in what part of the field of view the object lies and how much of the field of view the object occupies.
5. Draw the object in the circle. Position it so that it is in the same part of the circle as it appears in the field of view. Draw the object to scale. This means that it should take up the same proportion of space on the circle as it does in the field of view.
6. Label your drawing.
7. Estimate the size of the object in your drawing.

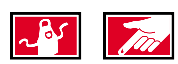
Part 3 Preparing A Wet Mount

Now that you have learned how to use a microscope properly, you are ready to prepare and view slides of your own, using a variety of materials.

What You Need

microscope, microscope slides, cover slips, medicine dropper, tweezers
small piece of newspaper, tap water, other samples, lens paper

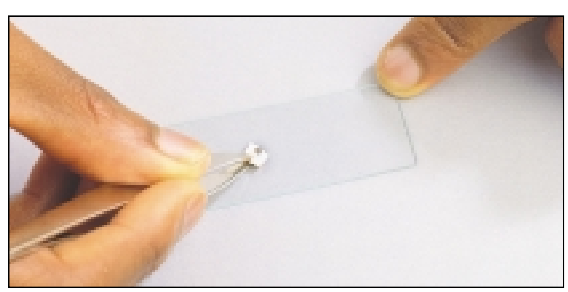
Safety Precautions



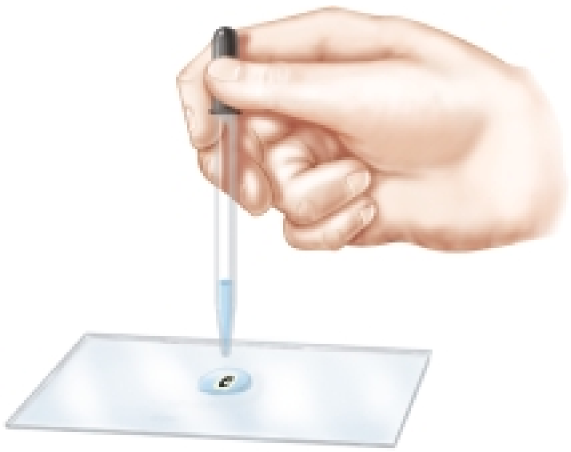
- Be careful when using sharp objects such as tweezers.
- Handle microscope slides and cover slips carefully so that they do not break and cause cuts or scratches.

What to Do

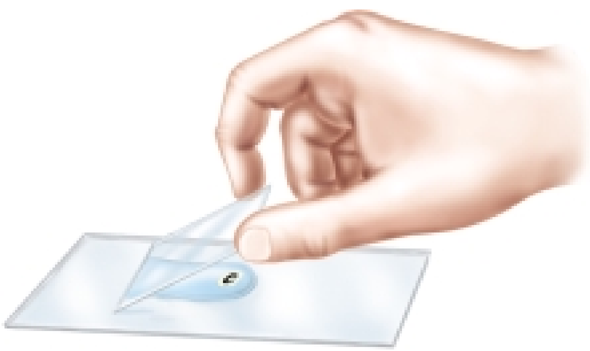
1. To prepare a wet mount, begin with a clean slide and cover slip. Wash the slide and cover slip with water and dry them carefully with lens paper. **CAUTION**: The cover slip is very thin. It is safest to dry both of its surfaces at the same time by holding the lens paper between your thumb and forefinger. Once cleaned, hold the slide and cover slip by their edges to avoid getting fingerprints on their surfaces.
2. Tear out a small piece of newspaper containing a single letter. Use an *e*, *f*, *g*, *s*, or *h*. Pick up the letter with the tweezers and place it in the centre of the slide.



3. Use the medicine dropper to place a very small drop of tap water on the newspaper sample. Then, hold a cover slip gently by its edges and place it at an angle of 45° on the surface of the slide near the edge of the newspaper sample.



4. Slowly and carefully lower the cover slip over the sample. Make sure there are no air bubbles trapped underneath the cover slip. This type of sample preparation is called a wet mount.



5. Set your microscope on the low-power objective lens. Place the slide on the microscope stage and centre the sample over the opening in the stage.
   - **(a)** Look through the eyepiece and move the slide until you can see the letter. Adjust the coarse-adjustment knob until the letter is in focus.
   - **(b)** Move the slide until you can see the torn edge of the newspaper. Slowly turn the fine-adjustment knob about one-eighth turn either way. Do you see the whole view in sharp focus at one time?
6. View the letter under the medium-power objective lens. Remember to observe from the side while you rotate the nosepiece into position. Use only the fine-adjustment knob to focus.
7. Examine the letter and note that it is made up of many small dots. To reveal the structure of small objects, the microscope must do more than magnify. It must also reveal detail. The capacity to distinguish detail is called resolution, and the measure of resolution is known as resolving power. The resolving power of a microscope is defined as the minimum distance two objects can be apart and still be seen as separate objects.

Instant Practice

1. Before rotating the nosepiece to a higher magnification, it is best to have the object you are examining at the centre of the field of view. Why?
2. To view a letter torn out of a newspaper (such as e) through the microscope the right way up, how would you position the slide on the stage?
3. The letters in a newspaper are composed of numerous small dots. How do you think newspapers produce colour photographs? Prepare a wet mount using a piece of a colour print from a newspaper and find out how the colour print is composed.
4. Prepare and examine microscope slides of different samples of materials, such as strands of hair, cotton, Velcro™, and grains of salt or sand. Obtain your teacher's approval of the material you select.

Troubleshooting

- *Do you see round or oval shapes on the slide?* These are likely to be air bubbles. Move the cover slip gently with your finger to get rid of them, or study another area of the slide.
- *Do you see a straight line?* This could be the edge of your cover slip.

CONNECTING AND READING AMMETERS AND VOLTMETERS

Meters in a Circuit

An **ammeter** is an instrument used to measure the electric current flowing through a component (for example, a light bulb) in a circuit. A **voltmeter** is an instrument used to measure the electric potential difference between two points in a circuit (for example, across a light bulb or across a battery). Figure 1 shows a simple circuit containing a battery, a switch, a light bulb, an ammeter to measure the current flowing through the light bulb, and a voltmeter to measure the potential difference across it.

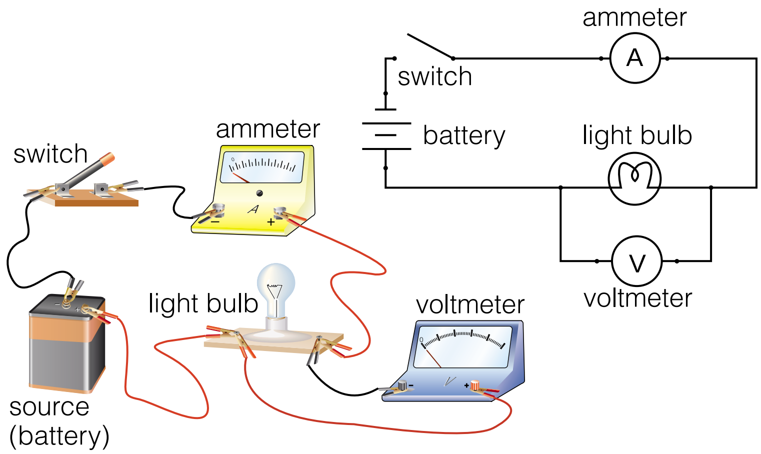


Figure 1 To measure the current flowing through the light bulb, the ammeter must be connected in series with the light bulb. To measure the potential difference across the light bulb, the voltmeter must be connected in parallel with the light bulb.

Polarity of the Meters

Both ammeters and voltmeters have two terminals that must be connected to the circuit. The negative terminal (–) is black and the positive terminal (+) is red. The electrons must enter any meter at the negative terminal and exit from the positive terminal to prevent damage to the meter. Since electrons leave the negative terminal of the source, the negative terminal of a meter must be connected to the negative terminal of the source. As well, the positive terminal of a meter must be connected to the positive terminal of the source. However, there may be other circuit elements between the source and the meter. If you trace the connecting wires in Figure 1 you will see that they are connected correctly.

Connecting an Ammeter

Because electric current is measured at a point, all of the current must pass through the ammeter at that point. When connecting an ammeter to a circuit, open the circuit by disconnecting a wire at the point at which you wish to measure the current. Then connect the ammeter so that the electrons will enter at the negative terminal and leave at the positive terminal. You will usually need one additional connecting wire to connect an ammeter to a circuit. Figure 2 shows a circuit that has been disconnected and an ammeter that is about to be added to the circuit in series with the light bulb.

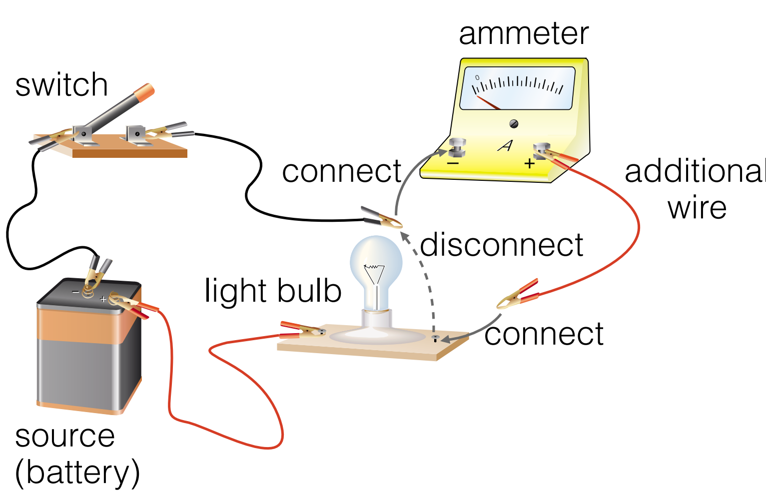


Figure 2 Connecting an ammeter to a circuit.

Connecting a Voltmeter

Because potential difference is measured between two points in a circuit, the terminals of the voltmeter must be connected at these two points. You do not need to open a circuit to connect a voltmeter. Using two additional wires, connect the terminals of the voltmeter on opposite sides of the component across which you want to measure the potential difference. Be sure that the negative terminal of the voltmeter is connected to the negative terminal of the source, and that the positive terminal of the voltmeter is connected to the positive terminal of the source. Figure 3 shows a circuit with an open switch and a voltmeter about to be connected in parallel with the light bulb.

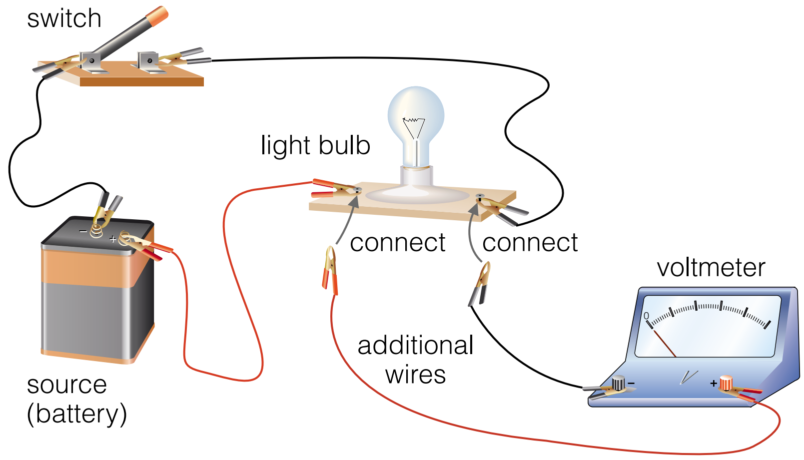


Figure 3 Connecting a voltmeter to a circuit

Reading Meters

Voltmeters and ammeters come in a wide variety of sizes and shapes. Some meters display values directly as numbers, as shown in Figure 4A. Other meters display results with a needle pointing to numbers on a dial, as shown in Figure 4B.

Figure 4A Meters that display numerical values directly are called digital meters.

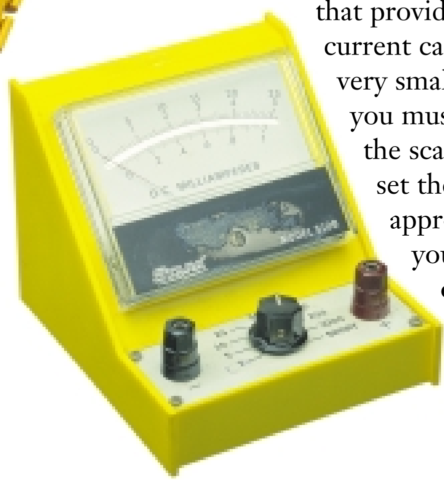


Figure 4B Meters that have needles pointing to a dial are called analog meters.

When looking at the digitial meter in Figure 4A, you might wonder why there are three sets of numbers on the dial. The numbers represent different scales of measurement. For example, one scale might report values of potential difference between zero and 2.5 V, while another scale will report values between zero and 10 V. Several different scales are needed because meters have electric circuits inside that allow them to measure different levels of current or voltage accurately. For example, a circuit that provides an accurate measurement of a large current cannot give an accurate measurement of a very small current. Therefore, when using meters, you must select the appropriate circuit by setting the scale on the meter. The best approach is to set the meter at the largest scale to get an approximate value. Then lower the scale until you have the highest possible reading without going off the scale.

Figure 5, on the next page, illustrates meters that have two different ways to change the scale. The meter in Figure 5A is a voltmeter with a dial that you can set at a particular value. In the figure, the dial is set at 10.

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

Figure 5B shows an ammeter with six different ranges of current. To change the scale on this meter, you choose among six positive terminals. In the example, the circuit wire is connected to the 500 mA terminal. Remember that mA represents milliamperes or thousandths of an ampere. So 500 mA is the same as 0.500 A. The "5" on the bottom scale is the first digit in 500 mA, so the 5 now represents 500 mA. The needle is pointing to 4.7, so the meter is reporting 470 mA of current.

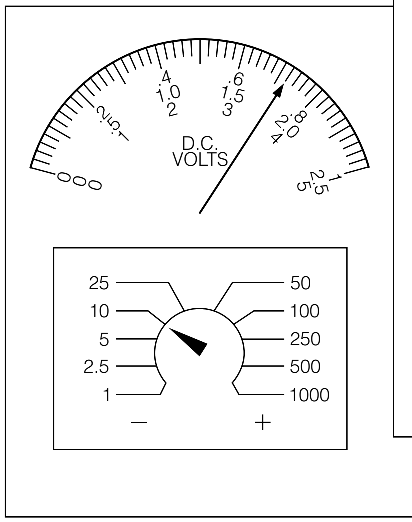


Figure 5A This voltmeter has a dial that changes the scale.

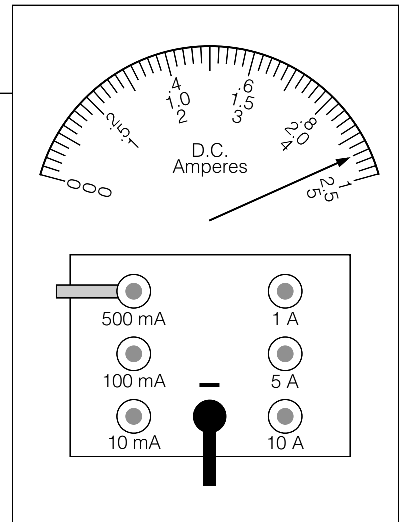


Figure 5B This ammeter has different positions in which to plug the positive lead.

Instant Practice

Determine the values of current or potential difference indicated by the meters in Figures 6A, B, C, and D.

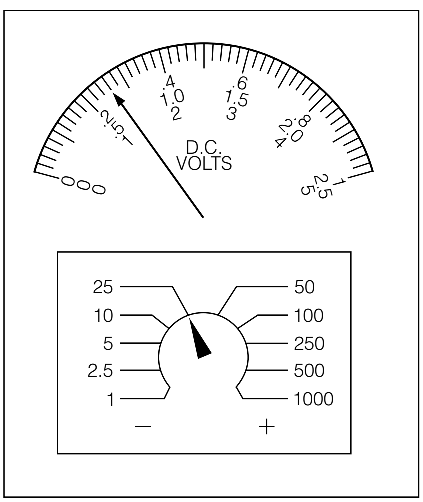


Figure 6A

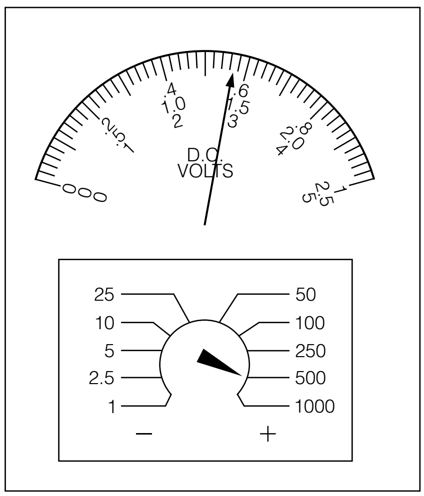


Figure 6B

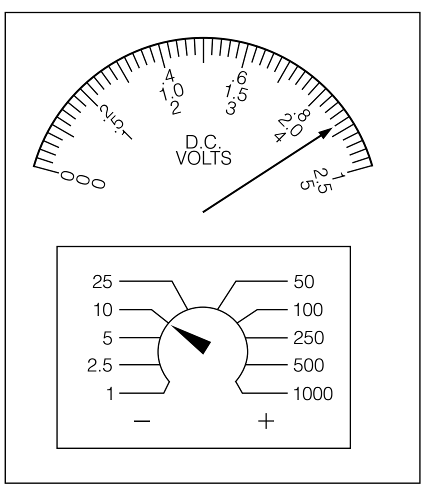


Figure 6C

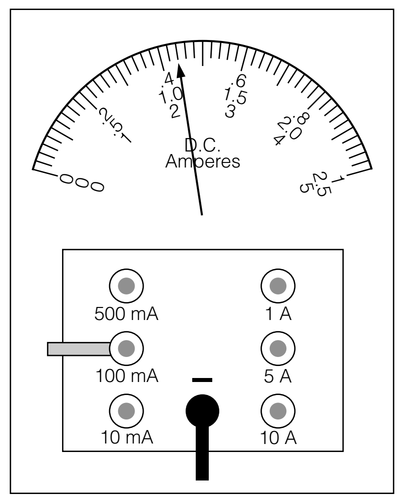


Figure 6D