Science Skills Guide

Organizing and Communicating Scientific Data

Drawing a Data Table

To learn how to set up a data table, read the paragraph below that contains data. Then compare the data in the paragraph to the data in the table below.

White rats have an average mass of 0.15 kg and a resting heart rate of about 350 beats per minute. An average 12.0 kg dog has a resting heart rate of about 100 beats per minute. Adult humans have an average mass of about 70 kg and a heart rate of about 72 beats per minute. An elephant with a mass of 4000 kg has a heart rate of about 30 beats per minute.

Table 1 Heart Rates and Masses of Four Animals

Type of Animal	Mass (kg)	Heart Rate (beats per min)
white rat	0.15	350
dog	12.0	100
human	70.0	72
elephant	4000	30

Notice that the data contain three categories:

- type of animal
- mass of animal
- heart rate of animal.

The number of categories tells you how many columns you need in your table.

There is a complete set of data for each of four animals. The number of sets of data tells you how many rows you will need in your table. You need one row for each set of data and one row for headings for each column. As well, you should always give your table a title.

Tips for Drawing Data Tables

1. Use a ruler to draw your table.
2. Print all letters and words so they will be easy to read.
3. Express numbers in your data as numerals (for example, 1, 2, 3) not as words (one, two, three).
4. Give the table a title. If there are small numbers in the title, you can express them in words. The variables in the observations or experiments can become the title of your data table. For example, "The Effects of Light on Plant Growth."
5. Your table has the shape of a box. Place the title outside the box.
6. Print headings neatly at the top of each column. Include units for the data with the headings, not in the columns.
7. Draw a line separating the headings from the data.
8. Record the data in the columns below the headings.
9. Separate the columns of data with lines.

Instant Practice

Draw a table from the data in the following paragraph.

A serving of cooked pasta has about 15 g of carbohydrate, 3 g of protein, and no fat. A serving of beef has no carbohydrate, 7 g of protein, and about 5 g of fat. A serving of bananas has 15 g of carbohydrate, no protein, and no fat. A serving of milk has 12 g of carbohydrate, 8 g of protein, and 3 g of fat. A serving of tomatoes has 5 g of carbohydrate, 2 g of protein, and no fat.

Graphing

A **graph** is often a line or curve that shows how one quantity depends on changes in another quantity. A graph is a good way to display data so that you can see patterns and relationships among variables.

Graphing Terms to Know

x- and y- axes: The *x*-axis is the horizontal line on a graph. The independent/manipulated variable is placed on the *x*-axis. The *y*-axis is the vertical line on a graph. The dependent/responding variable is placed on the *y*-axis.

Origin: The point at which the x and y axes meet. The origin is often, but not always, the point on a graph at which x and y are equal to zero.

Plotting: Drawing a point or line on a graph that represents data.

Scale of numbers: Equal divisions marked on the x and y axes so that they can be used for measuring. The magnitude (size) of the numbers on a scale must increase as you move away from the origin. As you go to the right or upward, the numbers become increasingly positive. As you go left or downward, the numbers become increasingly negative.

Interval: The value of the divisions between units marked on a scale (for example, 0, 1, 2, 3, … or 0, 5, 10, 15, …). The interval between the numbers on the scale must be equal in size.

Range: The difference between the largest and smallest of a series of numbers.

Key: (Legend): A small table that explains or identifies symbols on a graph. The legend should be placed close to the graph.

Example

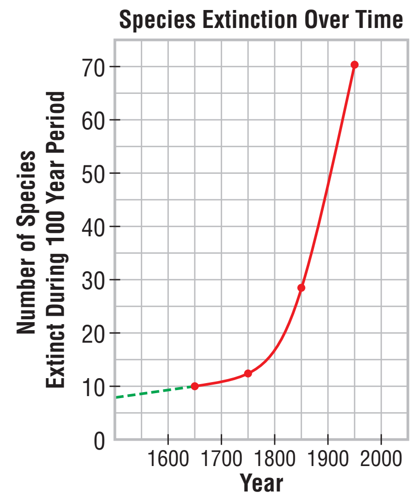
The following data table gives the number of species that became extinct during each 100 year period between 1600 and 1900. To learn how to draw a line graph from the data, examine the graph as you read the steps.

Table 2 Species Extinction Over Time

Year	Species Extinct During Century
1600 – 1700	10
1700 – 1800	11
1800 – 1900	28
1900 – 2000	70

Drawing a Line Graph

You can use a line graph whenever the data you collect depend on each other. Line graphs make it easy to see relationships between two quantities. You can use a line graph to predict values that are not even on the graph.



1. With a ruler and pencil, draw an x-axis and a y-axis on a piece of graph paper.
2. Label the axes. Write the years along the x-axis and "Number of Species Extinct During 100 Year Period" along the y-axis.
3. Decide on a number scale to use. Your x-axis will have four intervals of 100 years each. Your y-axis will go from 10 to 70. You can start at zero and end at a number above 70. Use a tick mark at major intervals on your scale.
4. Go to the point representing the middle of the century 1600 to 1700. Now move up until you are at a point that represents 10 species. Make a dot at this point. Repeat this procedure for all data points on the table.
5. Do not simply connect the data points when you draw a line graph. Experimental data points usually have some error. If the points are almost in a straight line, draw a straight line as close to most of the points as possible. There should be about as many points above the line as there are below the line. This line is called a **line of best fit.** If the data points do not appear to follow a straight line, then draw a smooth curve that comes as close to the points as possible. A line of best fit shows the trend of the data. It can be extended beyond the first and last points.
6. Give your graph a title.

Interpolation and Extrapolation

Often, scientists need to know the value of a variable at a point that was not measured. For example, you can use the shape of the graph to predict the number of species that were extinct in the year 1550. Notice that this year is not in the range of the measurements that were taken. It is beyond the range of the data.

Extrapolation is a way to approximate values that are beyond (outside of) the range of the data. Look at the graph again. The part of the line that is in green is an extrapolation of the data. Based on this extrapolation, predict how many species were extinct in the year 1550. What about the year 1500? How accurate do you think your predictions are?

What if, on the other hand, you wanted to predict the number of species that were extinct in the year 1700. This year is inside the range of the data.

Interpolation is a way to approximate values that are between points of a graph (inside the range of values). Predict how many species were extinct in the year 1700. What about the year 1800? How does the accuracy of your interpolated predictions compare with the accuracy of your extrapolated predictions?

Drawing a Bar Graph

A bar graph helps you to compare the number of items in one category with the number of items in other categories. The height of the bar represents the number of items in the category. Study the example in the next column, and then make your own bar graph.

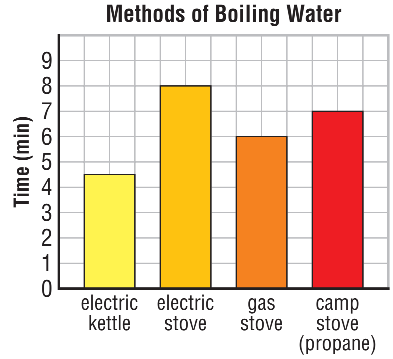
Example

Make a bar graph from the data in the table at the top of the next column. Use only the data on time in the second column. Do not graph the data (Cost) in the third column. As you read the steps, examine the completed graph on the right to see how the steps were followed.

Table 3 Time and Cost to Boil 900 mL of Water

Method	Time (min)	Cost (cents)
electric kettle	4.5	0.71
electric stove	8.0	1.25
gas stove	6.0	0.32
camp stove	7.0	11.1

1. Draw an *x*-axis and a *y*-axis on a sheet of graph paper. Label the *x*-axis with the names of the heating methods. Label the *y*-axis with the title "Time (min)." (See the bar graph below.)
2. Look at the data carefully in order to select an appropriate scale. The range of the data is between 4.5 min and 7.0 min. You can number the scale from 0 to 9. Write the numbers on your *y*-axis scale.
3. Decide on a width for the bars in the graph. They should be large and easy to read.
4. Mark the width of the bars on the *x*-axis. Leave the same amount of space between each bar.
5. To draw the bar for the electric kettle, go to the centre of the bar on the *x*-axis, then go up until you are halfway between 4 and 5. Make a mark to represent 4.5 min. Use a pencil and a ruler to draw in the first bar.
6. Repeat the procedure for the other heating methods.
7. When you have drawn all the bars, colour them so that each one is different. If you are comparing two or more independent/manipulated variables that you have plotted on the *x*-axis, you will need to make a legend or key to explain the meanings of each bar.
8. Give your graph a title.



Instant Practice

A science teacher asked her students what kind of pet they had or would like to have. She planned to have her students research the proper care and feeding of each pet. The responses are shown in the following table. Make a bar graph using the data.

Table 4 Pets Chosen by Students

Pet	Number of students choosing pet
cat	16
gerbil	11
hamster	13
goldfish	3
mouse	7
guinea pig	10
dog	14
hedgehog	10

Constructing a Histogram

The graph on the right is called a histogram. It is another type of bar graph. Notice that there is no space between the bars in a histogram but there is space between the bars in a bar graph. The reason for the space is that each bar represents a different item.

In a histogram, the x-axis represents one continuous item, divided into size categories. In the histogram, notice that the x-axis represents temperature, divided into two-degree categories. Thus, the x-axis is quantitative, meaning that it contains numerical values. In a typical bar graph, the x-axis is qualitative and cannot be described with numbers.

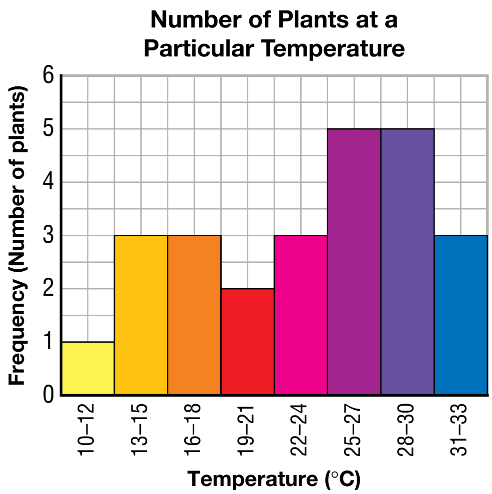
Example

A group of students conducted a test on plant growth. They placed plants in rooms with different temperature ranges and observed the effects on the plants. Table 5, called a frequency table, shows how many plants were placed in each location. As you read the steps, examine the completed histogram below.

Table 5 Temperature of Rooms

Temperature (°C)	Frequency (number of plants)
10–12	1
13–15	3
16–18	3
19–21	2
22–24	3
25–27	5
28–30	5
31–33	3

1. On a piece of graph paper, draw an x-axis and a y-axis. Label the x-axis "Temperature (°C)" and the y-axis, "Frequency (number of plants)."
2. Separate the x-axis into eight equal segments. Label the segments using the temperatures listed in the frequency table.
3. Make a scale on the y-axis that goes to 6.
4. Move your pencil up the y-axis to 1, and make a light mark. Then, using a ruler, make a bar that is the width of the 10–12°C temperature range.
5. Repeat this procedure for each temperature range and corresponding number of plants.



Designing and Conducting Experiments

A useful experiment usually starts with an observation. The observation might be as simple as watching a child on a playground swing such as the one shown below.

A swing has a rhythmic motion.

Observing and Inferring

If your observation can lead to the development of an experiment, you must be able to ask a question that can be answered by a scientific investigation. You might ask, "What features of a playground swing or any other swinging object determine the rhythm of the swinging motion?" To answer the question, you might think back to when you were younger. You knew that you could make a swing go higher, but it always seemed to swing back and forth at the same rate. You have narrowed the question down to what determines the rate at which a swinging object goes back and forth. You have *inferred* that some characteristic of a swinging object determines the rhythm. You could compare a child on a swing to some other previous experience. Maybe you bumped into a hanging planter at home and watched it swing. It seemed to swing faster than the child on the swing. The hanging planter is a shorter system than the child on the swing. You might infer that the length of the rope influences the rate of swinging. This is an idea that you can test by creating a model of a child on a swing. You can model a child on a swing by building a simple pendulum (see the photograph below).

Hypothesizing and Predicting

When you have developed a model, you can use it to formulate a hypothesis. You might think about the size of the mass at the end of the string on your pendulum. You might hypothesize that a heavier mass would swing faster. If this is the case, you could predict that a larger mass would cause the time for one complete swing to be shorter. The term that describes the length of time for the pendulum to swing from one end to the other and back again is the *period*. You are nearly ready to carry out your experiment. First, you must identify all of the variables involved when a pendulum swings.

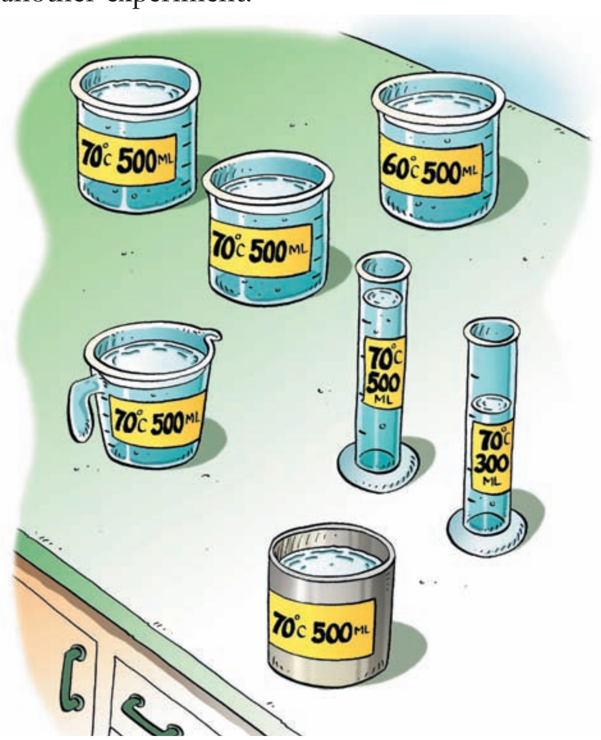
These students are modelling a child on a swing by setting up a pendulum.

Variables

A variable is anything that might affect the outcome of the experiment. The period of the pendulum is a variable. All of the other variables that might affect the period are:

- the mass of the pendulum bob (the object at the end of the string),
- the length of the string, and
- how far you pull the pendulum bob to one side before letting it go.

In order to carry out a fair test, you must test the effect of only one specific variable at a time. You must ensure that all the other variables do not change. Scientists say that you *control* the other variables. This is important because, if you changed both the mass of the bob and the length of the string and you observed a change in the period, you would not know whether the change in the mass or in the length of the string caused the period to change. Study the figure below and see if you can identify the variables in another experiment.

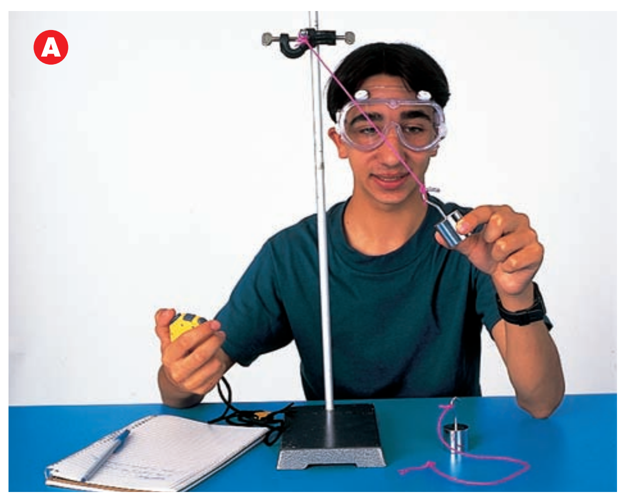


Examine the containers of water. Assume that you want to know what factors affect the length of time it takes for water to evaporate. How many variables can you find in the figure? What are those variables? How would you test each variable individually?

Independent, Dependent, and Controlled Variables

The variable that you choose to test is called the manipulated or **independent variable.** You can remember which variable is the independent variable by remembering, "**I** choose to test the **I**ndependent variable." You can select which independent variable that you will test. The responding or **dependent variable** is the one that you observe to see if it has been affected by the changes to the independent variable. All of the other variables that you are not testing are **controlled variables.** They remain the same while you change the conditions of the independent variable. These concepts will become clear as you study the pictures of the student in the photographs.

In part (A) of the pendulum experiment, the length of the string is the independent/manipulated variable.

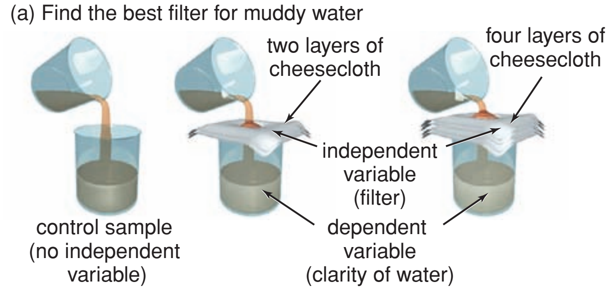


The student is testing two different lengths to see how they affect the period of the pendulum. He will start the stopwatch when he releases the pendulum bob and measure the time for one period. In this case, time is the dependent/responding variable. Notice that the student is using the same mass and he is holding the mass the same distance from the central position. These are the controlled variables.

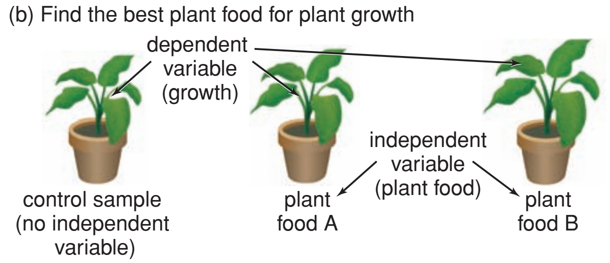
In part (B) of the pendulum experiment, the mass is the independent/manipulated variable. Notice that the length of the string is the same in both cases. The length of the string is now a controlled variable.

Control Sample

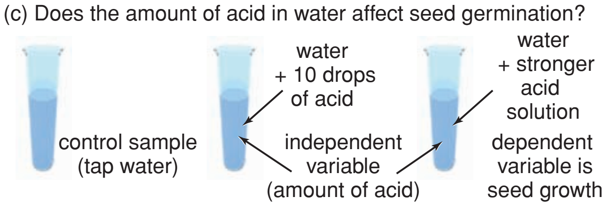
In many experiments, you need to have a control sample in which there is no independent/manipulated variable at all. Examine the figures below to understand when you need to have a control sample.



(a) If you compared only the two filters, you would not know whether the filters were doing anything at all. You need to compare both filters to the case in which there is no filter. The sample with no filter is the control sample.



(b) If you tested only the two plant foods and plant (B) grew taller than plant (A), you would not know if plant food A had any effect at all. You need to compare both plants with plant food to a third plant that received no plant food.



(c) To fully understand the effect of acid on seed germination, you have to compare the effect of two acid strengths to a control sample with water only and no acid.

Recording Data

Before you conduct an experiment, be sure that you know what tests you are going to perform and what measurements you will take. Prepare tables for your data before you start your experiment. Also, list values of the controlled variables with each data table. If you were going to do the pendulum experiment, you might make a table such as the one on the right. Note that the controlled variables are listed on the bottom row. Now you are ready to conduct your experiment.

Mass of Pendulum Bob		Length of string		Angle between string and vertical support	
Mass (g)	Average Period (s)	Length (cm)	Average Period (s)	Angle (°)	Average Period (s)
25		50		5	
50		100		10	
75		150		15	
100		200		20	
Values of Controlled Variables					
Length constant at 100 cm Angle constant at 10°		Mass constant at 50 g Angle constant at 10°		Length constant at 100 cm Mass constant at 50 g	

After you have set up your apparatus and received your teacher's permission, you can begin to collect data. Taking one measurement is never enough. It is too easy to make an error in measurements. You need to take at least four measurements for each value of the independent/manipulated variable. You can then calculate an average value. Write your average value in the table.

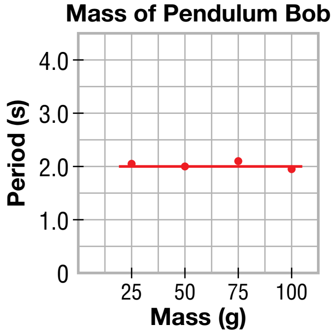
Often, it is easier to interpret your results if you graph your data. Your pendulum results might look like those in the table and graphs below. Because there is always some error in the data, the points will not lie on a smooth line. Therefore, draw a smooth line or curve close to the points.

Mass of Pendulum Bob	
Mass (g)	Average Period (s)
25	2.1
50	2.0
75	2.2
100	1.9
Length constant at 100 cm Angle constant at 10°	

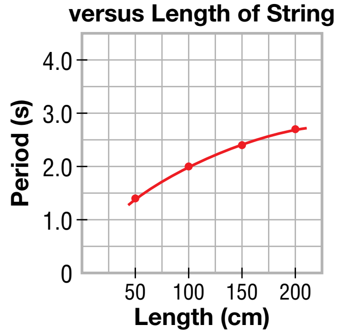
Length of string	
Length (cm)	Average Period (s)
50	1.4
100	2.0
150	2.4
200	2.7
Mass constant at 50 g Angle constant at 10°	

Angle between string and vertical support	
Angle (°)	Average Period (s)
5	2.1
10	1.9
15	2.2
20	2.0
Length constant at 100 cm Mass constant at 50 g	

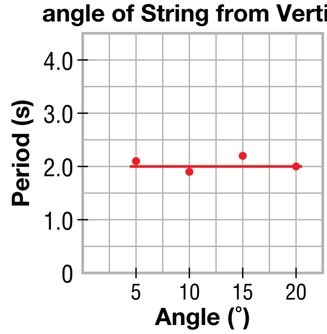
Period of Pendulum versus Mass of Pendulum Bob



Period of Pendulum versus Length of String



Period of Pendulum versus angle of String from Vertical



Summarize Results

Always write a summary of your results in a descriptive paragraph. Your summary of the pendulum experiment might be similar to this.

> When the mass of the pendulum bob was changed, the period stayed the same. When the length of the string was changed, the period changed. When the string was made longer, the period became longer. When the angle between the string and the vertical support stand was changed, the period stayed the same.

Conclusion

Finally, you will write a conclusion statement. Your conclusion will explain the meaning of the results. If your experiment was based on a hypothesis, your conclusion should state whether the results supported your hypothesis. Imagine that your hypothesis for the pendulum experiment had been:

> "A larger mass will make the pendulum swing faster than a smaller mass will make it swing. Therefore, the period of the pendulum will be shorter for larger masses."

Your conclusion statement would have to say that the results did not support your hypothesis. Your conclusion statement might read like this:

> "The results did not support the hypothesis that a large mass will produce a shorter period than will a small mass. Mass had no effect on the period of the pendulum. The angle between the string and the vertical support stand also had no effect on the period. The length of the string was the only variable that affected the period of the pendulum. As the string was made longer, the period of the pendulum swing also became longer."

Should you consider an experiment to be a failure if the results did not support your hypothesis? No! Your recorded data is valid. You demonstrated that the mass of the pendulum bob and the angle between the string and the support stand had no effect on the period. That information is just as important as the conclusion that the length of the string *did* determine the period of the pendulum.

Instant Practice

How could you design an experiment to test the question, "What effect does the size of the hole in tubing have on the rate at which water flows through the tube?" or "What factors affect the amount of sugar that will completely dissolve in water?" When you design your experiment, be sure to answer the following questions.

1. What are all of the possible variables that could affect your results?
2. What is your independent/manipulated variable?
3. What is your dependent/responding variable?
4. What are the controlled variables for this experiment?
5. How are you going to ensure that all of the controlled variables are held constant?
6. Do you need a control sample? If so, what will your control sample be?
7. What will be the form of the data that you are recording?
8. What will you need to put in your data table?
9. Will you need to graph the data? If so, what type of graph will you choose?

Plan your experiment and obtain your teacher's approval before conducting your experiment. **Note:** Be sure to include all necessary safety precautions.

Metric Conversion and SI Units

Throughout history, groups of people have developed their own units of measurement. When different groups of people began to communicate, they became confused because they did not understand each other's units of measurement. For example, imagine trying to report your weight in scruples or buying a "hogshead" of strawberries! For consistency, scientists throughout the world have agreed to use the metric system of units of measurement.

The Metric System

The **metric system** is based on multiples of ten. 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. A prefix (a part of a word joined to the beginning of another word) tells you what number to use when you multiply or divide. For example, *kilo-* means "multiplied by 1000." One kilometre is one metre multiplied by 1000. You can write this relationship mathematically as shown here.

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

The prefix *centi-* means "divided by 100." As shown below, one centimetre is one metre divided by 100.

$$1 \text{ cm} = \frac{1}{100} \text{ m} \quad \text{or} \quad 1 \text{ cm} = 0.01 \text{ m}$$

In the metric system, the same prefixes are used with nearly all units of measurement such as units of mass, weight, distance, and energy. The table on this page lists the most commonly used metric prefixes.

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

(**Note:** Time does not have a metric form of measure. Time is measured in seconds, minutes, and hours. There are 60 s in 1 min, 60 min in 1 h, and 24 h in 1 d.)

The following examples show you how to convert from one metric unit to another.

Problem Tip

When you are solving problems and you have the same unit in the numerator and in the denominator, you can cancel the units. Notice how the units are cancelled in the following examples.

Example 1

The length of Canada's longest river, the Mackenzie River, is 4241 km. Convert the length of the river from kilometres to metres.

Solution

$$4241 \text{ km} = \square \text{ m}$$

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

$$(4241 \cancel{\text{km}})\left(\frac{1000 \text{ m}}{\cancel{\text{km}}}\right) = \frac{4241 \cancel{\text{km}} \times 1000 \text{ m}}{\cancel{\text{km}}}$$

$$4241 \text{ km} = 4\,241\,000 \text{ m}$$

Example 2

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

Solution

$$250\text{ g} = \boxed{}\text{ kg}$$
$$1000\text{ g} = 1\text{ kg}$$
$$(250\text{ }\cancel{\text{g}})\left(\frac{1\text{ kg}}{1000\text{ }\cancel{\text{g}}}\right) = \frac{250\text{ }\cancel{\text{g}} \times 1\text{ kg}}{1000\text{ }\cancel{\text{g}}}$$
$$250\text{ g} = 0.250\text{ kg}$$

Quantities Described by More Than One Term

Mass

One quantity for which you will need to learn more than one unit of measurement is mass. To report an amount of mass, you would usually use the unit of grams with a prefix. For example, one thousand grams is a kilogram (kg). A special unit has been given to one thousand kilograms. That unit is the tonne (t). A tonne is defined as one thousand kilograms. When working with very large amounts of mass, many people prefer to use units of tonnes instead of grams. The relationships are summarized here.

$$1\ 000\ 000\text{ g} = 1000\text{ kg} = 1\text{ t}$$

Area

You can also express large areas in two different units of measurement. The basic unit of area is the square metre (m^2). For example, a square with sides of 1 m has an area of $1\text{ m} \times 1\text{ m} = 1\text{ m}^2$. Ten thousand square metres is given the unit hectare (ha). You usually use the hectare to describe areas of land. You can write the relationship between square metres and hectares as shown here.

$$10\ 000\text{ m}^2 = 1\text{ ha}$$

Volume

You can express volume in cubic metres (m^3). For example, a cube that is 1 m long, 1 m wide, and 1 m high has a volume of $1\text{ m} \times 1\text{ m} \times 1\text{ m} = 1\text{ m}^3$. When you are working with fluids, however, you usually express the volume in units of litres (L) or millilitres (mL). One millilitre has the same volume as one cubic centimetre (cm^3). One litre is one thousand millilitres.

Some important relationships are listed below. Notice that one litre is NOT equivalent to a cubic metre. There are one thousand litres in a cubic metre.

$$1\text{ cm}^3 = 1\text{ mL}$$
$$1000\text{ mL} = 1\text{ L}$$
$$1000\text{ L} = 1\text{ m}^3$$

Metric Unit Conversions Involving Squares or Cubes

When you are converting units of area and volume, you must be very careful when you determine the number of square or cubic units that are equal to each other. For example, one hundred square centimetres is not equal to one square metre. The following examples show you how to calculate the correct relationships.

Example 1

Convert 125 cm^2 into m^2.

Solution

$$125\text{ cm}^2 = \boxed{}\text{ m}^2$$
$$100\text{ cm} = 1\text{ m}$$
$$(100\text{ cm})^2 = (1\text{ m})^2$$
$$100^2\text{ cm}^2 = 1^2\text{ m}^2$$
$$10\ 000\text{ cm}^2 = 1\text{ m}^2$$
$$(125\text{ }\cancel{\text{cm}^2})\left(\frac{1\text{ m}^2}{10\ 000\text{ }\cancel{\text{cm}^2}}\right) = \frac{125\text{ }\cancel{\text{cm}^2} \times 1\text{ m}^2}{10\ 000\text{ }\cancel{\text{cm}^2}}$$
$$125\text{ cm}^2 = 0.0125\text{ m}^2$$

Example 2

Convert 3.5 m^3 into cm^3.

Solution

$$3.5\text{ m}^3 = \boxed{}\text{ cm}^3$$
$$1\text{ m} = 100\text{ cm}$$
$$(1\text{ m})^3 = (100\text{ cm})^3$$
$$1^3\text{ m}^3 = 100^3\text{ cm}^3$$
$$1\text{ m}^3 = 1\ 000\ 000\text{ cm}^3$$
$$(3.5\text{ }\cancel{\text{m}^3})\left(\frac{1\ 000\ 000\text{ cm}^3}{1\text{ }\cancel{\text{m}^3}}\right) = \frac{3.5\text{ }\cancel{\text{m}^3} \times 1\ 000\ 000\text{ cm}^3}{1\text{ }\cancel{\text{m}^3}}$$
$$3.5\text{ m}^3 = 3\ 500\ 000\text{ cm}^3$$

Use the table of prefixes on the previous page and the relationships discussed above to solve the following Instant Practice problems.

Instant Practice

1. A can contains 0.355 L of pop. How many millilitres does the can contain?
2. The height of a table is 0.75 m. How high is the table in centimetres?
3. A package of chocolate-chip cookies has a mass of 396 g. What is the mass of the cookies in milligrams?
4. One cup of water contains 250 mL. What is the volume of one cup of water in litres?
5. The distance from your kitchen to the front door is 6000 mm. How far is the front door in metres?
6. A student added 0.0025 L of lemon juice to water. How much lemon juice did the student add in millilitres?
7. A jug contains 1525 cm^3 of water. What is the volume of the water in units of m^3?

SI Units

Even when scientists began to use the metric system, some confusion still arose. Some scientists would report distance or length in centimetres while others used metres. As well, some scientists reported mass in grams while others reported it in kilograms. Finally, scientists gathered at an international conference in Paris and agreed upon a specific set of units for communicating with other scientists. In 1960, the SI system of units was accepted worldwide. The name SI is taken from the French name *Le Système International d'unités.*

There are seven base units in the SI system. Many other units consist of a combination of base units. These units are called *derived* units, which you will learn about in later science courses. You will use the following base units in this course.

Base Units:

- The SI unit of mass is the kilogram (kg).
- The SI unit of distance is the metre (m).
- The SI unit of time is the second (s).

(**Note:** There are no metric units for time. However, the second (s) is an SI unit.)

When solving problems, you should always report your answers in SI units unless the problem requires a different type of unit. Study the examples below. Then complete the Instant Practice problems that follow.

Example 1

Convert 426 cm to the SI unit for length.

Solution

$$\text{SI unit} = \text{m}$$
$$426\ \text{cm} = \square\ \text{m}$$
$$100\ \text{cm} = 1\ \text{m}$$
$$(426\ \cancel{\text{cm}})\left(\frac{1\ \text{m}}{100\ \cancel{\text{cm}}}\right) = \frac{426\ \cancel{\text{cm}} \times 1\ \text{m}}{100\ \cancel{\text{cm}}}$$
$$426\ \text{cm} = 4.26\ \text{m}$$

Example 2

Convert 1.7 h into SI units.

Solution

$$\text{SI unit} = \text{s}$$
$$1.7\ \text{h} = \square\ \text{s}$$
$$1\ \text{h} = 60\ \text{min}$$
$$1\ \text{min} = 60\ \text{s}$$
$$(1.7\ \cancel{\text{h}})\left(\frac{60\ \cancel{\text{min}}}{\cancel{\text{h}}}\right)\left(\frac{60\ \text{s}}{\cancel{\text{min}}}\right) = \frac{1.7\ \cancel{\text{h}} \times 60\ \cancel{\text{min}} \times 60\ \text{s}}{\cancel{\text{h}} \times \cancel{\text{min}}}$$
$$1.7\ \text{h} = 6120\ \text{s}$$

Instant Practice

Convert the following quantities to the SI base unit.

1. 7.02 g
2. 32 min
3. 8.13 km
4. 25 961 mm
5. 223 625 cm
6. 3.25 h

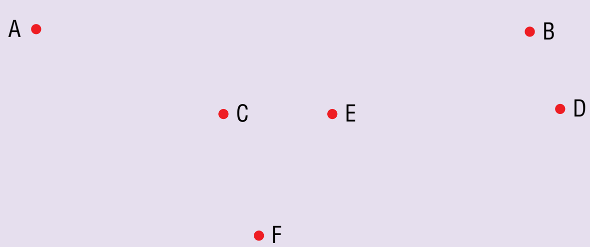
Measurement

Measuring Length

You can use a metre stick or a ruler to measure short distances. Metre sticks and rulers are usually marked off in millimetres and centimetres. To measure a distance, place the zero mark of the metre stick or ruler at one end of the distance to be measured and read the length at the other. Notice that the zero point is usually *not* at the end of the ruler.

Instant Practice

Use a ruler to measure the distance between the following pairs of points: A and D; C and E; B and F.



Measuring Area

Area is the amount of the surface of an object. You might want to determine the area of a piece of paper, a wall, or the surface area of a cube. If the area of an object is made up of common geometric shapes, you can measure the dimensions of the shape and use mathematical formulas to calculate the area. A piece of paper, for example, is often rectangular. You would measure the length and the width and then use this formula to calculate the area of the paper:

$A = l \times w$ (area = length × width)

Note: When you are making calculations, always be sure to use the same units of measurement. If you mix centimeters and metres, your calculations will be incorrect.

Instant Practice

Imagine that you are in charge of an art project that will transform one wall of your classroom into a large mural to show a variety of patterns. You may use as many different patterns and materials as you like. However, each piece must be a 30 cm × 30 cm square. How many squares will you need to make your mural?

1. Choose the unit of measurement that will be most practical for the area of the mural.
2. Measure the height and width of the wall you will cover.
3. Calculate the area of the wall in the unit you have chosen.
4. Calculate the number of 30 cm × 30 cm squares to fill one square unit. For example, if you chose metres, the square unit would be square metres (m^2).
5. Multiply this number by the area of the wall in the square unit that you chose.

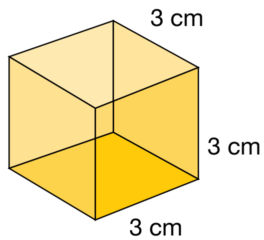
These students are using 10 cm × 10 cm squares. You are using 30 cm × 30 cm squares.

Measuring Volume

The **volume** of an object is the amount of space it occupies or the empty space in a hollow object. If an object is made up of common geometric shapes, you can measure the dimensions of the object and use mathematical formulas to calculate the volume:

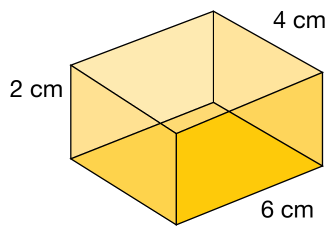
$V = l \times w \times h$

$V = 3\text{ cm} \times 3\text{ cm} \times 3\text{ cm}$
$= 27\text{ cm}^3$

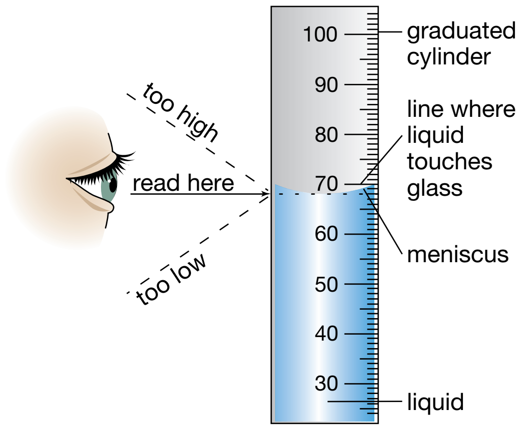


$V = l \times w \times h$

$V = 6\text{ cm} \times 4\text{ cm} \times 2\text{ cm}$
$= 48\text{ cm}^3$



The volume of fluids is usually expressed in litres or millilitres. You can measure the volume of a liquid directly by using a graduated cylinder as shown below. To measure accurately, be sure that your eye is level with the *bottom* of the meniscus. The meniscus is the curved surface of the liquid, as shown below.

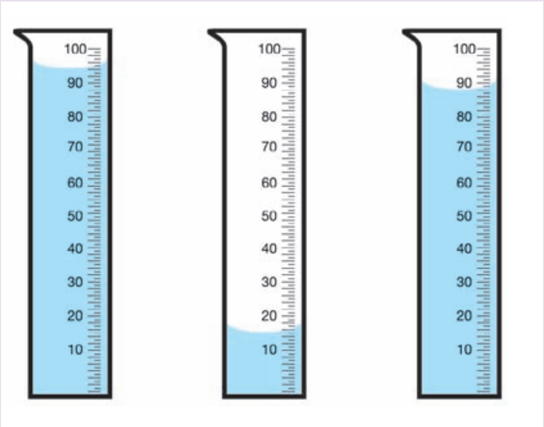


You can use liquids to help you measure the volume of an irregularly shaped solid. You would first measure a volume of a liquid such as water (Photo 1). Then, carefully slide the object into the water (Photo 2). Determine the total volume in the cylinder (Photo 3). The volume of the solid is equal to the difference between the volume before and after adding the solid.

Volume of object = volume of water with solid − volume of water only

Instant Practice

1. Read each volume shown below.



Measuring Mass

The **mass** of an object is the amount of matter that makes up the object. Mass is usually measured in milligrams, grams, kilograms, or tonnes. A balance is used for measuring mass. Your school might have triple beam balances like the one shown here. To measure the mass of a solid using a triple beam balance, follow these steps:

1. Set the balance to zero by sliding all three riders back to their zero points. Use the adjusting screw to be sure that the pointer rests at the zero point at the far end of the balance.

2. Place the object on the pan of the balance. The pointer will move up.
3. Slide the largest rider along until the pointer is just below zero. Then move the rider back one notch.
4. Repeat step 3 with the middle rider.
5. Adjust the smallest rider until the pointer swings equally above and below zero.
6. Add the readings on the three scales to find the mass.

To measure the mass of a powdery solid such as sugar, start by measuring the mass of an empty beaker. Next, pour the solid into the beaker. Then measure the mass of the beaker and solid together. To find the mass of the solid, subtract the mass of the empty beaker from the mass of the solid and beaker.

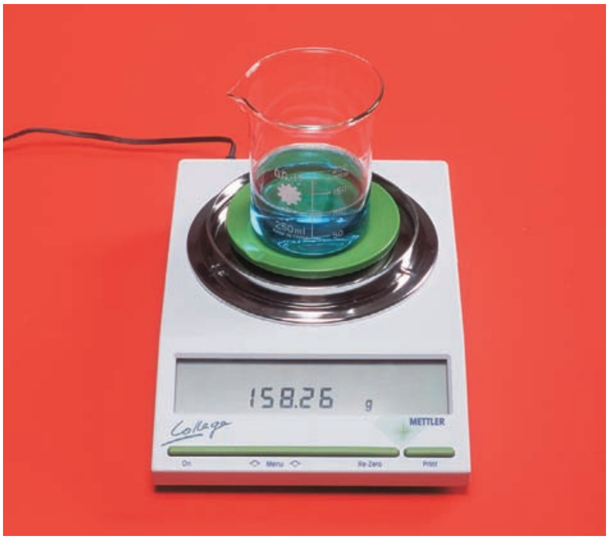
$$\text{Mass of sugar} = \text{Mass of sugar and beaker} - \text{Mass of empty beaker}$$

Instant Practice

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

The mass of the empty beaker is 61.5 g.

The mass of the sugar and beaker together is 161.5 g. The mass of the sugar equals the mass of the sugar and beaker together minus the mass of the beaker: 161.5 g − 61.5 g = 100 g.



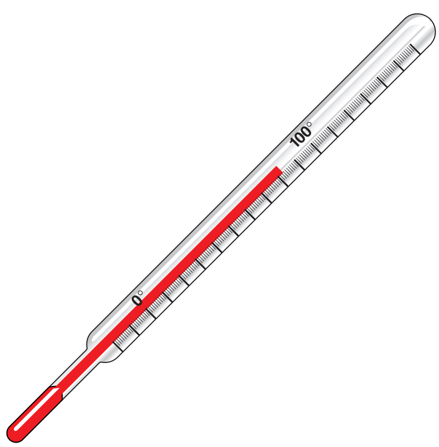
In advanced science courses, you might use an electronic balance like this. Just place the object on the pan and read the mass.

Measuring Temperature

Temperature is a measure of the average energy of motion of the particles in a substance. You can measure the temperature of a material by using a thermometer. You usually express the temperature of a substance in degrees Celsius. Zero degrees Celsius (0°C) is the freezing point of water. One hundred degrees Celsius (100°C) is the boiling point of water. The SI unit of temperature is the kelvin (K). Zero kelvins (0 K) is the coldest possible temperature. It is also called absolute zero. 0 K is equal to −273°C.

When using a thermometer to measure temperature, remember these three important tips.

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



In school laboratories, you will probably use a thermometer like this one. The temperature scale is in degrees Celsius.

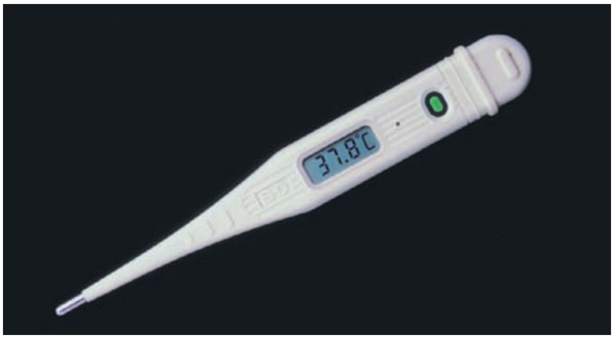
Instant Practice

Your teacher will supply your class with three large containers of water, each at a different temperature.

1. Twelve students will each be provided with a thermometer. When your teacher says "now," the students will take temperature readings of the water in the different containers. Four students will be asked to take a temperature reading of the water in one container. Four others will take the temperature reading of the water in the second container, and four others will take a reading of the water in the third container. Each student should keep the temperature reading a secret until putting it on a class chart.
2. Make a class chart on the chalkboard to record each of the students' temperature readings. The three columns will be:

Container 1	Container 2	Container 3
Temperature Reading (°C)	Temperature Reading (°C)	Temperature Reading (°C)

3. Each student will record the temperature reading of the water in the container used.
4. Did each person record the same temperature reading of the water in the same container? If the temperature readings were not all the same, explain why you think this might be so.

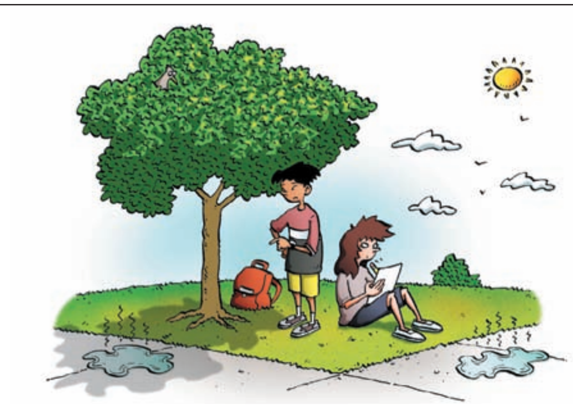


A digital thermometer like this one can be used to take your temperature.

Qualitative and Quantitative Observations

The rain has stopped and the Sun is out. You notice that a puddle has disappeared from the sidewalk. What happened to that puddle of water that was here a while ago? You could probably quickly answer that question, but how would you check the validity of your answer? You would start where all science starts: by making observations.

First, you might observe what happens to some other puddles. You would watch them closely until they disappeared and record what you observed. One observation you might make is, "The puddle is almost all gone." If you did, you would be making a **qualitative observation,** an observation in which numbers are not used. A little later, you might also say, "It took five hours for the puddle to disappear completely." You have made a **quantitative observation,** an observation that uses numbers.



Beginning your observations of water puddles

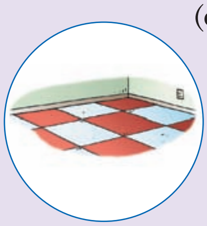
Concluding your observations of water puddles

Instant Practice—Making Qualitative and Quantitative Observations

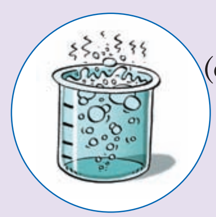
In your notebook, copy the observations below. Beside each, write "Qual" if you think it is a qualitative observation and "Quan" if you think it is a quantitative observation.

(a) Food colouring made the water blue.
Adding 3 mL of food colouring turned 250 mL of water blue.

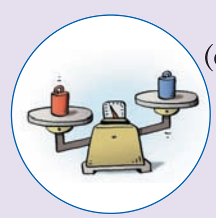
(b) The water became warmer.
The water's temperature increased by 5°C.



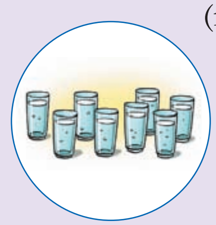
(c) We needed just over a dozen floor tiles for our model room.
We needed 14 floor tiles for our model room.



(d) The liquid boiled in 5 min.
The liquid took only a few minutes to boil.



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



(f) He drinks eight glasses of water each day.
He drinks 2 L of water each day.

Communicating Your Lab Work in a Lab Report

What if a scientist made a new and important discovery but didn't tell anyone? The discovery would do no good at all, because it would not be communicated to the scientific community. To communicate their discoveries, scientists submit papers to scientific journals where they are published. Then other scientists can verify the results and use the results for further experiments of their own. Your lab reports are similar to scientific papers. The sample report below shows you how you can use the headings in the Investigations to help you organize and write your report.

Give your report a title and write it at the top of the page.

Write the question or questions that you were trying to answer in the investigation. Use complete sentences to write the questions.

Make a hypothesis and write it out in a full sentence. In some investigations, you might have a prediction instead of a hypothesis. Your hypothesis or prediction should be something that can be verified or disproved. It also should be related directly to the question. If the investigation includes independent and dependent variables, the hypothesis should indicate a relationship between these variables.

Make a list of all of the materials that you used. This list includes all of the pieces of laboratory apparatus that are used over and over. It also includes chemicals and other materials that will be discarded at the end of the investigation. If specific quantities of the chemicals were used, include the amounts.

Write out every step in the procedure very clearly. Include safety precautions. Notice that most of the procedure steps start with an action word such as "put" or "prepare." These steps should be written in a way that another person could follow them and repeat the investigation. If diagrams are needed to show how different pieces of apparatus fit together, include a diagram.

If you collected data, include the data in a table. If you made a graph from your data, include the graph. Remember that you only include the data in this section. Save your analysis and conclusions for the later sections.

Acids and Bases in the Home

Question

Can you predict whether a household liquid will be an acid or base depending on its use?

Hypothesis

It is not possible to predict whether a household liquid is an acid or base.

Materials

8 test tubes	dilute acid
test tube rack	dilute base
glass stirring rod	vinegar
eye dropper	mayonnaise
labelling tape	liquid drain cleaner
paper towels	window cleaner
red litmus paper	cola soft drink
blue litmus paper	liquid laundry soap
water	

Procedure

CAUTION: Do not let any of the liquids get on your skin. If it does, rinse your skin with a lot of water.

1. Prepare a data table with the following headings: Sample, Blue Litmus Paper, Red Litmus Paper. Make eight rows and write the name of sample in the first column. Record the data in the other columns.
2. Put the eight test tubes in the test tube rack. Label each test tube with tape by writing the name of each of the eight liquids in the materials list on the tape.
3. With the eye dropper, put about 1 mL of each liquid into each of the test tubes with the correct label. Rinse the eye dropper with water between each type of liquid.
4. Place eight small pieces of red litmus paper and eight small pieces of blue litmus paper on a paper towel.

5. Use the eye dropper to transfer one drop of the dilute acid to a piece of red litmus paper. Transfer another drop of dilute acid to a piece of blue litmus paper.
6. Record the final colour of each piece of litmus paper.
7. Rinse the eye dropper with water and dry it with some paper towel.
8. Repeat steps 4 through 6 for each of the other seven liquids.

Data Table		
Sample	Blue Litmus Paper	Red Litmus Paper
dilute acid	turned red	stayed red
dilute base	stayed blue	turned blue
vinegar	turned red	stayed red
mayonnaise	turned red	stayed red
liquid drain cleaner	stayed blue	turned blue
window cleaner	stayed blue	turned blue
cola soft drink	turned red	stayed red
liquid laundry soap	stayed blue	turned blue

In this section, you examine your data and look for connections between variables or other factors. The questions in the "Analyze" section of the Investigation will guide you through this section. Be sure to answer all of the questions in the "Analyze" section. If you made tables, you explain what these tables revealed. If you made graphs, you explain the meaning of the graphs.

Analyze

1. When acid was placed on red litmus paper, it stayed red. When acid was placed on blue litmus paper, it turned red.
2. When base was placed on red litmus paper, it turned blue. When base was placed on blue litmus paper, it stayed blue.
3. The following table shows the results for the household liquids.

Red litmus paper stayed red. Blue litmus paper turned red.	Red litmus paper turned blue. Blue litmus paper stayed blue.
vinegar	drain cleaner
mayonnaise	window cleaner
cola soft drink	liquid laundry soap

Finally, you compare your results with your hypothesis or prediction. You state whether your hypothesis or prediction was verified of disproved. In either case, you state any conclusions that your results revealed. Once again, the questions in the "Conclude and Apply" section in the Investigation will guide you in writing this section. Be sure to answer all of the questions. If your conclusions can be used in everyday life, state how they can be used.

Conclude and Apply

4. Acid turns blue litmus paper red but red litmus paper stays red.
5. Base turns red litmus paper blue but blue litmus paper stays blue.
6. Vinegar, mayonnaise, and cola soft drinks are acids.
7. Drain cleaner, window cleaner, and liquid laundry soap are bases.
8. The hypothesis is not correct. It is possible to predict whether a household liquid is an acid or base.

Common Laboratory Equipment

When you do scientific experiments at school, you often will use equipment that is found in science laboratories throughout the world. In your science class this year and in future years, you will develop skills and safe practices in the use of laboratory equipment. A selection of equipment that you will be using is presented below and on the two pages that follow. Your teacher will show you how to use laboratory equipment properly and safely.

Protective equipment: specially designed coverings to protect your eyes, hands, and clothing from chemicals and heat that could cause harm or stains that are difficult to remove. For example, safety glasses (1), heat resistant gloves (2), and lab coats (3). Special rubber gloves are used to protect hands/skin from contact with chemicals.

Equipment for measuring: includes balances, graduated cylinders, and thermometers

balance (4)*:* used to measure the mass of an object or sample of matter. A traditional balance works by balancing the mass of one thing against a known mass (as in an equal-arm or a triple-beam balance). Modern electronic balances, seen within photo below, measure and display mass directly.

graduated cylinder (5)*:* used to measure the volume of a liquid or a granulated solid (one that can be poured, such as salt or sugar). Graduated cylinders come in different sizes to hold volumes of liquid that range from 10 mL to 1000 mL. The scale is divided (graduated) more finely than the scale on a beaker, so volume measurements are more precise and accurate.

Equipment for observing objects: includes tools that have lenses

microscope (6)*:* used to magnify (make larger) objects up to 400 times their actual size. (High-tech microscopes can magnify objects up to millions of times their actual size.) Microscopes are useful for seeing details of extremely small items.

magnifying glass (7)*:* used to magnify objects within a limited range so that various features are easier to observe. Magnifying glasses are useful because they allow objects to appear much larger than they are.

Equipment for heating objects: includes hot plates and burners

hot plate (8)*:* used to heat liquids. Hot plates generate enough heat to boil water, but they do so without the

danger that is associated with flames from a burner. Hot plates are good for general heating of liquids in beakers or other flat-bottomed containers, but less useful for heating solids, or heating to very high temperatures. A Bunsen burner is the best choice in this situation.

Bunsen burner (9)*:* used to heat solids and liquids. Bunsen burners, like all burners, use fuel to produce an open flame, so extreme caution is necessary if they are to be used.

Glassware: includes beakers, test tubes, and flasks, and could be made of plastic instead of glass.

beaker (10)*:* used to hold, mix, and measure liquids. Beakers come in different sizes to hold volumes of liquid that range from 25 mL to 600 mL and more. For more precise and accurate measurements of the volume of liquids, you would use a graduated cylinder. It can also be used for heating substances or for mixing larger amounts of chemicals

test tube (11)*:* small tube that is closed at one end and used to hold samples of chemicals (usually liquids). The samples may be mixed with small amounts of other chemicals to observe possible changes. When heating substances in a test tube, make sure that the tube is made of material that will not break when heated.

flask: narrow-necked bottle with straight sides (Erlenmeyer flask, 12) or rounded sides (Florence flask, 13) used to hold, mix, and heat liquids. Only heat liquids within a flask that is approved to withstand heat.

Petri dish (14)*:* a clear, flat, round dish with a cover that can be used to hold small amounts of liquids or solids. (Petri dishes that contain a gelatin-like substance called agar can be used to grow bacteria, but this must be done under careful conditions.)

watch glass (15)*:* a concave disk that can be used as a cover (for a beaker, for instance) or to evaporate a small amount of liquid such as a solution.

stirring rod (16)*:* used to stir liquids and mixtures in beakers and flasks. Only use approved stirring rods to stir solutions.

Equipment for holding, supporting, containing, and transferring: includes stands, tongs, stoppers, and stationary holders

retort stand (17)*:* used, often along with a clamping device, to hold or support glassware so that chemicals can be heated or mixed and observed.

clamp (18)*:* a device that is usually attached to a stand to support or hold glassware such as a test tube, a flask, or a tube. A ring clamp is shown below. Other clamps are available for holding items in place. Remember to always put the clamp as low on the stand as possible to ensure the stand does not become top heavy.

tongs (19)*:* used to pour or move glassware such as test tubes or beakers. An example of test tube tongs appear in the photo below.

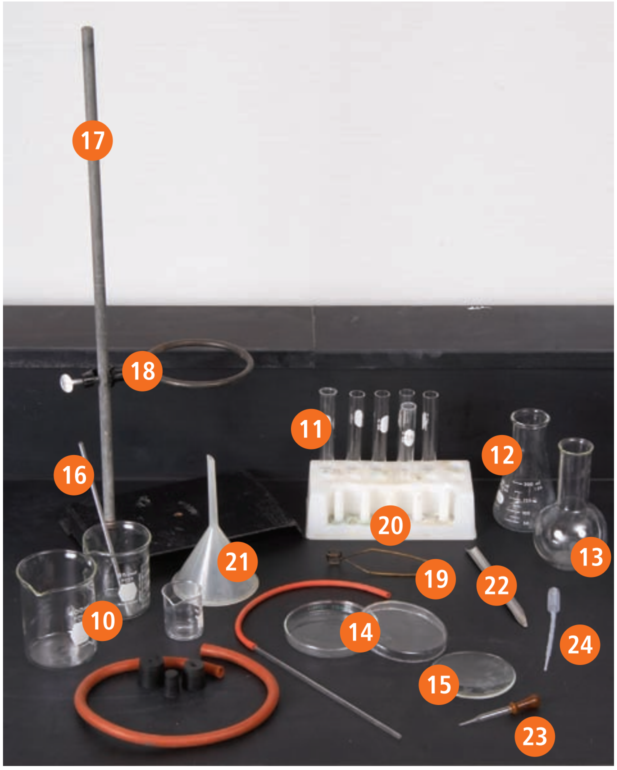
test tube rack (20)*:* used to hold one or more test tubes safely and securely, leaving your hands free for other tasks.

funnel (21): used to transfer liquids or granulated solids into containers that have small openings

scoopula (22)*:* used to transfer small amounts of solids to other equipment such as a test tube, beaker, flask, or watch glass. (You might also hear it referred to as a spatula scoop.) Remember to use a scoopula for transferring only one substance at a time to avoid cross contamination of chemicals.

eye dropper (23)*:* used to transfer very small volumes of liquid into other equipment. Some eye droppers are calibrated so that you can measure specific volumes ranging up to 1 mL. (You might also hear it referred to as a medicine dropper.)

pipette (24)*:* used to transfer small precise volumes of liquid from one container to another.

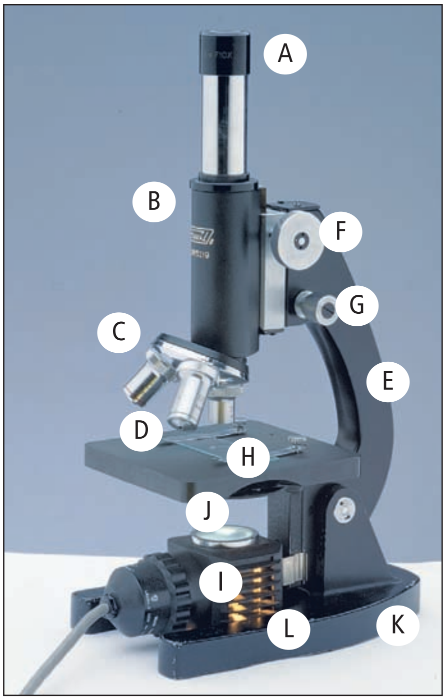


Using a Microscope

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. It 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. Before you use your microscope, review its parts and their functions.

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.

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

F. 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 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.

K. Base
Supports the whole microscope

L. 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.

Using the Microscope

These are the basic steps for finding and viewing an object with the microscope.

1. Make sure the low power objective lens is in place and that it is set at its lowest position.
2. Use the stage clips to secure the slide to the stage.
3. Slowly turn the coarse adjustment knob to bring the object on the slide into focus.
4. Then use the find adjustment knob to bring the object into sharper, clearer focus.
5. If you need to observe the object under higher magnification, rotate the revolving nosepiece to bring the medium power objective lens into place.
6. Use the fine adjustment knob to bring the larger image into focus. (**CAUTION!** Never use the coarse adjustment knob with the medium or high power objective lens.)
7. When you finish, return the low power lens into position. Then, using the coarse adjustment knob, move the low power lens to its lowest level.
8. When you return the microscope to its storage area, remember to use one hand to grasp it securely by the arm, and support the weight of the microscope with your other hand under the base. Hold the microscope in front of you, close to your body, as you bring it to the storage area. (**CAUTION!** Never move a microscope by holding it by the arm alone.)

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.

How to Prepare Specimens for Viewing.

When using a compound microscope to view specimens, the specimen must be placed on a small glass slide and covered with a very thin square of glass called a **cover slip.** There are two main types of specimen slides used in schools. These are **permanent slides** and wet mounts. Permanent slides may be used over and over. Often the specimen has been stained with a chemical to make certain parts of the specimen more visible. A special type of glue is used to permanently hold the cover slip in place.

The other type of specimen slide is called a **wet mount.** The wet mount is very useful when viewing living specimens, particularly microscopic organisms, as you can see them moving, eating, and even reproducing. A wet mount is a temporary specimen slide because the specimen is disposed of after viewing and the slide and cover slip can be reused.

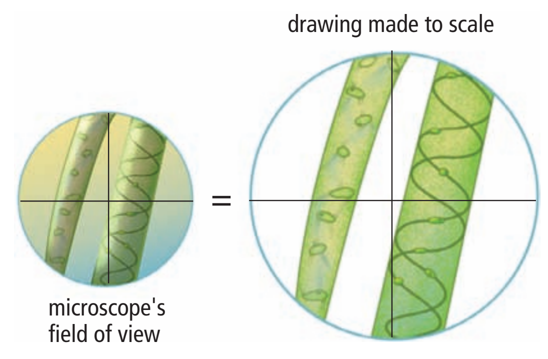
To Make a Wet Mount

1. Place the specimen/sample on a slide.
2. Using an eye dropper, add a drop of water. Sometimes a stain is used to make the specimen more visible. The water helps support and prevents living specimens from drying out.
3. Carefully put the cover slip over the specimen/sample as follows: Place the cover slip at an angle onto the slide so that it touches the drop of water. Using a tooth pick or other small pointer, slowly lower the cover slip onto the drop. This will prevent the formation of air bubbles under the cover slip, which will interfere with your viewing of the specimen. **CAUTION:** Be careful when handling the cover slip as it is very thin glass and can break easily.
4. If there is too much water and the cover slip is "floating around" you can remove some of the excess water by holding the edge of a paper towel next to the edge of the cover slip.
5. If there is too little water you can add more water by adding a drop next to the cover slip. This water will get pulled under the cover slip.
6. If you need to add stain to the specimen after you have made a wet mount, you can do this by putting a drop of the stain on one side of the cover slip. Then hold a paper towel to the other side of the cover slip. As water is pulled into the paper towel the stain will be pulled in under the cover slip to replace the water that was removed.
7. To view your specimen/sample, follow the directions for "using the microscope".
8. When you are finished viewing your specimen, dispose of the specimen as directed by your teacher. Then wash the slide as directed by your teacher. Because they are so fragile, cover slips are difficult to clean and should be disposed of in the broken glass container as directed by your teacher.

Instant Practice—Drawing

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.



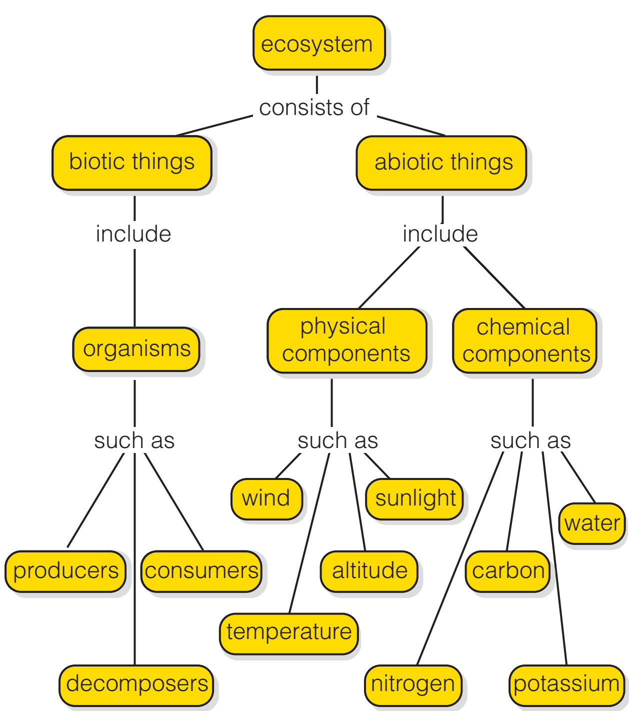
3. Using low or medium power, locate a sample from the prepared slide that interests you. Imagine that the field of view is also divided into four equal sections.
4. Note in what part of the field of view the object lies and how much of the field of view the object occupies.
5. Draw the object in the 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.

Using Graphic Organizers

A **graphic organizer** is a way of arranging ideas visually. A typical graphic organizer consists of a group of boxes or circles in which key terms or concepts are written. Lines connecting the boxes show how the concepts are connected. Sometimes a short phrase is written on the lines to explain the connection. Graphic organizers are tools that help you understand and remember new ideas and information. You can often recognize new relationships when you use a graphic organizer. Several examples of graphic organizers are described below. These graphic organizers are sometimes also called *concept maps*.

Network Tree

A graphic organizer called a **network tree** starts with a description of one central concept or idea written in a box. Terms that describe characteristics or smaller parts of the central concept are written in more boxes. The lines, or branches of the tree, show how the central concept is broken down into smaller parts. The example below shows the things that make up an ecosystem.

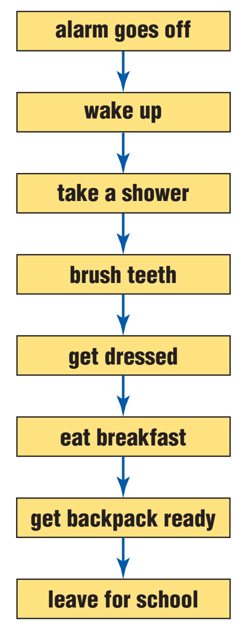


Flowchart

A graphic organizer called a **flowchart** shows a sequence of occurrences or steps in a process. The flowchart below shows the events that follow a volcanic eruption.

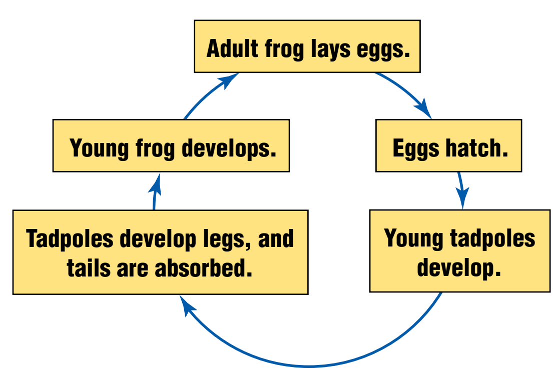
Events Chain

A graphic organizer called an **events chain** shows the order in which events occur. The events chain on the right shows what happens after your alarm goes off in the morning.



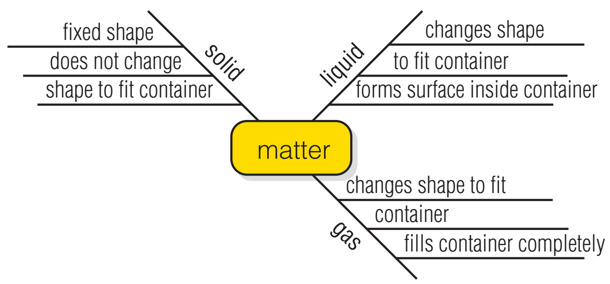
Cycle Map

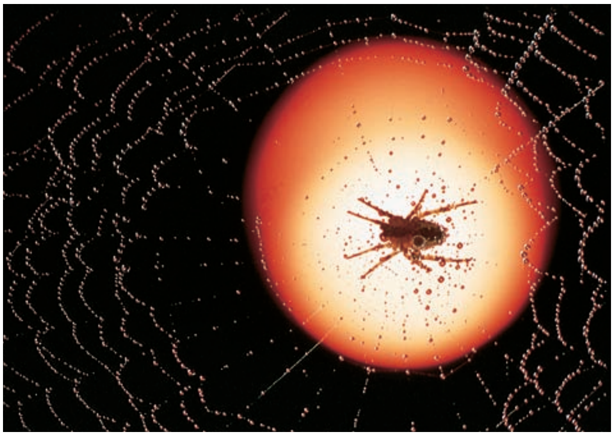
A graphic organizer called a **cycle map** is like an events chain that has no beginning and no ending. The events occur over and over. Since the events are placed in a circle, you need arrows to show the order in which the events occur. The cycle map below shows the life cycle of a frog.



Spider Map

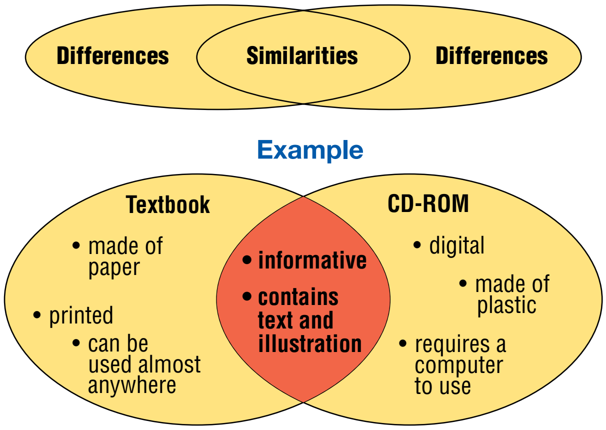
A graphic organizer called a **spider map** connects several objects or ideas to one central event or object. You can use a spider map for brainstorming. To draw a spider map, you place the most important event or object in the centre of the page. Then you write related ideas, events, or descriptions on lines drawn outward from the centre. These topics might not be related to each other, but they are related to the central topic. Finally, you write other ideas or descriptions on horizontal lines connected to the lines that point outward. The map soon begins to look like a spider, as shown here. This spider map describes the three states of matter. The central idea, matter, is the "body" of the spider. The related ideas, solid, liquid, and gas, are the "legs" of the spider.





Venn Diagram

A graphic organizer called a **Venn diagram** shows the similarities and differences among objects or ideas. Venn diagrams are made of two or more overlapping ovals or circles. Each oval represents a concept, an object, or an idea. In the area in which the ovals overlap, you write the *similarities* between the objects or ideas. You write the *differences* in the parts of the circles that do not overlap. Study the following example to see the similarities and differences between a print textbook and an e-book CD-ROM.



Instant Practice

1. Use these words to produce a network tree: hockey, team sports, ice, diamond, field, bat, puck, hardball, cleats, ice skates, baseball, soccer ball, stick, soccer, feet.
2. Produce an events chain that starts with lunch and ends with your return home from school.
3. Produce a cycle map using the following words: summer, winter, fall, spring.
4. Make a Venn diagram to compare and contrast a video cassette and a DVD.
5. In a group, create a spider map based on one of the following topics:
   (a) food and nutrition
   (b) music
   (c) scientific discoveries
   (d) communication