Science Skills Guide

Safety

Safety Symbols

The following safety symbols are used in *Discovering Science 9* to alert you to possible dangers. Be sure you understand each symbol used in an activity or investigation before you begin.

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

Instant Practice—Safety Symbols

Describe the safety symbols you might see in the following areas and why they would be there:

- technical arts room
- home economics room
- cafeteria
- your kitchen
- garage or storage shed

Scientific Inquiry, Problem Solving, and Decision Making

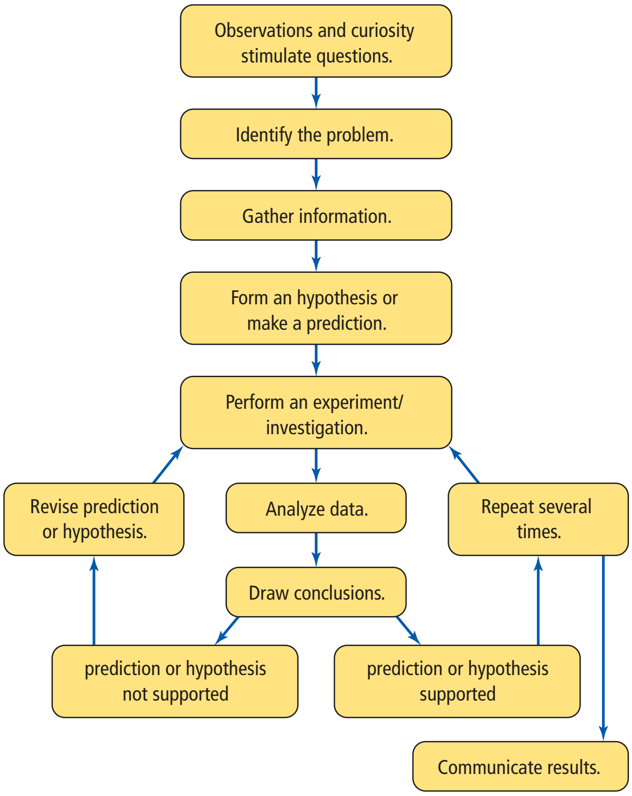
Some of the key skills you will use in this science course are scientific inquiry, problem solving, and decision making. However, answering questions in science, finding solutions to problems, and deciding on appropriate courses of action in different situations are not simple one-step tasks. Each of these skills is actually a multi-step process.

Here you will find models of suggested processes for each of these skills. The processes that have been outlined are not the only way to approach these skills. You may need to add, delete, or modify steps to fit the situation, or you may find that you are able to make improvements to these processes. Use these models as guidelines to get you started.

A Process for Scientific Inquiry

One model of the scientific inquiry process is shown in the concept map below.

A Process for Scientific Inquiry



The Language of Scientific Inquiry

You will need to understand several key terms to carry out scientific inquiry:

hypothesis – a statement about an idea that you can test, based on your observations. For example, "The type of nutrients supplied to a plant have an effect on its growth rate."

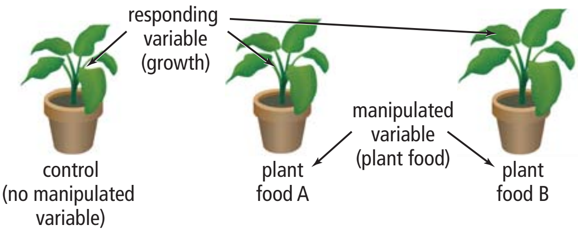
prediction – a forecast about what you expect to observe. For example, "A plant that is given food A will grow faster than a plant given food B."

variables – any factors that could affect the test being conducted. For example, temperature, amount of sunlight, amount of water, and amount/type of nutrients could all affect the growth rate of a plant.

manipulated/independent variable – the variable that you, as the experimenter, change (*i.e.*, the variable being tested). For the examples given above, the type of food—food A or food B—given to the plant is the manipulated/independent variable.

responding/dependent variable – the variable that you, as the experimenter, observe or measure to determine whether the manipulated/independent variable has had any effect. For the examples given above, the growth rate of the plant is the dependent/responding variable.

control – a test that you carry out with no manipulated/dependent variable. A control for the above examples might be a plant grown in a standard potting soil, without any added nutrients, while the experimental plants would have different types of nutrients—food A and food B added to this standard potting soil.



fair test – a valid and unbiased test, achieved by ensuring that there is only ONE manipulated/independent variable in the test. For example, if you want to conduct a fair test to determine whether nutrients have an effect on plant growth, you must ensure that all other variables are the same for all plants tested. You will need to start with identical plants and ensure that they receive the same amount of sunlight, are grown at the same temperature, and are watered identically. If you are testing the type of nutrients given, you will need to ensure that equal amounts of nutrients are given.

model – a mental picture, diagram, physical mock-up, working device, or mathematical expression that helps you to visualize or allows you to carry out your test. For example, you might draw a diagram that illustrates your setup for the experiment and details how you will ensure that all plants receive the same treatment for sunlight, water, and temperature.

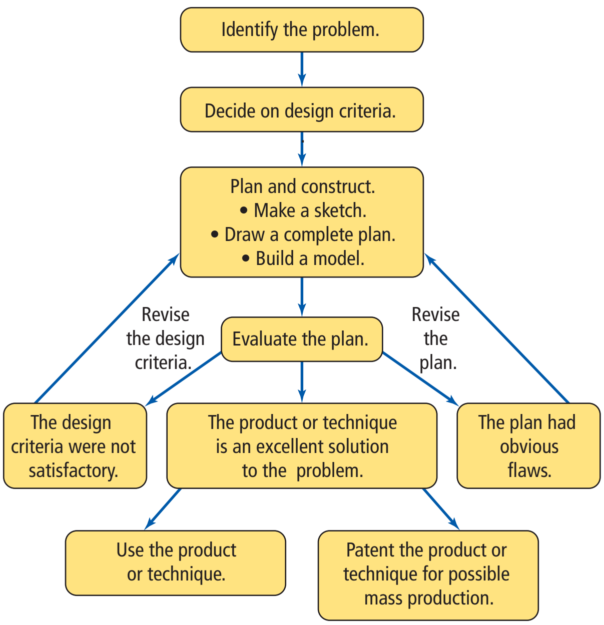
conclusion – a statement that indicates whether your results support or do not support your hypothesis. For example, if the plant given food B grew faster than the one given food A, you would conclude that your hypothesis—that the type of nutrients supplied to a plant affects its growth rate—was correct. However, you would conclude that your prediction—that food A would result in a higher growth rate—was incorrect.

theory – an explanation of an event that is supported by thorough testing and is therefore accepted by most scientists. For example, if there were consistent, reliable evidence to suggest that food B makes plants grow faster because it is needed for photosynthesis, this might become an accepted theory.

A Process for Technological Problem Solving

The following is a process for solving a technological problem, in which you must develop a technique or design and construct a product. How could you modify this model to apply to problem solving in general?

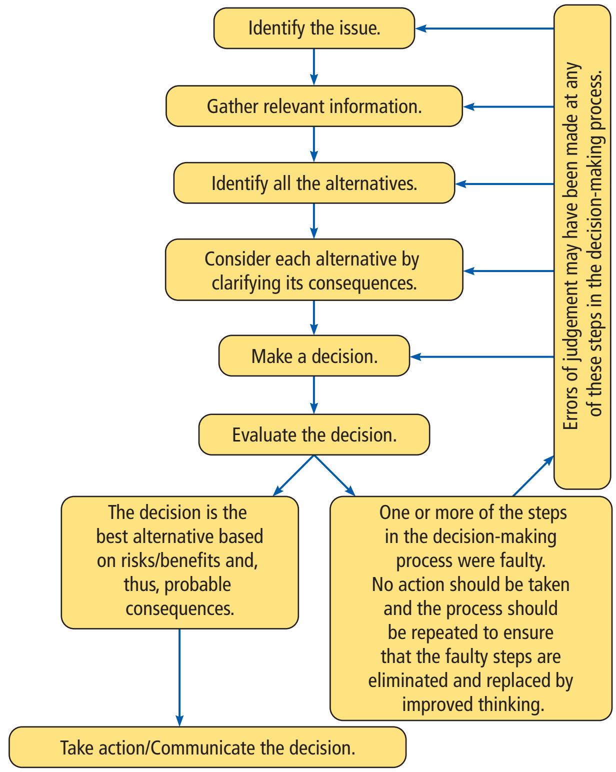
Solving a Technological Problem



A Process for Decision Making

As with scientific inquiry and technological problem solving, having a process to use for decision making helps you to focus your thinking and stay on track.

A Process for Decision Making



How to Do a Research-Based Project

Imagine if your teacher simply stated that he or she wanted you to complete a research-based project on endangered species. This is a really big topic, and it is now your job to decide which smaller aspect of the topic you will research. One way to approach a research project is to break it up into four stages—exploring, investigating, processing, and creating.

Explore—Pick a Topic and Ask Questions

You need to start by fi nding out some general things about endangered species. Make a list of questions as you conduct your initial research, such as, What factors cause species to become endangered? Why does it matter? What types of species are endangered? Suppose, in the course of your research, you decided to learn more about polar bears. A good research question about polar bears would be, Why are polar bears endangered? An even better question could be, What can I do to help prevent polar bear extinction? Both of these questions are deep and can be subdivided into many subtopics.

Investigate—Research Your Topic

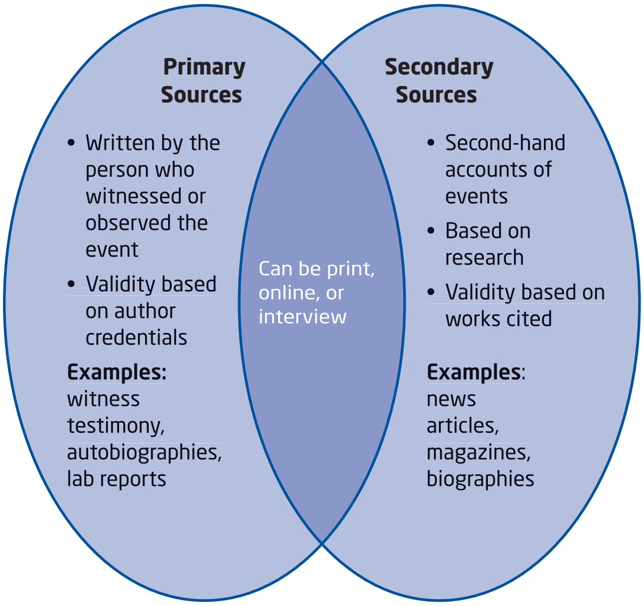
Sources of Information There are many sources of information. For example, you can use a print resource, such as an encyclopedia from the reference section of the library.

Another approach is to go on-line and check the Internet. When you use the Internet, be careful about which sites you choose to search for information. You need to be able to determine the validity of a website before you trust the information you find on it. To do this, check that the author is identified, a recent publication date is given, and the source of facts or quotations is identified. It is also important that the website is published by a well-known company or organization.

You may also want to contact an expert on your topic. A credible expert has credentials showing his or her expertise in an area. For example, an expert may be a doctor or have a master's degree. Alternatively, an expert could have many years of experience in a specific career or field of study.

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

You should also ask yourself if the sources you are using are primary or secondary.



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

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

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

Process—Ask More Questions and Revise Your Work

Now that you have done some research, what sub-questions have you asked? These are the subtopics of your research. Use the subtopics to find more specific information. If you find that you have two or three sub-questions that have a lot of research supporting them and a few that do not have much research, do not be afraid to "toss out" some of the less important questions or ideas.

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

Recording Source Information Research papers always include a bibliography—a list of relevant information sources the authors consulted while preparing them. Bibliographic entries give the author, title, and facts of publication for each information source. Ask your teacher how you should prepare your list of works cited.

Create—Present Your Work

Before you choose a format for your final project, consider whether your researched information has answered the question you originally asked. If you have not answered this question, you need to either refine your original question or do some more research! You also need to consider who the audience is for your project. How you format your final project will be very different if it is meant for a Grade 2 class compared to the president of a company or a government official. You could present your project as a computer slide presentation, a graphic novel, a video, or a research paper.

Instant Practice—Conducting Research

1. Describe the steps you should follow in preparing a project on the topic of renewable forms of energy.
2. The following example is not an effective question on which to base a research project: *How many moons does Jupiter have?* Modify the question to make it an effective research question.

Using Graphs in Science

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

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

Choosing the Right Graph for the Job

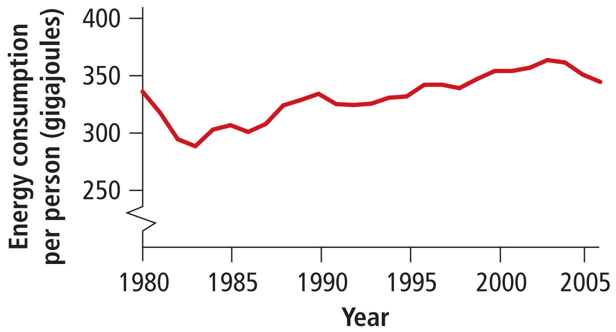
It is important to choose the appropriate type of graph to organize and communicate your data. Some guidelines are given below.

Line Graphs

A line graph is used to show the relationship between two variables. It shows how the responding/dependent variable is affected by changes in the manipulated/independent variable. The manipulated variable is usually shown on the *x*-axis, while the responding variable is shown on the *y*-axis.

Line graphs are useful for

- making comparisons between a large number of categories. For example, the graph below shows the annual energy usage per person from 1980 to 2006.



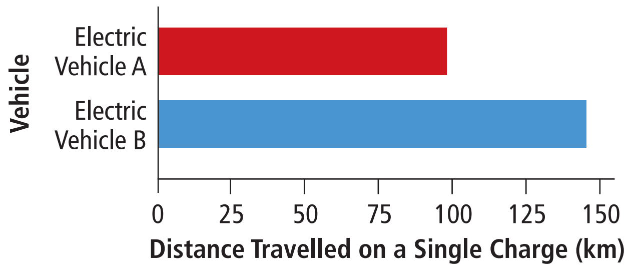
- showing how a variable changes over time.
- showing general trends in the relationship between variables. Does an increase in the manipulated/independent variable cause an increase or a decrease in the responding/dependent variable?
- finding the mathematical relationship between two variables. Rates and ratios can be calculated from a line graph by finding the slope of the line.

Bar Graphs

A bar graph is used to compare a numerical quantity with some other category at a glance. The second category may or may not be a numerical quantity. It could be places, items, organisms, or groups, for example.

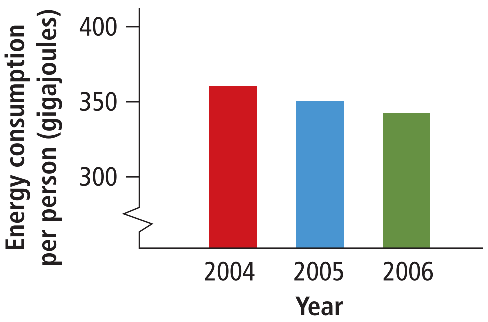
Bar graphs are useful for

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



- comparing a responding/dependent variable among discrete categories within a group, such as provinces in Canada, months in a year, or planets in the Solar System.
- reporting the results of surveys. For example, you might want to show how many people said "Yes" and how many said "No" to each question on a survey.

- showing annual changes. For example, you might use a bar graph to show how energy usage had changed from 2004 to 2006. (However, if you were comparing a large number of categories, such as annual energy use from 1980 to 2006, it would be better to use a line graph.)

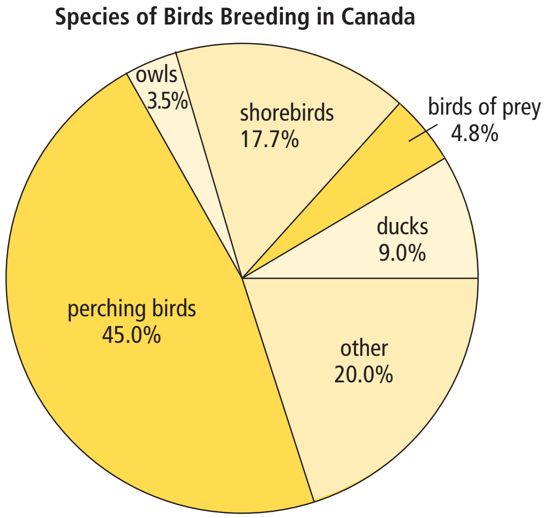


Circle Graphs

A circle graph (sometimes called a pie chart) uses a circle divided into sections (pieces of pie) to show the data. Each section represents a percentage of the whole. All sections together represent all (100%) of the data. A circle graph does not have axes.

Circle graphs are useful for

- quick visual comparisons of proportions between segments of a whole.



- showing, at a glance, the most common category within a fixed set of categories. It is easy to see from the graph above that perching birds are the most common category of the breeding birds sampled.

Limitations of circle graphs include the following:

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

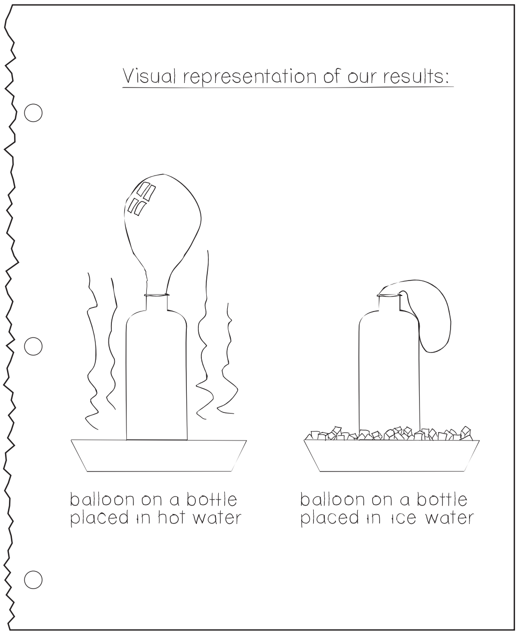
Instant Practice—Choosing Graph Types

1. What would be the best type(s) of graph to use for each purpose?
   (a) calculating the rate at which a chemical reaction takes place
   (b) comparing the gravitational pull of each of the planets in our Solar System
   (c) showing how production of hydroelectricity has changed from 1960 to today
   (d) comparing the amount of each chemical element present in a sample
   (e) showing the relationship between the age of a cell and the number of mutations in its DNA

Scientific Drawing

Have you ever used a drawing to explain something that was too difficult to explain in words? A clear drawing can often assist or replace words in a scientific explanation. 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.

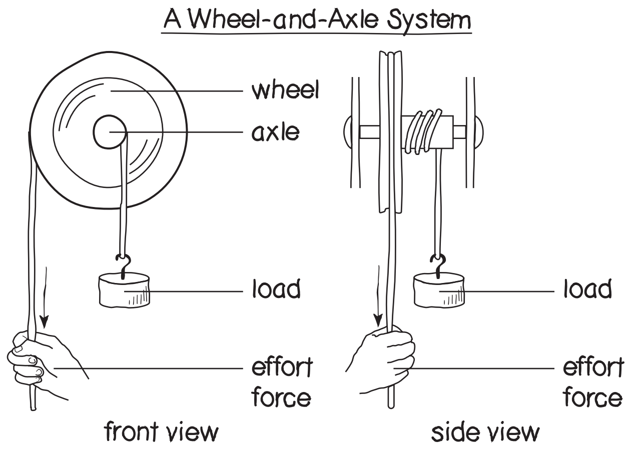
Examine the drawing shown below. It is taken from a student's lab report on an experiment to test the expansion of air in a balloon. The student's written description of results included an explanation of how the particle model can explain what happens to the balloon when the bottle is placed in hot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



Making a Scientific Drawing

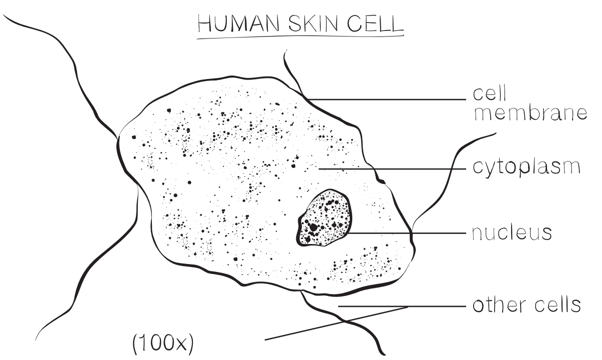
Follow these steps to make a good scientific drawing.

1. Use unlined paper and a sharp pencil with an eraser.
2. Give yourself plenty of space on the paper. You need to make sure that your drawing will be large enough to show all necessary details. You also need to allow space for labels. Labels identify parts of the object you are drawing. Place all of your labels to the right of your drawing, unless there are so many labels that your drawing looks cluttered.
3. Carefully study the object that you will be drawing. Make sure you know what you need to include.
4. Draw only what you see, and keep your drawing simple. Do not try to indicate parts of the object that are not visible from the angle you observed. If you think it is important to show another part of the object, do a second drawing, and indicate the angle from which each drawing is viewed.



5. Shading or colouring is not usually used in scientific drawings. If you want to indicate a darker area, you can use stippling (a series of dots). You can use double lines to indicate thick parts of the object.

6. If you do use colour, try to be as accurate as you can and choose colours that are as close as possible to the colours in the object you are observing.
7. Label your drawing carefully and completely, using lower-case (small) letters. Think about what you would need to know if you were looking at the object for the first time. Remember to place all your labels to the right of the drawing, if possible. Use a ruler to draw a horizontal line from the label to the part you are identifying. Make sure that none of your label lines cross.
8. Give your drawing a title. The drawing of a human skin cell shown below is from a student's notebook. This student used stippling to show darker areas, horizontal label lines for the cell parts viewed, and a title—all elements of an excellent final drawing.

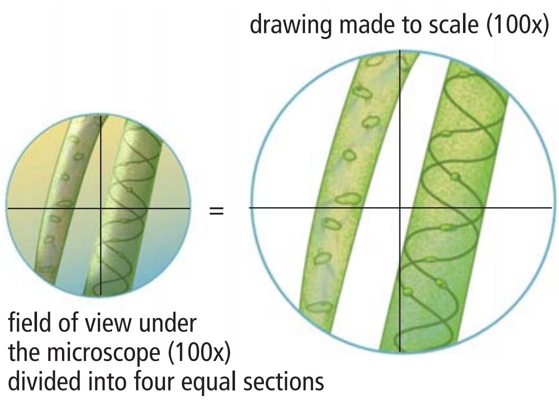


The stippling on this drawing of a human skin cell shows that some areas are darker than others.

Drawing to Scale

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

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



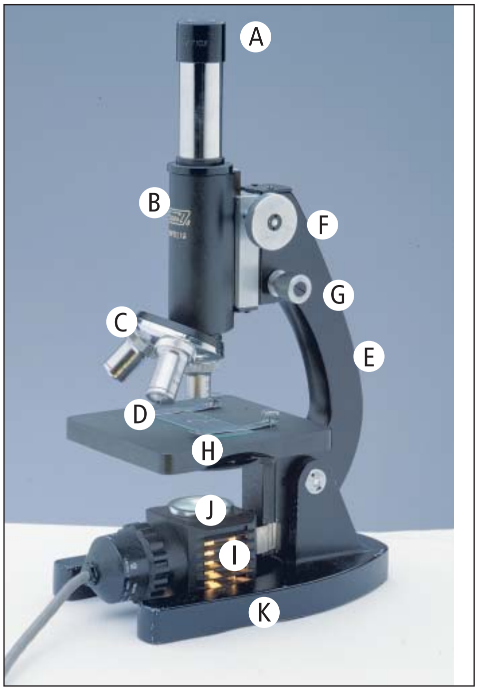
Instant Practice—Scale Drawings
Design a scale drawing of your bedroom, using the shape of the floor rather than a circle like the example given above. Include scale drawings of the furniture in your room. When you are finished, label the fire escape routes.

Using 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 you must use proper procedure and care. This *Science Skill* 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.

A. Eyepiece (or ocular lens)
You look through the eyepiece. 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
The tube holds the eyepiece and the objective lenses at the proper working distance from each other.

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

D. Objective lenses
The 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.) 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
The arm connects the base and the tube. Use the arm for carrying the microscope.

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

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

H. Stage
The 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
The condenser lens directs light to the object being viewed.

J. Diaphragm
The diaphragm controls the amount of light reaching the object being viewed.

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

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 turned on. If the microscope has no light, adjust your mirror.
- *Are you having trouble finding anything on the slide?* Be patient. 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 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. Otherwise, when you turn to medium and high power, you may not see the object you were viewing under low power.

Instant Practice—Applying Stains

A common problem when working with microscopic specimens is that it may be difficult to observe structures clearly. You can use various stains to colour the structures that you want to see. Common stains used for biological specimens are:

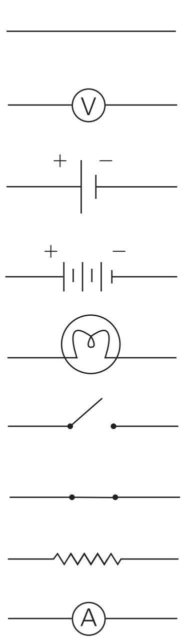
- Iodine—for staining starch
- Crystal violet—for staining bacterial cell walls
- Methylene blue—for observing nuclei in cheek cells

Suppose you want to observe the stages of mitosis in an onion root tip.

1. Slice off the root tips from a green onion, or from a yellow onion that has been allowed to grow in water for a few days.
2. Cut off the root tips and place them in a small amount of 1 M HCl for a few minutes to stop mitosis. **Warning:** HCl is a strong acid. Follow safety rules for working with acids.
3. Slice a very thin section of the onion root tip and place it on a microscope slide.
4. Add several drops of 1% toluidine blue to the root tip section. Leave the stain on for several minutes.
5. Blot off the extra stain with a paper towel. Add a few drops of water to the section to remove extra stain. Blot off. Repeat, if necessary. There should not be a lot of stain left on the section.
6. Add one drop of water. Place a cover slip, edge first, and lower it carefully over your specimen.
7. If the section is too thick, carefully apply gentle pressure to flatten the section.
8. Place the slide on your microscope, and use the low power for your first observation.

Using Electric Circuit Symbols and Meters

Circuit Diagram Symbols



Using Meters to Measure Voltage and Current

Types of Meters

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

The Terminals of a Meter

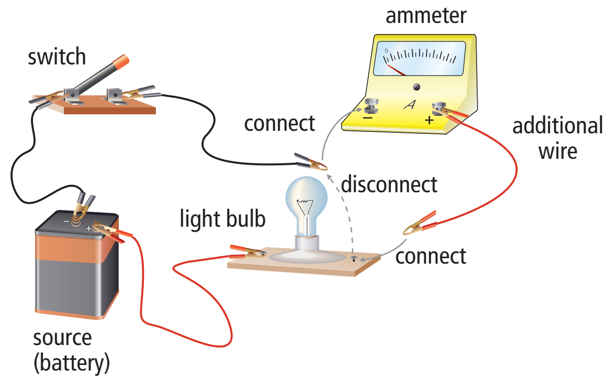
All meters have two terminals (connecting points) that you connect to the circuit. The negative terminal (−) is black. The positive terminal (+) is red. In a circuit, conventional current is defined as flowing from positive to negative. This means that current leaves the positive side of the battery or power supply and returns to the negative. In order not to damage the meter, you must take care to connect the meters so that the positive (red) terminal of the meter is connected to the positive side of the power source. That is, if you trace the current leaving the source it should enter the meter through its positive (+) terminal. The negative (−) terminal of the meter is always connected to the negative side of the source. The rule is "positive to positive, and negative to negative."

Connecting an Ammeter

An ammeter is used to measure the electric current in a circuit. Electric current is the amount of charge passing a given point per second. To measure the current at a given location in an electric circuit, the ammeter must be connected so that all the current is allowed to pass through the ammeter. To do this, you must disconnect the circuit at the location where you wish to measure the current. Then insert the ammeter so that current leaving the power source enters the positive (red) terminal of the ammeter and leaves from the negative (black) terminal.

A. Digital meters display the numerical values directly.

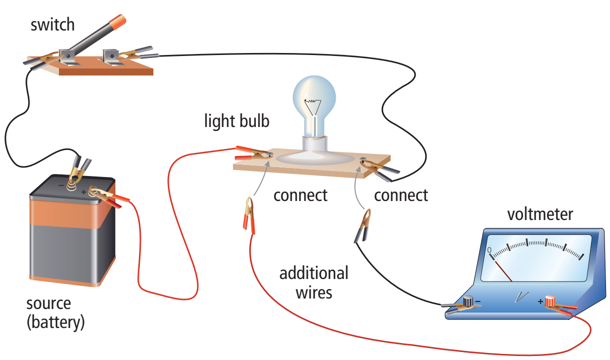
B. Analogue meters have a needle pointing to different scales.



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

Connecting a Voltmeter

A voltmeter is a device used to measure electric potential difference, or voltage as it is more commonly called. A voltage exists between two points in a circuit such as across a battery, light bulb, or resistor. When connecting a voltmeter to a circuit, you do not need to disconnect or open the circuit. Since voltage is measured between two points of potential difference in a circuit, you connect the terminals of the voltmeter at these two points. Two wires from the terminals of the voltmeter are connected to opposite sides of the component where you wish to measure the potential difference. Again, as with the ammeter, the positive terminal of the voltmeter is connected on the positive side of the power source and the negative terminal of the voltmeter is connected on the negative side of the source.



Voltmeters are connected across a component in the circuit.

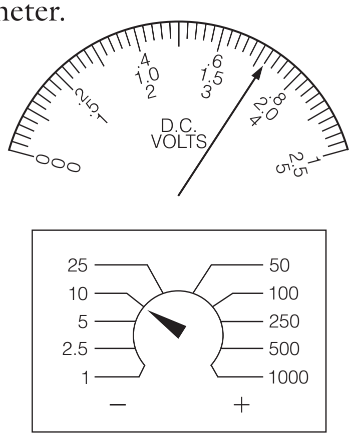
Connecting a Multimeter

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

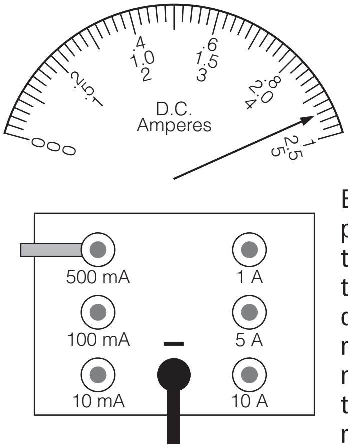
Reading a Meter

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

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



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

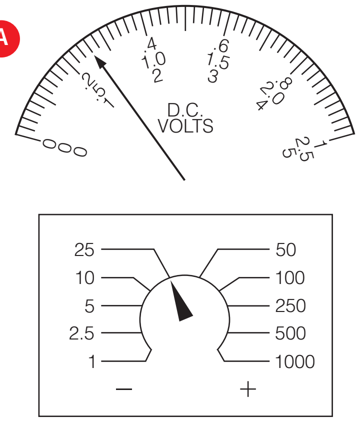


B. This ammeter has the positive wire connected to the 500 mA scale. The 5 on the bottom scale is the first digit in 500 mA, so the 5 now represents 500 mA. The needle is pointing to 4.7, so the meter is reporting 470 mA of current.

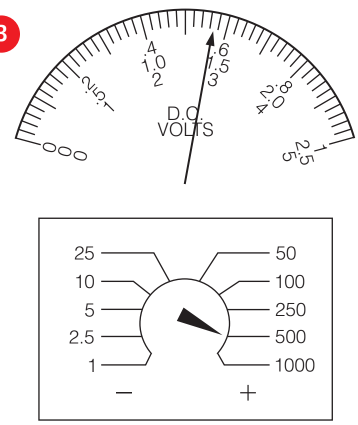
Instant Practice—Using Circuit Symbols and Electric Meters

1. Sketch the following circuit diagram symbols:
   (a) battery
   (b) light bulb
   (c) resistor
   (d) open switch
   (e) ammeter
   (f) voltmeter
2. State the colour that is associated with:
   (a) the positive terminal of a meter
   (b) the negative terminal of a meter
3. When you connect a meter to a circuit, to which side of the power source should you always connect the positive terminal of the meter?
4. For which type of meter do you need to disconnect the circuit before connecting the meter to the circuit?
5. A student wishes to use a meter to collect the most accurate measurement without damaging the meter. Describe the correct approach for choosing the appropriate scale.
6. Determine the value of current or voltage indicated by meters A to D in the next column.

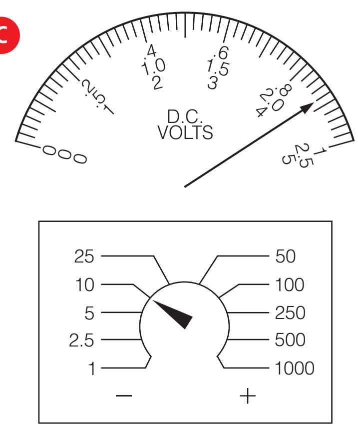
A



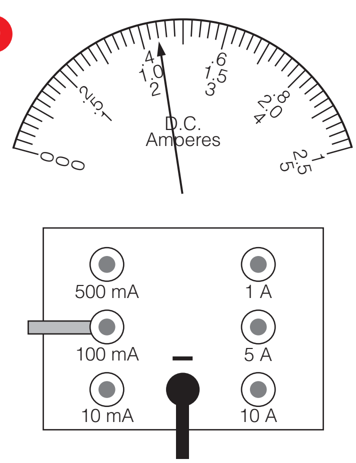
B



C



D

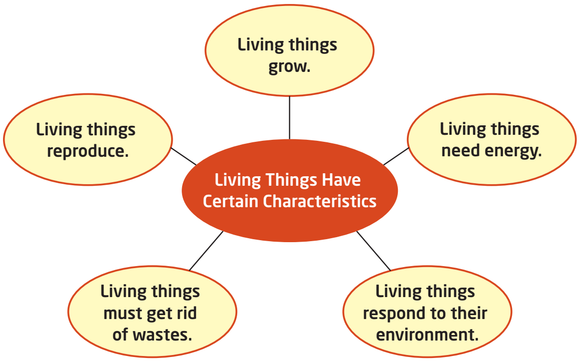


Organizing Your Learning: Using Graphic Organizers

When deciding which type of graphic organizer to use, consider your purpose: to brainstorm, to show relationships among ideas, to summarize a section of text, to record research notes, or to review what you have learned before writing a test. Several different graphic organizers are shown on these two pages.

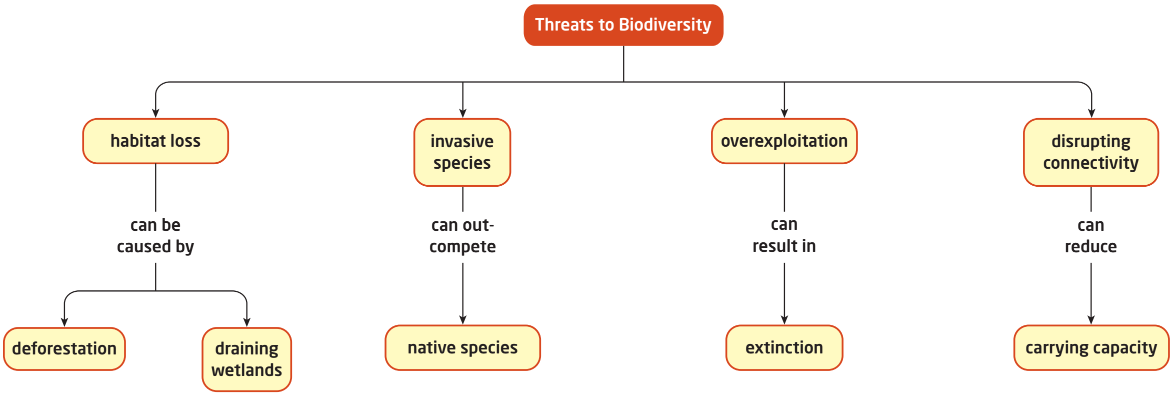
Main Idea Web

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



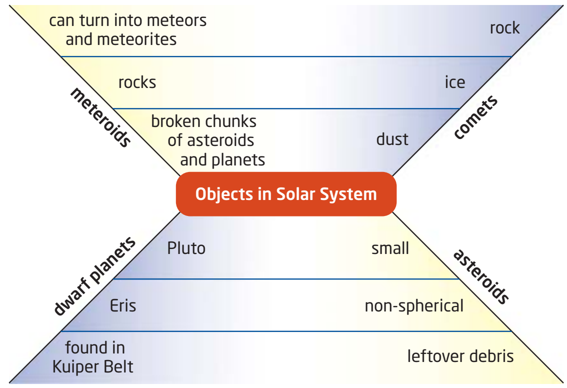
Concept Map

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



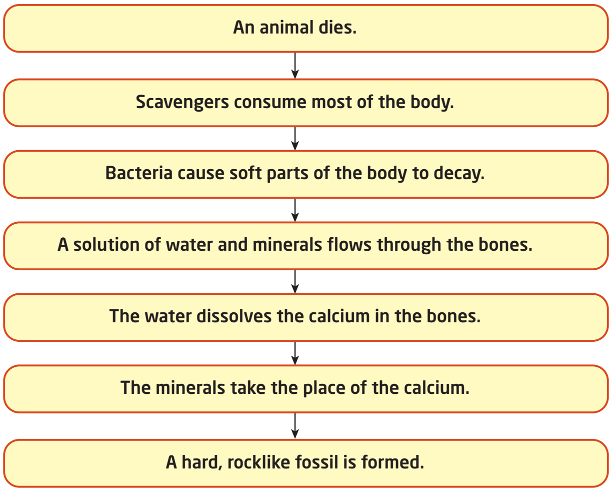
Spider Map

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



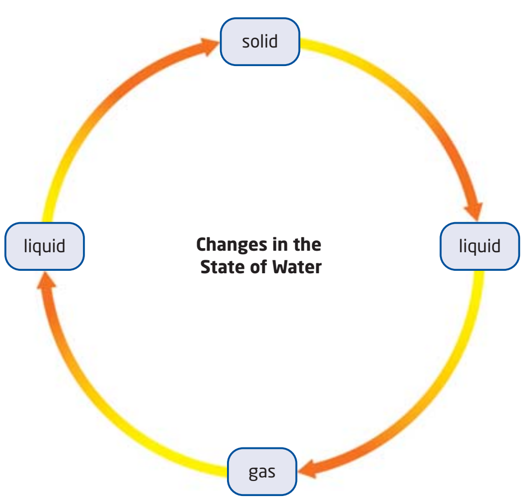
Flowchart

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



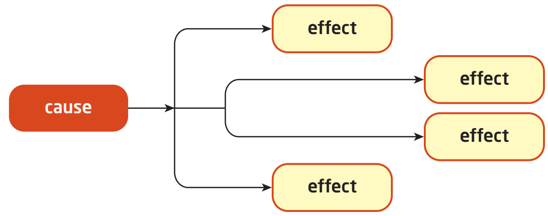
Cycle Chart

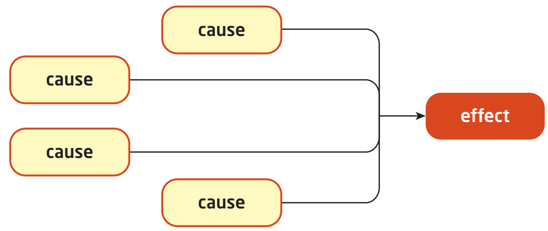
A *cycle chart* is a flowchart that has no distinct beginning or end. All the events are shown in the order in which they occur, as indicated by arrows, but there is no first or last event. Instead, the events occur again and again in a continuous cycle.



Cause-and-Effect Map

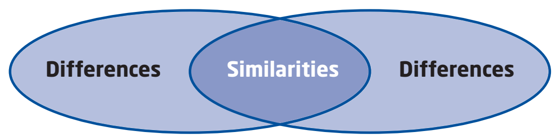
The first *cause-and-effect map* below shows one cause that results in several effects. The second map shows one effect that has several causes.

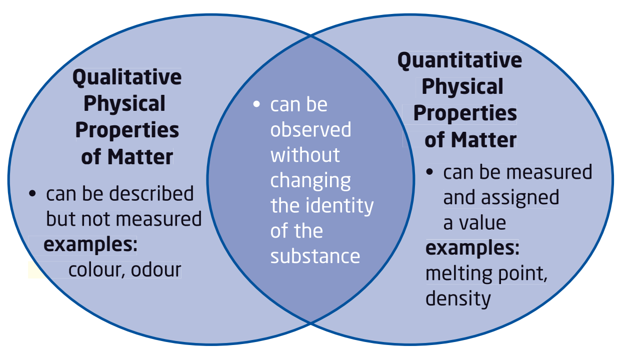




Venn Diagram

A Venn diagram uses overlapping shapes to show similarities and differences among concepts.





Instant Practice—Graphic Organizers

1. Create a Venn diagram that shows the similarities and differences between two of your favourite science topics.
2. Draw a spider map that reflects your prior knowledge about alternative energy sources.

Units of Measurement and Scientific Notation

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

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

The Metric System

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

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

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

The prefix "milli-" means divided by 1000. Thus, one millimetre is one-thousandth of a metre.

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

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

Commonly Used Metric Prefixes

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

Example 1

The distance from St. John's to Corner Brook is 422 km. Express this distance in metres.

Solution

$$\begin{aligned} 422 \text{ km} &= ? \text{ m} \\ 1 \text{ km} &= 1000 \text{ m} \\ 422 \text{ km} &= 422 \times 1000 \text{ m} \\ &= 422\ 000 \text{ m} \end{aligned}$$

Example 2

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

Solution

$$\begin{aligned} 1 \text{ kg} &= 1000 \text{ g} \\ 250 \text{ g} \times 4 &= 1000 \text{ g} \\ \frac{1000}{4} \text{ g} &= 250 \text{ g} \\ \frac{1}{4} \text{ kg} &= 0.25 \text{ kg} \end{aligned}$$

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

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

Instant Practice—Using Metric Measurements

1. A hummingbird has a mass of 3.5 g. Express its mass in mg.
2. For an experiment, you need to measure 350 mL of dilute acetic acid. Express the volume in L.
3. A bald eagle has a wingspan up to 2.3 m. Express the length in cm.
4. The heaviest blue whale ever recorded was a massive 190 tonnes. Express its mass in grams.
5. A student added 0.0025 L of food colouring to water. Express the volume in mL.

SI Units

In science classes, you will often be instructed to report your measurements and answers in SI units. The term SI is taken from the French name *Le Système international d'unités.* In SI, the unit of mass is the kilogram, the unit of length is the metre, the unit of time is the second, the unit of temperature is the kelvin, and the unit of electric current is the ampere. Nearly all other units are defined as combinations of these units.

Example 1

Convert 527 cm to SI units.

Solution

The SI unit of length is the metre.

1 m = 100 cm

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

Example 2

Convert 3.2 h to SI units.

Solution

The SI unit of time is the second.

1 min = 60 s; 1 h = 60 min

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

Instant Practice—Converting to SI Units

Convert the following quantities to SI units.

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

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	10^{-1}
hundredths	0.01	10^{-2}
thousandths	0.001	10^{-3}
ten-thousandths	0.0001	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 10 times larger than it actually is. To avoid mistakes when writing many zeros, scientists express very large and very small numbers in scientific notation.

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.

$= 5.8 \times 10\,000\,000$

$= 5.8 \times 10^7$

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

Example 2

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

Solution

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. Move the decimal point 11 places to the right. 0.000 000 000 053

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

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

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

Instant Practice—Scientific Notation

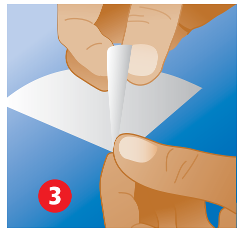
1. Express each of the following in scientific notation.
   (a) The approximate number of stars in our galaxy, the Milky Way: 400 000 000 000 stars
   (b) The approximate distance of the Andromeda Galaxy from Earth: 23 000 000 000 000 000 000 km
   (c) The estimated distance across the universe: 800 000 000 000 000 000 000 000 km
   (d) The approximate mass of a proton: 0.000 000 000 000 000 000 000 0017 g
2. Change the following to standard form.
   (a) 9.8×10^5 m
   (b) 2.3×10^9 kg
   (c) 5.5×10^{-5} L
   (d) 6.5×10^{-10} s

Using Chemistry Skills

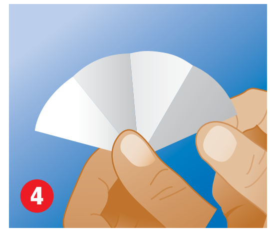
Folding a Round Filter Paper

1. Fold the piece of filter paper in half. Crease the fold very gently to avoid creating a weak spot that will tear.

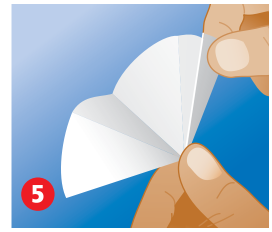
2. Fold the paper in half again to produce a quarter circle.



3. Fold the straight edge on one side back toward the centre fold. Do the same on the other side.



4. Open up the folds in the semi-circle so that the centre fold is facing away from you.

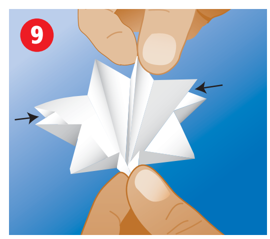


5. Fold the paper back and forth like an accordian. You will need to reverse the direction of your original centre fold.

6. Open up the folds into a fan shape.

7. Gently pull the folds open into a cone shape. You will see two sections that do not alternate folds as the others do.

8. Pinch in to create an additional fold in each of these sections.



9. All of the folds should now be alternating.

10. Finallly, place the filter paper into a funnel. Add a drop of water (or the liquid to be poured) to the centre of the paper to hold it in place before carefully pouring liquid through the funnel.

Note: If you are collecting the liquid, and disposing of the solid that is filtered out by the paper, you should turn your filter paper cone inside-out. You can invert the cone by pulling out gently on the edges of the paper. This will ensure that any dirt that has gotten onto the paper as you were folding will remain on the inside of the cone and will be filtered out of your sample. If you are collecting the solid rather than the liquid, this step is not necessary.

Creating Data Tables

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

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

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

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

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

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

Observations Made at Three Sample Stream Sites

headings show what is being recorded

columns and rows contain data

Sample Site	pH	Type of Organism	Number of Organisms
1		beetle	3
		snail	1
		dragonfly larva	8
2		beetle	6
		dragonfly larva	7
3		snail	5
		leech	1
		dragonfly larva	2

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

Instant Practice—Creating Data Tables

1. You are interested in how weeds grow in a garden. You decide to collect data from your garden every week for a month. You will identify the weeds and count how many there are of each type of weed. Design and draw a data table that you could use to record your data.

Glossary

How to Use This Glossary

This Glossary provides the definitions of the key terms that are shown in boldface type in the text. (Instructional boldfaced words such as "observe" and "explain" are not included.) The Glossary entries also show the sections where you can find the boldfaced words. A pronunciation guide, using the key below, appears in square brackets after selected words.

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

A

acetate [A-suh-taet] a type of plastic used in photographic film and overhead transparencies (7.1)

action-at-a-distance forces forces that can have an effect on an object without touching it (7.2)

adaptive optics optical design that uses an adaptable mirror or liquid crystal array to reduce image distortion, such as that caused by the atmosphere (12.3)

alkali metals Column 1 of the periodic table; include the metallic elements lithium, sodium, potassium, rubidium, cesium, and francium (2.2)

alkaline earth metals Column 2 of the periodic table; include the metallic beryllium, magnesium, calcium, strontium, barium, and radium (2.2)

amperes (A) unit for measuring electric current; very small currents are measured in milliamperes (mA); 1 A = 1000 mA (8.2)

asexual reproduction reproduction that requires only one parent and produces offspring that are genetic copies of the parent (5.2)

asterism a star pattern that is not a constellation; may consist of a small group of stars within a constellation or individual stars from different constellations (10.1)

asteroid one of many small rocky bodies in our solar system, most of which orbit the Sun between Mars and Jupiter (11.2)

astrolabe [A-struh-laeb] an ancient instrument used to locate and predict the positions of the Sun, Moon, planets, and stars (10.2)

astronomical unit (AU) a measurement equal to the average distance between the Sun and Earth, about 150 million km (11.2, 12.1)

atom the smallest particle of an element that retains the properties of that element (1.3, 7.1)

atomic mass the mass of an average atom of an element (2.2)

atomic number the number of protons in each atom of an element (2.2)

atomic theory an attempt to describe the nature of matter and explain how matter behaves (1.3)

aurora borealis/australis spectacular displays of light visible in the sky near the North and South Poles, respectively; caused by high energy particles in the solar wind entering Earth's atmosphere at the poles (11.1)

axis an imaginary line through Earth, extending from the North Pole to the South Pole; Earth spins on its axis at a speed of 1670 km/h, or 0.5 km/s (12.1)

B

battery a combination of electrochemical cells connected together (or a single electrochemical cell) that produces a potential difference (8.1)

best-fit line/line of best fit on a graph, a smooth curve (or straight line) that has the general shape outlined by plotted points; shows the trend of the data (8.3)

Big Bang theory the theory that proposes that the universe formed approximately 13.7 billion years ago when an unimaginably tiny volume of space suddenly and rapidly expanded to immense size (12.1)

binary fission [BIH-nae-ree FI-zhun] a form of asexual reproduction in which a single parent cell replicates its genetic material and divides into two equal parts (5.2)

black dwarf a stage in the life cycle of some stars; a dense, dark celestial body made up mostly of carbon and oxygen (12.2)

black hole a large sphere of incredibly tightly packed material with an extraordinary amount of gravitational pull created when a star collapses into itself; called "black" because nothing, not even light, can escape the powerful gravitational field (12.2)

Bohr-Rutherford diagram diagram of the atom that describes the arrangement of subatomic particles: neutrons and protons in the nucleus and electrons in electron shells (2.3)

boiling point the temperature at which a liquid changes into a gas (1.2)

budding a form of asexual reproduction; occurs when part of a cell pushes outward to form an outgrowth or bud that may or may not detach from the parent cell (5.2)

C

celestial body a natural object in space, such as the Sun, the Moon, a planet, or a star (10.1)

cell cycle the three stages of the life of a cell, which include interphase, mitosis, and cytokinesis (5.1)

cervix lower portion of the uterus; opening through which sperm pass as they enter the uterus; dilates to allow delivery of a baby (6.3)

charging by conduction process of transferring charge between objects by touching or rubbing (7.2)

charging by induction process of rearranging electrons on a neutral object by bringing a charged object close to it (7.2)

chemical bonds links between two or more atoms that hold the atoms together (3.1)

chemical change a change in matter in which chemical bonds are formed and broken and at least one new substance is produced (3.3)

chemical family groups of elements arranged in vertical columns in the periodic table that have similar physical and chemical properties (e.g., alkali metals, alkaline earth metals, halogens, noble gases) (2.2)

chemical formula symbols that show the elements in a compound and their ratios (3.2)

chemical name name of a compound that indicates the elements in it (3.2)

chemical properties characteristics that describe a substance's ability to react chemically with other substances to form new products (e.g., flammability) (1.2)

chemical symbol international symbol for each element consisting of one or two letters, such as O for oxygen and Na for sodium; the first letter is always capitalized; second letter is never capitalized (2.1)

chromosome a threadlike structure in a cell nucleus that carries hereditary information in the form of genes (4.1)

chromosphere the 3000 km thick layer of atmosphere beneath the Sun's corona, composed of hot (6000–20 000°C), low-density gas (11.1)

circuit breaker a safety device in an electrical circuit; acts as a switch to cut off power to a circuit if the current exceeds a safe level (9.1)

circuit diagram a drawing using symbols to represent the different components of a circuit (8.2)

circumpolar constellation [SUHR-kum-POH-luhr KON-ste-LAE-shun] a constellation that never appears to "set", or dip below the horizon; this classification depends on the position of the viewer (10.1)

combustibility the degree to which a substance will burn (1.2)

combustion the reaction of a substance with oxygen, combined with the release of energy; also called burning (3.3)

comet a small body made up of rocky material and ice that occurs in the Kuiper Belt and the Oort Cloud; when a comet is bumped into the inner solar system, the Sun's light may make the comet's tail visible from Earth (11.2)

complete metamorphosis a change in the form of an insect as it matures, such that the adult form of the insect is completely different from the larval stage (6.2)

conclusion an explanation of the results of an experiment as it applies to the hypothesis being tested (Science Skill 2)

condensation change of state from a gas to a liquid (3.3)

conductors materials that allow electrons to move freely on and though them (7.1)

constellation a distinctive pattern in the night sky formed by a group of stars; the pattern often looks like a familiar object, such as an animal (10.1)

contact forces forces that have an effect only on objects that they touch (7.2)

control in a scientific experiment, a standard to which the results are compared; often necessary in order to draw a valid conclusion; ensures a fair test (Science Skill 2)

corona the outermost part of the Sun's atmosphere, a layer of gas that can reach more than 3 000 000°C (11.1)

corrosion a chemical process by which a material is broken down; often a reaction between water or oxygen and a metal (3.3)

cosmological red shift wavelengths of radiated light that are being constantly stretched (lengthened) as the light crosses the expanding universe (12.1)

coulomb (**C**) the unit of electric charge; one coulomb is the amount of charge passing a point in one second when one ampere of current is flowing (7.1)

covalent compound a compound, such as water, in which two atoms share a pair of electrons (3.1)

current electricity the continuous flow of charge in a complete circuit (8.2)

cytokinesis [SIH-toh-ki-NEE-sus] the final stage of the cell cycle, which separates the two nuclei and cell contents into two daughter cells (5.1)

D

density ratio of a material's mass to its volume; usually measured in kg/cm^3 (1.2)

deoxyribonucleic acid (DNA) [dee-AHK-si-rih-boh-nyoo-KLAE-ik] a biological molecule found in the cell nucleus that carries genetic information; composed of sugar, phosphate, and four different bases (guanine, cytosine, adenine, and thymine) passed on from generation to generation during reproduction (4.1)

differentiation in humans, the process in which cell layers will eventually form the organs and tissues of a baby (6.3)

dissolving the formation of a solution as two substances mix together (3.3)

dwarf planet a celestial body orbiting the Sun that has enough mass to have a nearly round shape due to its own gravity, has not cleared the neighbourhood around its orbit, and does not orbit any object other than the Sun; generally smaller than a planet (11.2)

E

ecliptic the path followed by the Sun through the sky, as seen from the Earth (10.1)

efficiency the percentage of energy converted into a useful form by a process or a device compared to the total amount of energy consumed; calculated by dividing the useful energy output by the total energy input and multiplying by 100 to convert to a percentage (9.3)

electric circuit a complete pathway that allows electrons to flow (8.2)

electric current the amount of charge passing a point in a conductor every second (8.2)

electric force a push or pull between charged objects (7.2)

electric load any device that transforms electrical energy into other forms of energy, such as a light bulb, buzzer, heater, or motor (8.2)

electric potential energy electric energy stored in a battery (8.1)

electrical energy the ability to do work by pushing electrons around a circuit (9.2)

electrical power the rate of change in electrical energy (9.2)

electrical resistance the ratio of voltage to current (8.3)

electrochemical cells devices that convert chemical energy into electrical energy; also called batteries (8.1)

electrodes two terminals in a cell or other electricity source; usually made of two different metals or a metal and another material (8.1)

electrolyte substance that conducts an electric current; in a dry cell, the electrolyte is a moist paste; in a wet cell, the electrolyte is a liquid (8.1)

electromagnetic radiation energy that is carried, or radiated, in the form of waves that range in length from short to long; types include X rays, ultraviolet radiation, visible light, microwaves, infrared waves and radio waves (12.1)

electron shells regions that surround the nucleus of an atom and contain electrons; also called energy levels (2.3)

electrons negatively charged particles surrounding the atomic nucleus (1.3, 7.1)

element a pure substance that cannot be broken down into simpler components (1.2)

ellipse an oval shape for which the distance from one focal point to a point on the edge of the ellipse and then to the other focal point is the same no matter which point on the edge of the ellipse you choose (10.3)

elliptical galaxy one of three basic galaxy shapes; a galaxy that ranges in shape from a perfect sphere to an elongated but flattened ellipse and contains some of the oldest stars in the universe (12.2)

embryo [EM-bree-oh] the stage of a multicellular organism that develops from a zygote (6.1)

embryonic stem cell a cell that can become any one of a sexually reproducing organism's body cells (6.4)

EnerGuide a Canadian government program that rates the energy consumption and efficiency of heating, cooling, and ventilating equipment, new houses and vehicles, and household appliances; an EnerGuide label is placed on an appliance to display how much energy the device typically uses in a year (9.3)

energy the ability to do work (8.1)

energy level a region surrounding the nucleus of an atom; may be occupied by electrons; also called an electron shell (2.3)

eukaryotic [YOO-kae-ree-AW-tic] a cell in which chromosomes are contained within a nucleus

evaporation the change of state from liquid to gas (3.3)

F

fair test an investigation (experiment) carried out under strictly controlled conditions to ensure accuracy and reliability of results; all variables are controlled except the one variable under investigation (Science Skill 2)

fallopian tubes the passageways that connect the ovaries to the uterus; an egg is fertilized in one of the fallopian tubes before moving into the uterus; also called oviducts (6.3)

fertilization the process during which an egg cell is penetrated by a sperm cell and the haploid genetic information of both male and female gametes combines (6.1)

fetus the stage of a multicellular organism that develops from an embryo (6.3)

force a push or a pull exerted on an object (7.2)

fragmentation a form of asexual reproduction in which each fragment of an organism develops into a clone of its parent (5.2)

freezing solidification; change of state from a liquid to a solid (3.3)

fuel cell a source of electric current made up of two electrodes and an electrolyte and requiring a constant external supply of fuel (9.4)

fuse a protective mechanism in an electrical circuit; contains a metallic conductor strip that melts when excessive current passes through it, thus opening the circuit and stopping electron flow (9.1)

fusion the process in which the nuclei of atoms fuse together to form larger single atoms, creating an enormous amount of energy (12.2)

G

galaxy an enormous collection of gases, dust, and billions of stars held together by gravity (12.1)

gametes specialized cells necessary for reproduction; in animals, male gametes are called sperm cells and female gametes are called egg cells (6.1)

gamma rays high-frequency electromagnetic radiation released from exploding stars, neutron stars, and galaxies; cannot be detected by telescopes on Earth's surface because the rays are absorbed by Earth's atmosphere (12.3)

gene segment of DNA located at a specific place on a chromosome; each contains information to produce proteins (4.1)

gene mutation a change in the specific order of the A, G, C, and T bases that make up a particular gene (4.2)

generator a device that converts mechanical energy into electrical energy, often by rotating a coil of wire inside a stationary magnet (9.4)

genetic diversity inherited genetic differences in a species that give many organisms a survival advantage (6.1)

genome the entire set of genetic information stored within the chromosomes of an organism (6.4)

geocentric representing Earth as the centre of the universe (10.2)

geosynchronous orbit [gee-oh-SIN-kron-uhs] the orbit of a satellite that is moving at the same speed and direction as Earth's rotation, with the result that the satellite stays stationary above a fixed point on Earth (11.3)

grounding connecting a conductor so that electric charge flows into Earth's surface (7.1)

grounding terminal the round prong of an electrical plug; allows excess current to flow from an electrical device to ground to prevent electrical shock (9.1)

H

halogens Column 17 of the periodic table; include the non-metallic elements fluorine, chlorine, bromine, iodine, and astatine (2.2)

hazard symbol a warning printed on a container to indicate that either the container or the product is dangerous (1.1)

heliocentric representing the Sun as the centre of the universe (10.2)

heredity the passing on of traits from an individual to its offspring (4.1)

high mass star star that has 12 or more times the mass of the Sun; consumes fuel quickly to rapidly reach a large size, but also burns out quickly (12.2)

Hubble Space Telescope an optical telescope that was launched into Earth orbit in 1990; provides images of distant galaxies and stars; light reaching its mirrors has not been distorted by the atmosphere (12.3)

hydroelectric electrical energy generated from the mechanical energy of falling or flowing water (9.4)

hypothesis [hih-PAW-thuh-sis] a testable proposal used to explain an observation or to predict the outcome of an experiment; often expressed in the form of an "If …, then …" statement (Science Skill 2)

I

incomplete metamorphosis subtle progression through three insect life stages: egg, nymph, and adult; immature phases look like small versions of the adult insect (6.2)

insulators materials, such as glass, plastics, ceramics, and dry wood, that do not allow electrons to move easily on or through them (7.1)

interphase the first and longest stage of the cell cycle, in which cells carry out life functions and cells that divide prepare for cell division (5.1)

interstellar matter the material that fills space, made up of gas (mostly hydrogen) and dust (12.2)

ionic compound a compound, such as table salt, in which oppositely charged ions are attracted to each other (3.1)

irregular galaxy one of three basic galaxy shapes; a galaxy that has neither spiral arms nor an obvious central core, made up of a mix of newly forming stars and old stars (12.2)

J

joule (**J**) the unit for measuring energy (9.2)

junction point the location where a circuit divides into multiple paths or where multiple paths combine (9.1)

K

karyotype a photomicrograph that shows the number of chromosomes a person has, as well as the chromosomes' size and shape, prepared by cutting and pasting chromosomes taken from body cells during mitosis; used to diagnose genetic disorders (6.4)

kilowatt-hour (**kWh**) a measure of electrical energy; the product of power, in kilowatts, and time, in hours (9.2)

Kuiper Belt [KIH-puhr belt] a flat disk of millions of small bodies orbiting the Sun beyond the orbit of Neptune (11.2)

L

law a description of events, patterns, or relationships in science that have been observed over and over again (1.3)

laws of static charge laws stating that like charges repel, opposite charges attract, and neutral objects and charged objects attract each other (7.2)

light-year the distance that light, which moves at 300 000 km/s, travels in a year; equals about 9.5 trillion km (12.1)

M

magnitude the apparent brightness of a star, as viewed from Earth; depends on how bright the star is and how close it is to Earth (10.1)

main sequence star star in the main stage of its life cycle, where it produces energy by converting hydrogen to helium; approximately 90 percent of stars in the universe are main sequence stars (12.2)

manipulated/independent variable in an experiment, a factor that is selected or adjusted to see what effect the change will have on the responding dependent variable (Science Skill 2)

mass the amount of matter in a substance or an object; the more matter, the greater the mass; usually measured in kilograms (kg) (1.2)

mass number the number of protons and neutrons in the nucleus of an atom of an element (2.2)

mating the process by which gametes arrive in the same place at the same time in some animals this involves copulation; for plants and for organisms that have external fertilization, copulation is not involved (6.2)

matter anything that has mass and volume (1.2)

meiosis [mih-OH-sus] the process that produces gametes with half the number of chromosomes as body cells (6.1)

melting the change of state from a solid to a liquid (3.3)

melting point the temperature at which a solid begins to liquefy (1.2)

metal an element that is typically hard, shiny, malleable, ductile, and a good conductor of heat and electricity (2.1)

metalloid an element that shares some properties with metals and some properties with non-metals (2.2)

metamorphosis a change in the form of an insect as it matures (6.2)

meteor a meteoroid that burns up as it passes through Earth's atmosphere (11.2)

meteorite a meteoroid that is large enough not to burn up entirely as it passes through Earth's atmosphere, and therefore reaches Earth's surface (11.2)

meteoroid a rocky chunk, broken off an asteroid or planet, which floats through space (11.2)

microgravity the condition of weightlessness experienced in space; less than one millionth the effect of gravity experienced on Earth (11.3)

mitosis [mih-TOH-sus] the second, and shortest, stage of the cell cycle; the process in which the duplicated genetic material from the cell's nucleus is divided between two daughter cells (5.1, 6.1)

molecule a group of atoms in which the atoms are held together by the sharing of one or more pairs of electrons (3.1)

model a verbal, mathematical, or visual representation of a scientific structure or process, which allows scientists to construct and test inferences and theories (e.g., the particle theory of matter) (Science Skill 2)

moon a celestial body that orbits a planet (11.2)

mutagen [MYOO-tuh-jen] a substance or factor that can cause mutations in DNA (4.2)

N

nebula [NEB-yoo-luh] a cloud of gas and dust in space (12.1)

neutral the uncharged state of a particle or object; occurs when the positive charge in the nucleus is exactly balanced by the negative charge of the electrons (7.1)

neutron uncharged particle in the nucleus of an atom (1.3)

noble gases Column 18 of the periodic table; include the elements helium, neon, argon, krypton, xenon, and radon (2.2)

non-metal an element that is typically not shiny, malleable, or ductile and that is a poor conductor of heat and electricity; usually a gas or brittle solid at room temperature (2.1)

non-renewable unable to be replaced within a human lifetime; refers to energy sources such as fossil fuels and nuclear energy (9.4)

nuclear energy energy released by a nuclear reaction (9.4)

nucleus in chemistry, the positively charged centre of an atom, which contains protons and neutrons (plural: nuclei) (1.3); in biology, an organelle that contains an organism's hereditary information and controls all the activities within a cell (4.1)

O

ohm (Ω) the unit of measurement for electrical resistance (8.3)

Ohm's law the mathematical relationship comparing voltage (V), current (I), and resistance (R), written as $R = \frac{V}{I}$ (8.3)

Oort Cloud [ohrt klowd] a spherical cloud of small icy fragments of debris at the outskirts of the Sun's gravitational influence; thought to be a source of comets (11.2)

optical telescope reflecting or refracting telescope used to focus light from distant objects (11.3)

orbit the regular path of an object, such as a celestial body or an artificial satellite, around another body such as a star or a planet (10.3)

Oscillating theory [AH-sil-aet-ing THEE-ree] states that the universe is closed and will go through a series of expansions and contractions, or Big Bangs and Big Crunches, in an ongoing cycle (12.1)

ovary one of two female sex glands that are connected to the uterus by the fallopian tubes; produces mature ova and female hormones (6.3)

oviducts the passageways that connect the ovaries to the uterus; an egg is fertilized in one of the oviducts before moving into the uterus; also called fallopian tubes (6.3)

P

parallax the apparent shift of an object against a stationary background caused by the change in position of the observer (12.1)

parallel circuit an electrical circuit that has more than one path (9.1)

penis the tube-like male reproductive organ that contains the urethra, which delivers sperm and excretes urine (6.3)

period horizontal row in the periodic table (2.2)

periodic table organized list in which elements are arranged in rows and columns according to their atomic number and their patterns of similar properties (2.2)

photosphere the thin outer layer of the Sun where hot gas rises to the surface, cools, and then sinks back into deeper layers; reaches temperatures of about 5800°C (11.1)

physical change a change in matter in which the appearance may change but no chemical bonds are broken or made and no new substance is formed (3.3)

physical property a characteristic of matter that you can observe or measure, such as state, colour, or density (1.2)

planet a celestial body that orbits one or more stars, is large enough that its own gravity holds it in a spherical shape, and is the only body occupying the orbital path (10.1, 11.2)

planetesimal a rocky clump with a diameter of approximately 1 km or more that may eventually come together with other rocky clumps to form a planet (12.1)

pollen fine, powder-like grains that carry the male gametes (sperm cells) of seed plants (6.2)

pollination the transfer of male gametes in pollen from the male reproductive part of a plant to the female reproductive part of a plant (6.2)

potential difference the amount of electric potential energy per one coulomb of charge at one point in a circuit compared to the potential energy per coulomb of charge at another point in the circuit; also called voltage (8.1)

power the rate of change in energy; also the rate at which work is done or energy is transformed (9.2)

power rating a measurement of how much electrical energy an electrical device consumes for every second it is in use (9.2)

prediction a forecast about what you expect to observe when you do an investigation (Science Skill 2)

probe a space vehicle carrying scientific instruments and sent to fly past, orbit, or land on a celestial body to collect data (11.3)

products new substances formed in a chemical reaction (3.3)

proton positively charged particle in the atomic nucleus (1.3, 7.1)

Q

quasar a region of extremely high energy that develops as the supermassive black hole in the centre of a galaxy attracts more matter into itself (12.2)

R

radio telescope a large receiver that collects radio waves (which have longer wavelengths than visible light) and therefore can detect objects that are invisible to optical telescopes (11.3)

reactants substances that react in a chemical reaction (3.3)

reactivity degree to which a substance combines chemically with other substances (1.2)

red shift a shifting of light from an object toward the red (longer wavelength) end of the spectrum as the object moves away from Earth (12.1)

renewable able to be renewed or replaced within a human lifetime; refers to energy sources such as wind, solar, biomass, geothermal, or hydroelectricity (9.4)

replication the process during which the cell copies the 3 billion base pairs of DNA information in the nucleus (5.1)

reproductive system an organ system in the human body that produces the gametes necessary to make offspring; the male reproductive system also delivers the males gametes (sperm) to the female gamete (egg) for fertilization and development; the female reproductive system also houses the developing embryo (6.3)

resistance the property of any material that slows down the flow of electrons and converts electrical energy into other forms of energy (8.3)

resistor an electrical component with a set amount of resistance that slows down current and transforms electrical energy into other forms of energy (8.3)

responding/dependent variable in an experiment, the factor that changes in response to a change in the manipulated/independent variable (Science Skill 2)

retrograde motion an apparent switch in the motion of a celestial body from eastward to westward motion, or vice versa, as viewed from Earth (10.2)

revolution the motion of Earth as it orbits the Sun at 30 km/s; one full revolution takes almost a year (12.1)

rotation the motion of Earth as it spins on its axis from west to east at 1670 km/h; one full rotation takes almost a day (12.1)

rover a small, sophisticated, robotic probe designed to land on a planet, explore and test the surface, and send information back to Earth (11.3)

S

satellite an electronic device put in orbit around Earth to relay information (11.3)

scrotum a loose sac of skin that hangs below the penis and contains the testes; protects the testes, maintaining them at a cooler temperature than the body core (6.3)

series circuit a circuit that has only one path for current to travel (9.1)

sexual reproduction reproduction that requires two parents and produces offspring that are genetically different from each other, from either parent, and from any other member of their species (6.1)

solar prominences large loops of super-hot gas that extend out from the Sun's surface (11.2)

solar radiation energy emitted from the Sun in the form of electromagnetic radiation (11.1)

solar wind streams of high-energy particles ejected by the Sun; when some of these particles enter Earth's atmosphere they cause the auroras, or the northern and southern lights (11.1)

space weather conditions produced by the Sun that have an effect on the inner solar system, and particularly on technological devices on or near Earth; may also affect human health (11.1)

spectral lines lines that stand out in the spectral pattern of a star; in an emission spectrum, lines are bright with a black background; in an absorption spectrum, lines are dark against a continuous spectrum; vary depending on the atomic elements in the star (12.1)

spiral galaxy one of three basic galaxy shapes; a galaxy with many long "arms" spiralling out from a centre core made up of stars that formed long ago (12.2)

spore a reproductive cell that grows into a new individual by mitosis (5.2)

star a celestial body of hot gases with a nuclear furnace at its core that makes its own thermal energy (10.1, 12.2)

state a property of a substance describing it as a solid, a liquid, or a gas (1.2)

static charge an electric charge that can be collected and held very nearly fixed in one place (7.1)

stem cell a cell that has the potential to become many different types of cells; two types of stem cells are embryonic stem cells and adult stem cells (6.4)

subatomic particles particles such as protons, neutrons, and electrons that are smaller than atoms; the prefix "sub-" means below (1.3)

sunspots dark patches on the Sun's surface that are slightly cooler, about 3500°C, than surrounding areas (11.1)

supernova a dramatic, massive explosion that occurs when a large, high mass star collapses in on itself (12.2)

syndrome a particular disease or disorder with a specific group of symptoms that occur together (6.4)

T

telescope an instrument that gathers and focusses light or other types of electromagnetic radiation to magnify distant objects (10.2)

testes the male sex glands, which produce male gametes and release hormones (6.3)

theory an explanation of an event that has been supported by consistent, repeated experimental results and has therefore been accepted by most scientists (1.3, Science Skill 2)

thermal energy heat energy produced from the burning of fossil fuels (9.4)

thermonuclear reaction the fusion of two or more atoms to create a different, larger atom, and a great deal of energy (11.1)

trait a characteristic that can vary in size or form from individual to individual within a species; can be passed on from generation to generation (4.1)

transformer an electrical device that changes voltage (9.4)

transit the passage of a planet between the Earth and the Sun (11.2)

transition metals a set of metallic elements found at the centre of the periodic table; have a complex electron arrangement that sets them apart from other metallic elements (2.2)

triangulation a technique for determining the distance to a visible object by creating an imaginary triangle between the observer and the object and then calculating the distance (12.1)

turbine a cylinder with blades or paddles; its rotation turns a coil of wire within a magnet to generate electricity (9.4)

U

urethra [yoo-REE-thruh] the tube in the penis through which urine or sperm passes as it leaves the body (6.3)

uterus the hollow female reproductive organ that protects and nourishes the zygote during development (6.3)

V

vagina the tube through which a baby or an unfertilized egg leaves the body; passageway through which sperm reach the cervix (6.3)

Van de Graaff generator a device that uses friction to produce a large static charge on a metal dome (7.1)

variable a factor that can influence the outcome of an experiment (Science Skill 2)

vas deferens a long muscular tube in which sperm mix with fluids to form semen as the sperm move from the testes to the urethra (6.3)

vegetative reproduction reproduction in which special cells, usually in plant stems and plant roots, divide repeatedly to form structures that will eventually develop into a plant identical to the parent (5.2)

volt (**V**) the unit of potential difference; one volt causes a current of one ampere to flow through a conductor with a resistance of one ohm (8.1)

voltage the amount of electric potential energy per one coulomb of charge at one point in a circuit compared to the potential energy per coulomb of charge at another point in the circuit; also called potential difference (8.1)

volume the amount of space taken up by a substance or object, usually measured in litres (L) or cubic centimetres (cm^3) (1.2)

W

watt (**W**) a unit of power; one watt is one joule of energy transformed in one second (9.2)

white dwarf a stage in the life cycle of some stars; a celestial body that

Workplace Hazardous Materials Information System (WHMIS) system of eight warning symbols used throughout Canada to provide safety information about chemicals (1.1)

Z

zodiacal constellations [zuh-DIH-uh-kuhl KON-stuh-LAE-shuns] twelve star groups that form the patterns of the zodiac signs: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces; twelve stations along the ecliptic (10.1)

zygote [ZIH-goht] the new diploid ($2n$) cell formed by the process of fertilization; receives half its chromosomes from its female parent and half from its male parent (6.1)

Answers to Unit 1 Practice Problems

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1. (a) aluminum iodide
   (b) sodium oxide
   (c) magnesium phosphide
   (d) silver iodide
   (e) calcium selenide
   (f) potassium sulphide
   (g) rubidium fluoride
   (h) silver nitride
   (i) potassium bromide
   (j) strontium phosphide
   (k) cadmium sulphide
   (l) silver oxide
   (m) cesium sulphide
   (n) calcium iodide
   (o) sodium fluoride

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Bold faced numbers correspond to **bold faced** terms in the text
f indicates a figure
t indicates a table

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UNIT 1

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