
# Introduction to Science

## Junior Science

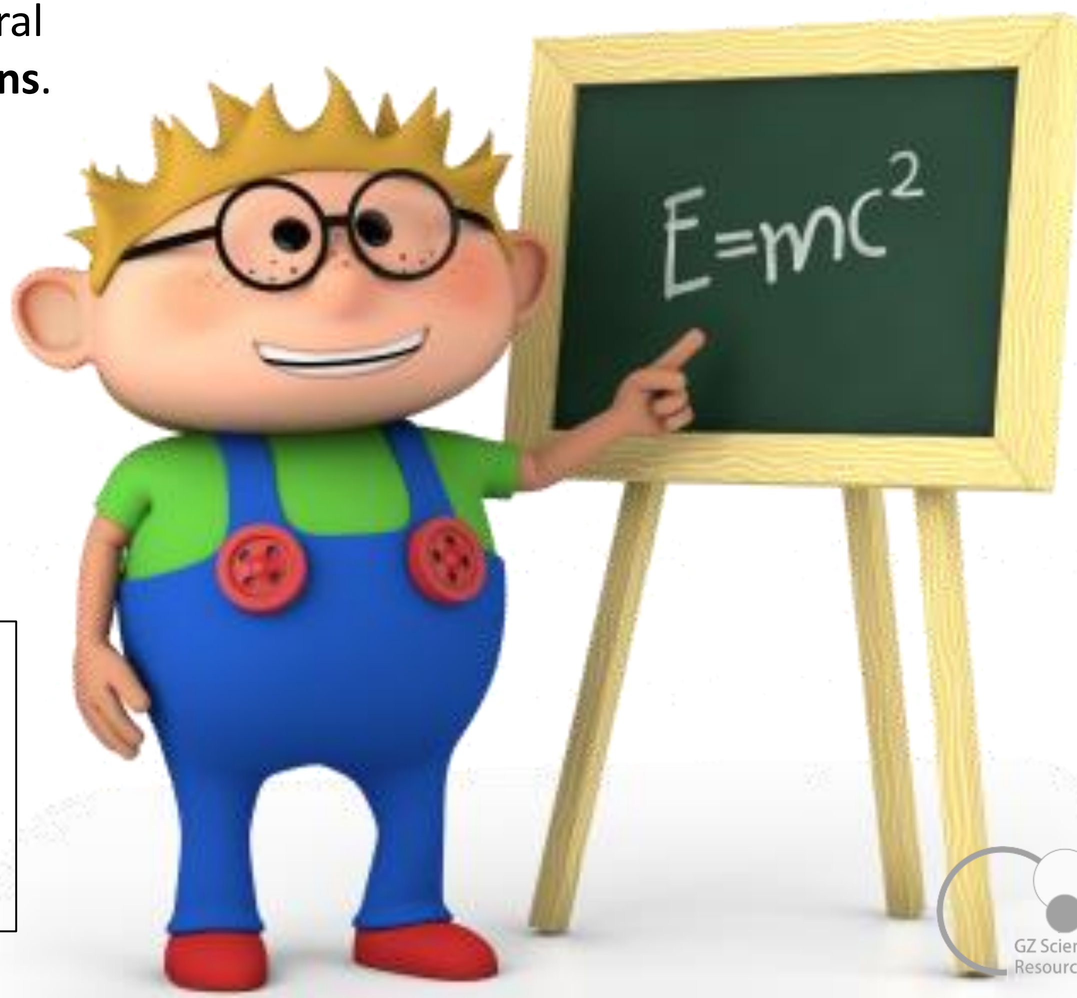
# What is Science?

Science is <u>both</u> a collection of **knowledge** and the **process** for building that knowledge.

Science asks **questions** about the natural world and looks for natural **explanations**.

Science works only with **testable** ideas and uses **observations** to make **conclusions**.

**Theories** are developed based on the **evidence** scientists collect.




**Moral** judgments, decisions about how to use science discoveries, and conclusions about the **supernatural** are <u>outside</u> the area of science

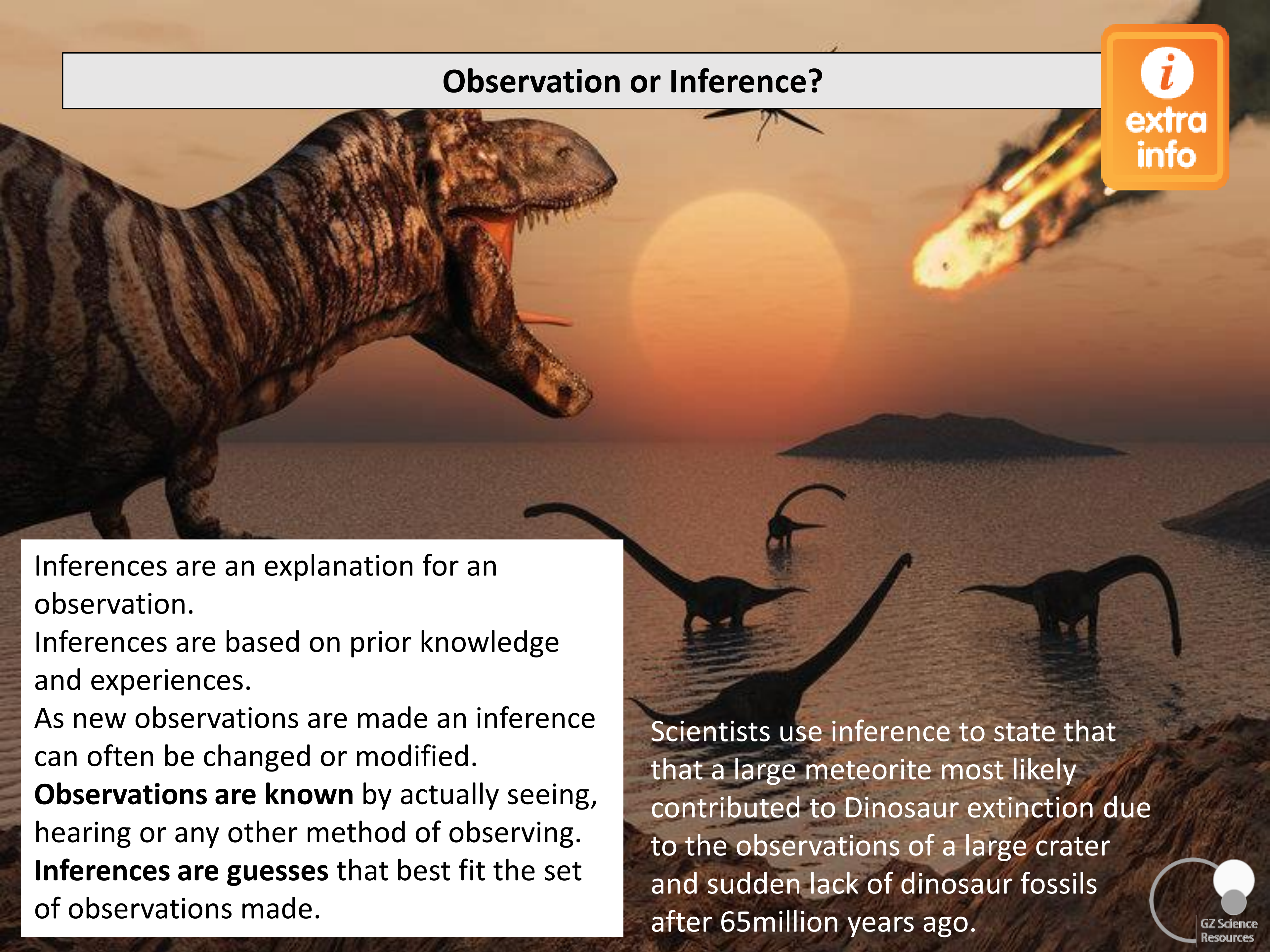
# Observation in Science

To observe means to record or make note of something we have experienced. We also think of observations as watching something, but in Science, observations may be made with any of our senses (by seeing, feeling, hearing, tasting, or smelling) or even using tools to make observations that are then changed into something our senses detect.

Observation tools include thermometers, microscopes, telescopes, radars, computer sensors and spaces probes. Sometimes these tools are able to observe and collect data that humans cannot directly sense. By using these tools scientists can often make many more observations and much more **precisely** than our senses are able to.


GZ Science Resources

# Observation or Inference?

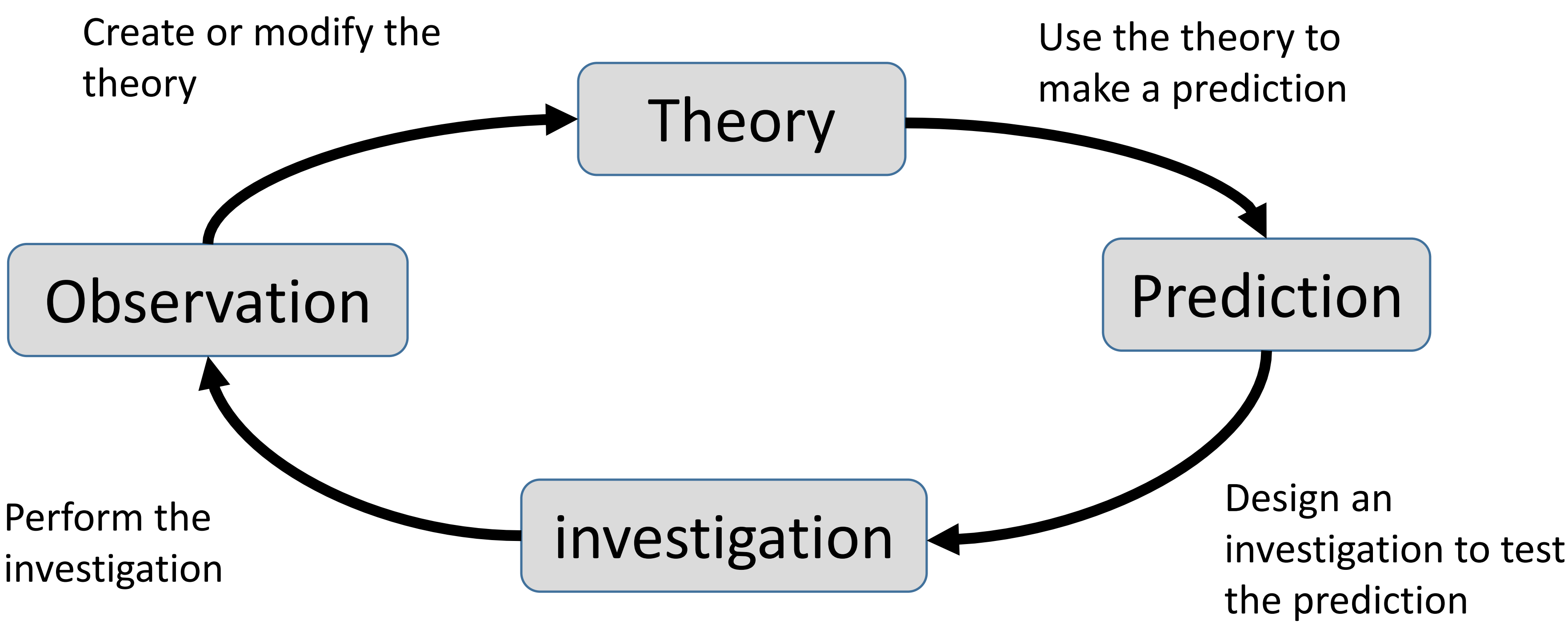



Inferences are an explanation for an observation.
Inferences are based on prior knowledge and experiences.
As new observations are made an inference can often be changed or modified.
**Observations are known** by actually seeing, hearing or any other method of observing.
**Inferences are guesses** that best fit the set of observations made.

Scientists use inference to state that that a large meteorite most likely contributed to Dinosaur extinction due to the observations of a large crater and sudden lack of dinosaur fossils after 65million years ago.

# I have a Theory

Many people understand the word theory means a guess about what something is or how it works but in Science the word means something else.
A Scientific theory is the **best explanation available** currently for how the world works. A theory has been **thoroughly tested** and is supported by **large amounts of evidence**.




Scientific theories must also be **flexible** and be modified or changed so it is able to explain any tested observations that do not fit the original version.

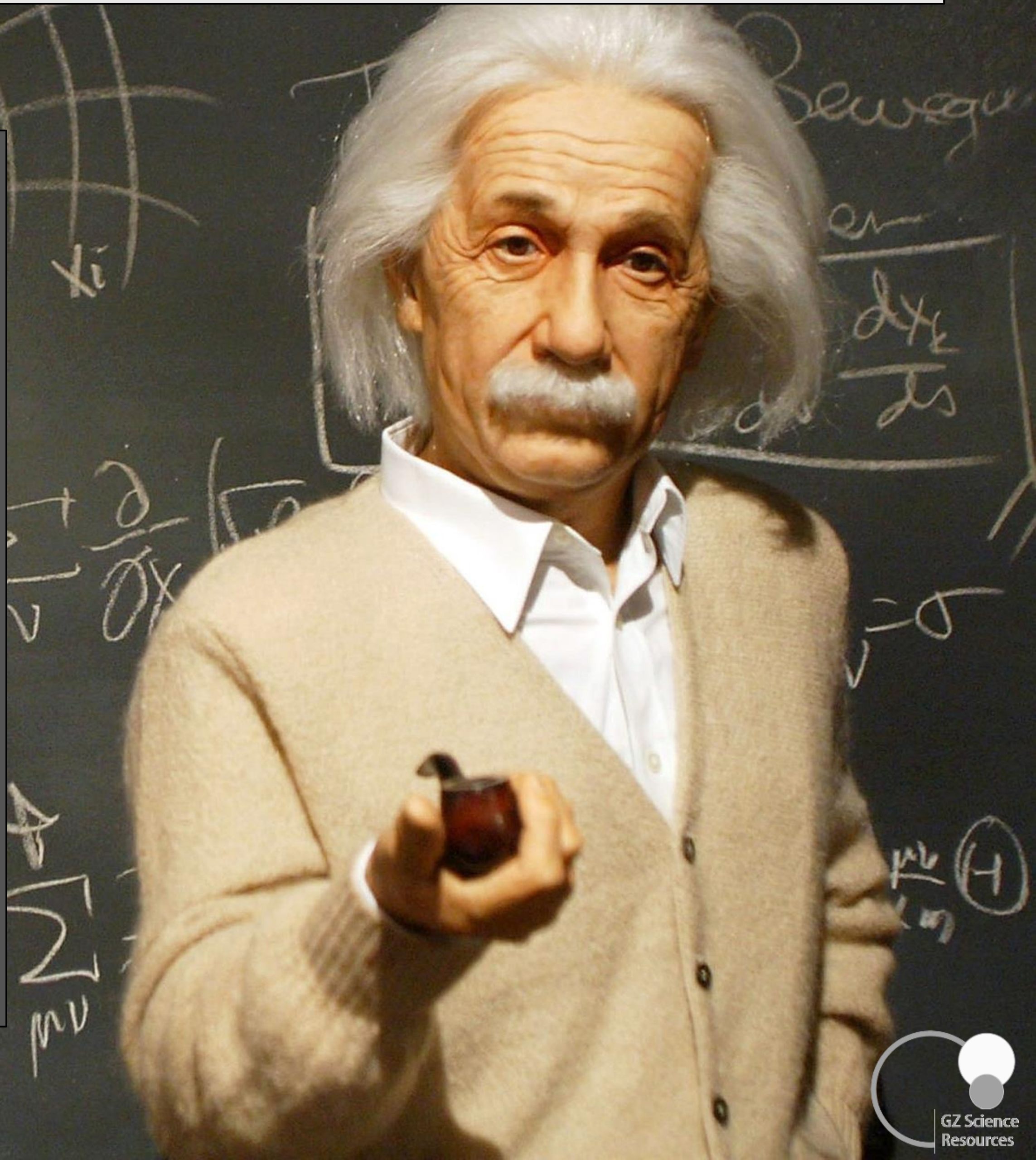
extra info

## Standing on the shoulders of Giants

Science ideas are often the result of **many scientists contributing** observations and evidence which build on previous knowledge.

Before Scientists begin testing their predictions they need to research what has already been found out in the past so they know what to look for.

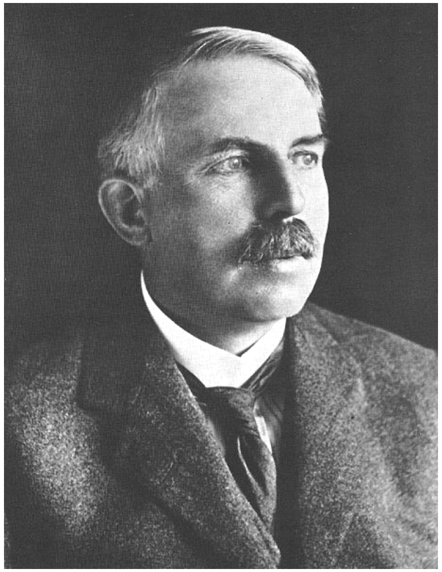
Scientists such as Isaac Newton, Albert Einstein and Sir Ernest Rutherford all built on knowledge from others that came before them.



extra info

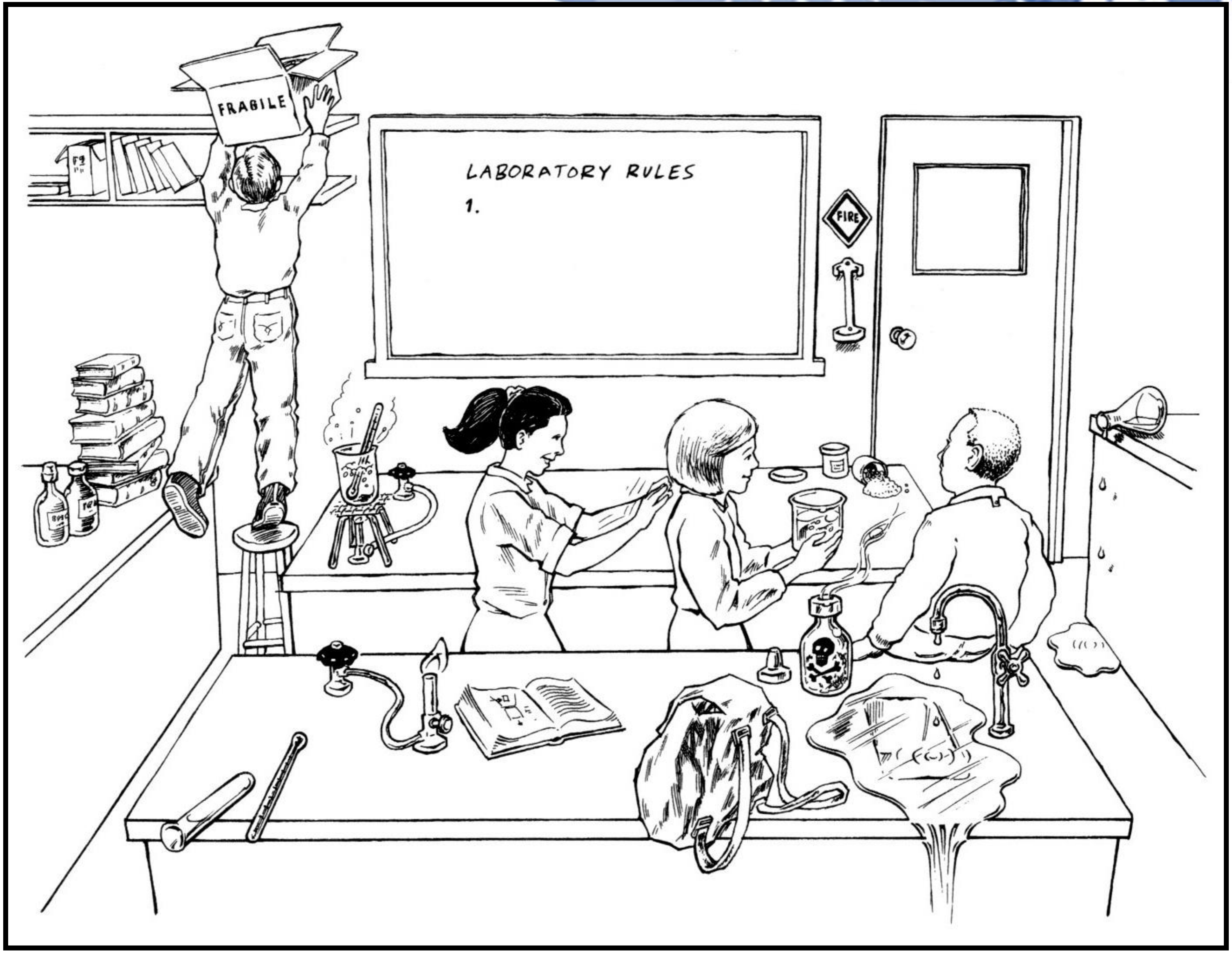
# Who wants to be a Scientist?

The New Zealander Joan Wiffen was well known as a tireless hunter of New Zealand Dinosaur bones – disproving the long established idea that no dinosaurs made it across to NZ before it broke away from Gondwana or if they did then New Zealand's active geological past destroyed any evidence of dinosaur fossils. Although she was not formally trained as a scientist, she self taught herself the correct ways of working scientifically.



The New Zealand Scientist Sir Ernest Rutherford completed his secondary schooling and three university degrees here at home then went on to continue his Scientific education at other universities overseas including Cambridge University, England. He was most famously known for inferring the structure of the atom from his testing and tireless observations. Sir Rutherford collaborated with many other scientists and freely shared his evidence with others.

# Spot the Dangers in the lab



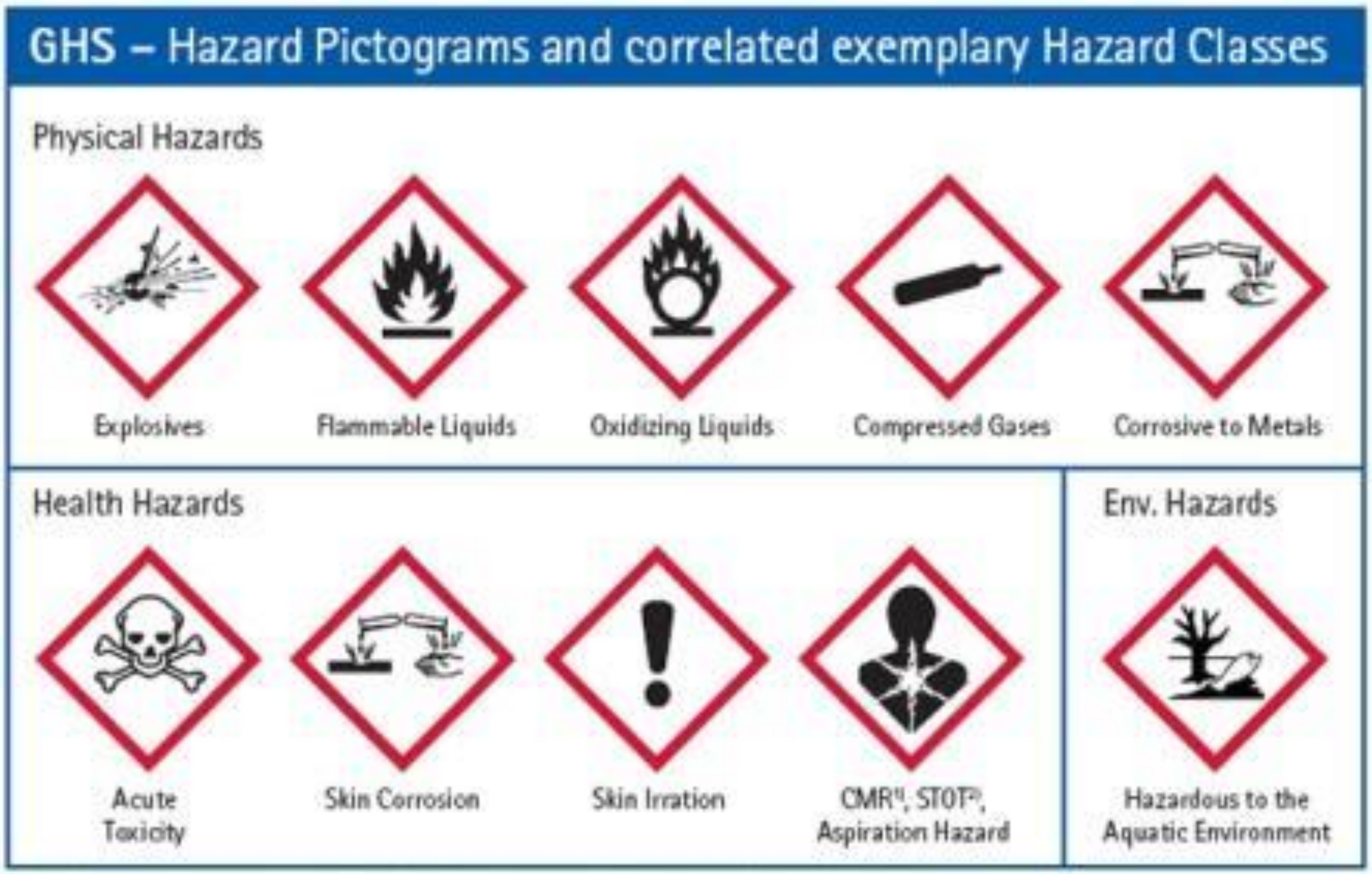
# Laboratory Rules

A School Science Laboratory can be a fun place that allows you to investigate and observe Science taking place. It can also be a dangerous place if rules are not followed. To protect yourself and the classroom from harm we need to follow School Lab Rules carefully each time we are in the class or taking part in a practical.

1. Don’t smell or taste chemicals.
2. Place bags under your desks.
3. Wear safety equipment if asked.
4. Tie long hair back during practicals.
5. No running in class.
6. Tell the teacher if you break equipment.
7. Clean up your work area after practicals.
8. No eating in the class.
9. …………………
10. …………………

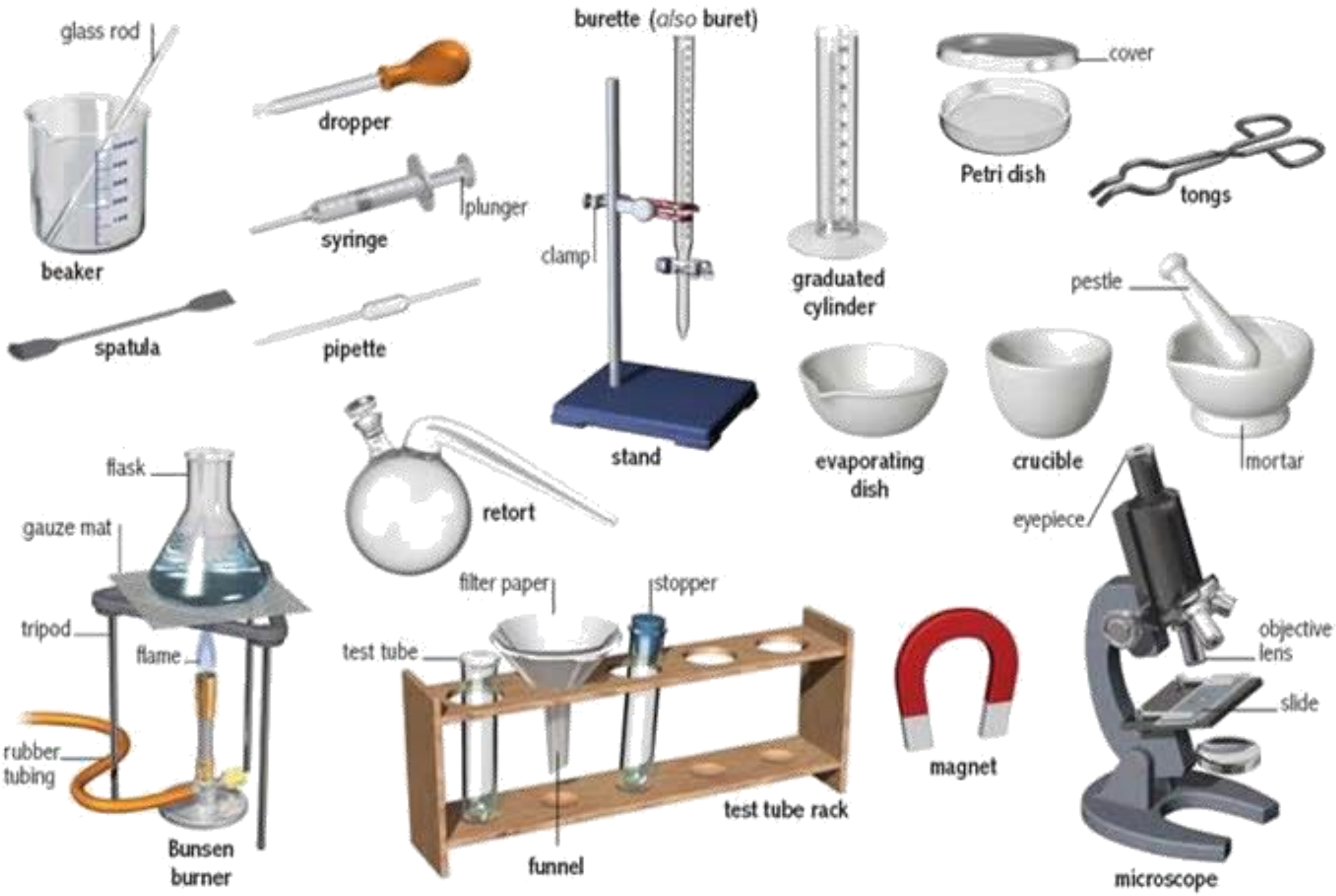
# Laboratory safety symbols

Easy to recognise safety Hazchem symbols are often used in Labs and on labels of chemicals when special care is required.  A chemical may be poisonous or be explosive or burn when it touches skin. Safety symbols and Lab rules are designed to warn and protect you from dangerous situations.



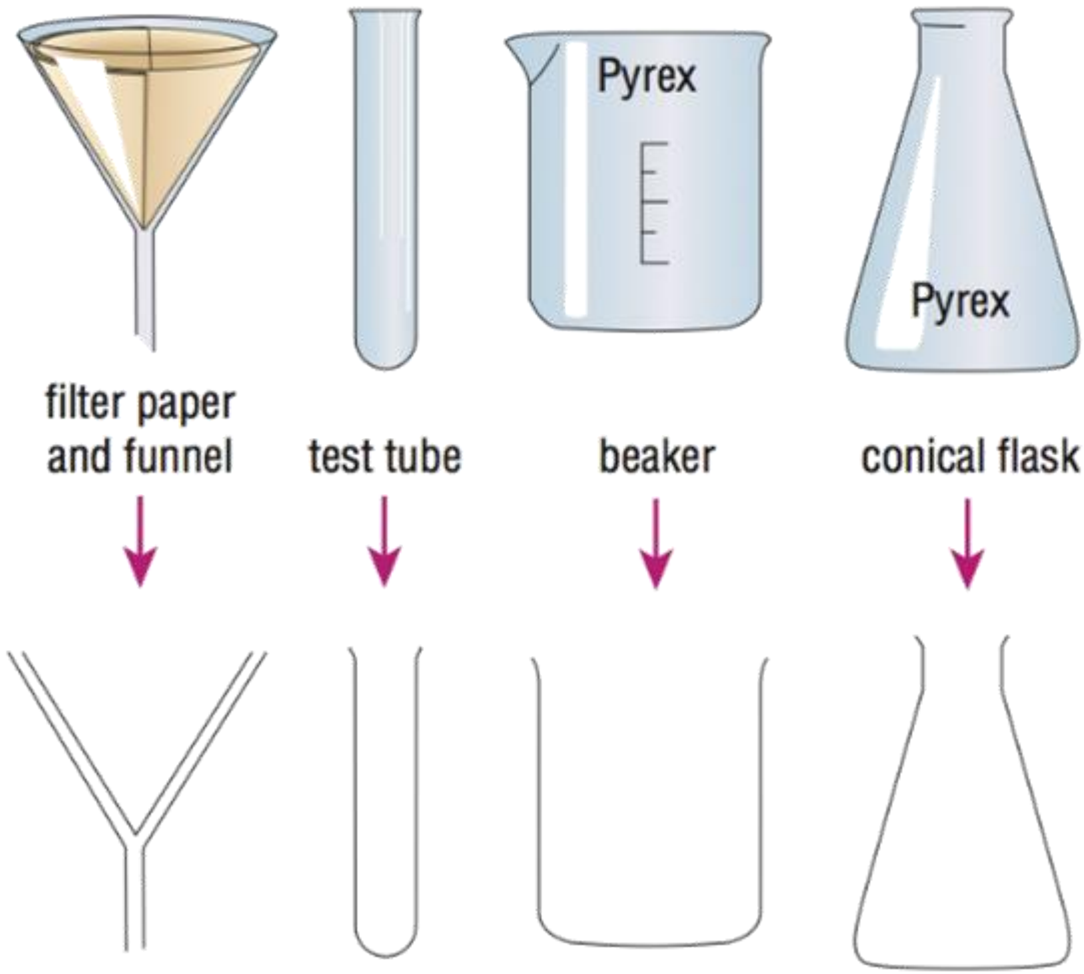
# Common Laboratory equipment

Science labs contain equipment that are used to carry out investigations and experiments. This equipment may be quite different from what we have in our homes but it is often designed for specific uses.
The names and uses of the equipment will need to be learnt along with how to use it.




GZ Science Resources

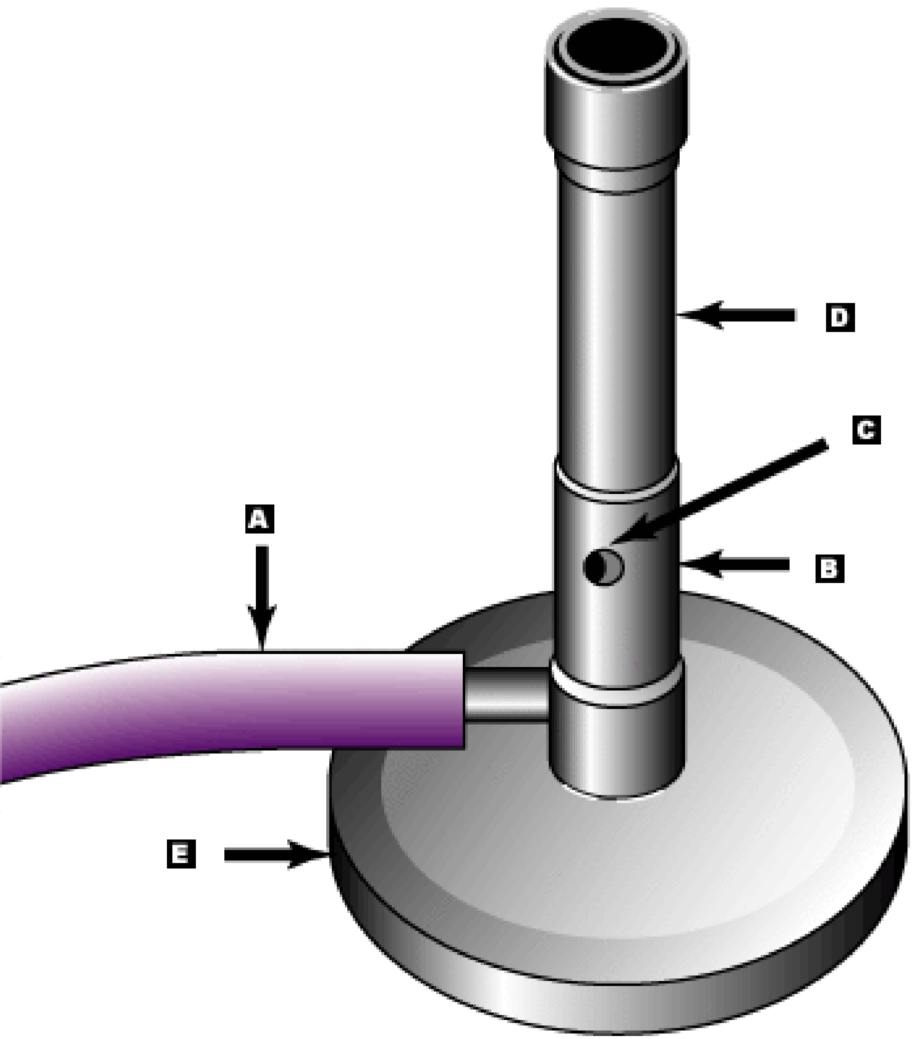
# Drawing equipment in Science




In the science lab we use special equipment. Often we have to draw the equipment. We use diagrams to show the equipment, which saves us time drawing. The scientific diagrams are recognised world wide.

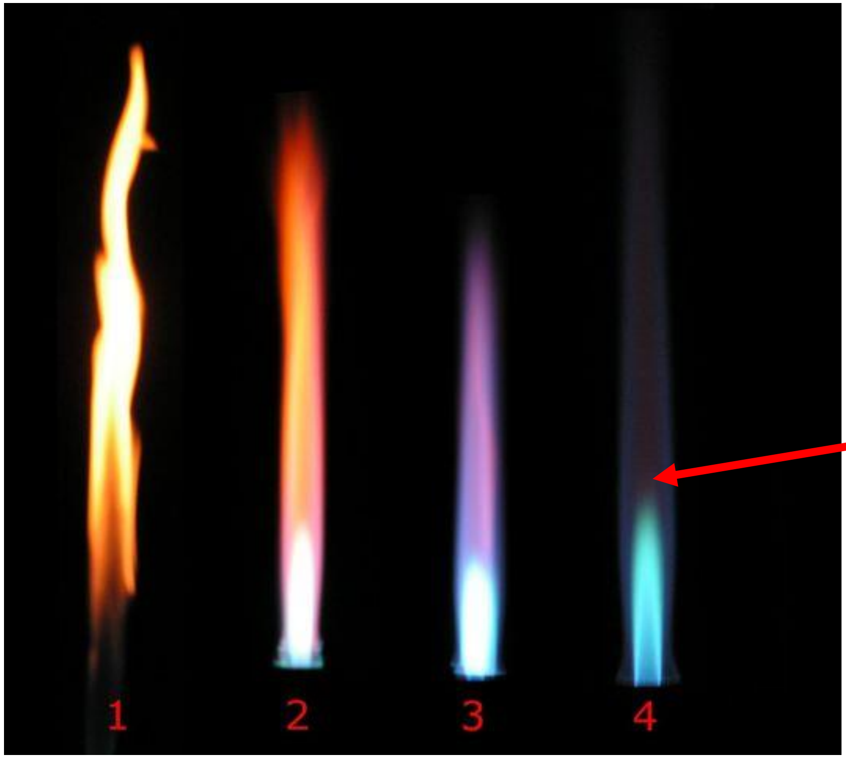
GZ Science Resources

# Draw and label the Bunsen Burner




| Part of the Bunsen Burner | Function |
|---|---|
| A. Gas hose | To allow gas to enter the burner |
| B.  Collar | To control the amount of air entering the burner |
| c. Air Hole | To allow air to enter the burner |
| D. Barrel | To raise the flame to a suitable height for heating and burning |
| E. Base | To support the burner and make it more stable |

# The Bunsen Burner Flame




When using the Bunsen Burner to heat boiling tubes etc place it at the hottest place at the top of the bright blue flame.

The Bunsen Burner burns gas with oxygen in the air to make a hot flame used in the laboratory. When the air hole is closed (1) the flame is large and orange. This flame only partly allows oxygen to burn with the gas so is cooler and creates soot. As the air hole is opened more (2-4) the flame becomes bluer and hotter. The best flame to use is (4) with the air hole mostly open.

# Measurements in Science

The process of science involves observation, investigation and testing. Scientific observations can be made directly with our own senses or may be made indirectly through the use of equipment to collect data. Being able to take **accurate** measurements is important. The units and type of equipment used depends on whether you are measuring length, volume, temperature or mass.

# Measuring in Science

| Quantity | Unit | Symbol | Equipment used |
|---|---|---|---|
| Volume | litre | L | flask |
| | millilitre | mL | measuring cylinder |
| Temperature | Celsius | °C | thermometer |
| Mass | kilograms | Kg | Scales |
| | grams | g | Scales |
| Length | Metres | m | Metre ruler |
| | millimetres | mm | Hand ruler |

Note: **Weight** is the result of force (gravity) acting on mass and is measured in Newton's using a spring balance. Weight and Mass are often confused.

# Converting measurements

extra info

Quantities are often measured in different **scales** depending upon what is most appropriate for the original size. In Science (and Mathematics) we use common **prefixes** to indicate the scale used.
We sometimes want to convert scales from one to another to compare data or to place the measurements into equations.

| **Prefix** | | **Scale** |
| --- | --- | --- |
| Kilo | = | 1000 |
| Centi | = | 1/100$^{th}$ |
| Milli | = | 1/1000$^{th}$ |

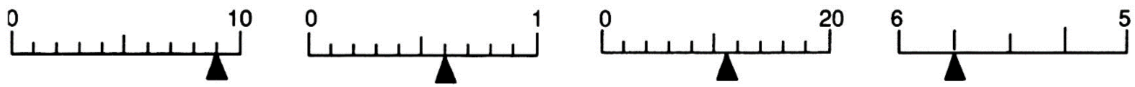
So 1 kilometre = 1000 metres
1 metre contains 100 centimetres
1 metre contains 1000 millimetres

To convert from grams to kilograms **divide** by 1000
(or metres to kilometres and millilitres to litres)

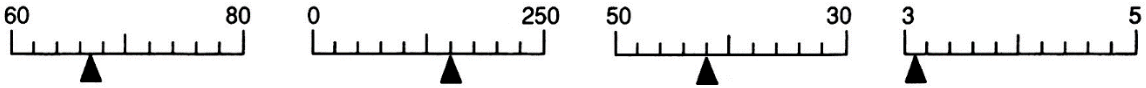
To convert from kilograms to grams **multiply** by 1000
(or kilometres to metres and litres to millilitres)

# Measurements in Science

**1** Fill in the readings on the scales shown.

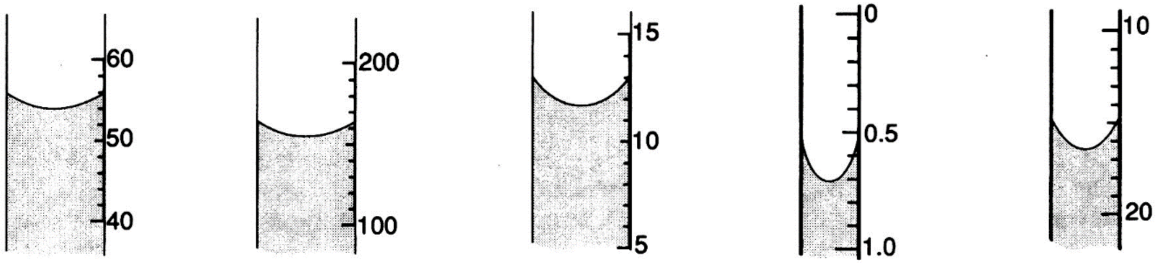



A __________ B __________ C __________ D __________



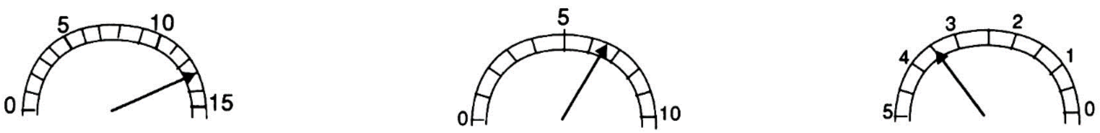

E __________ F __________ G __________ H __________

**2** What do these measuring cylinders and pipettes read?




a __________ b __________ c __________ d __________ e __________

**3** What amounts do these meters read?




a __________ b __________ c __________

As well as recording the number what must we also record?

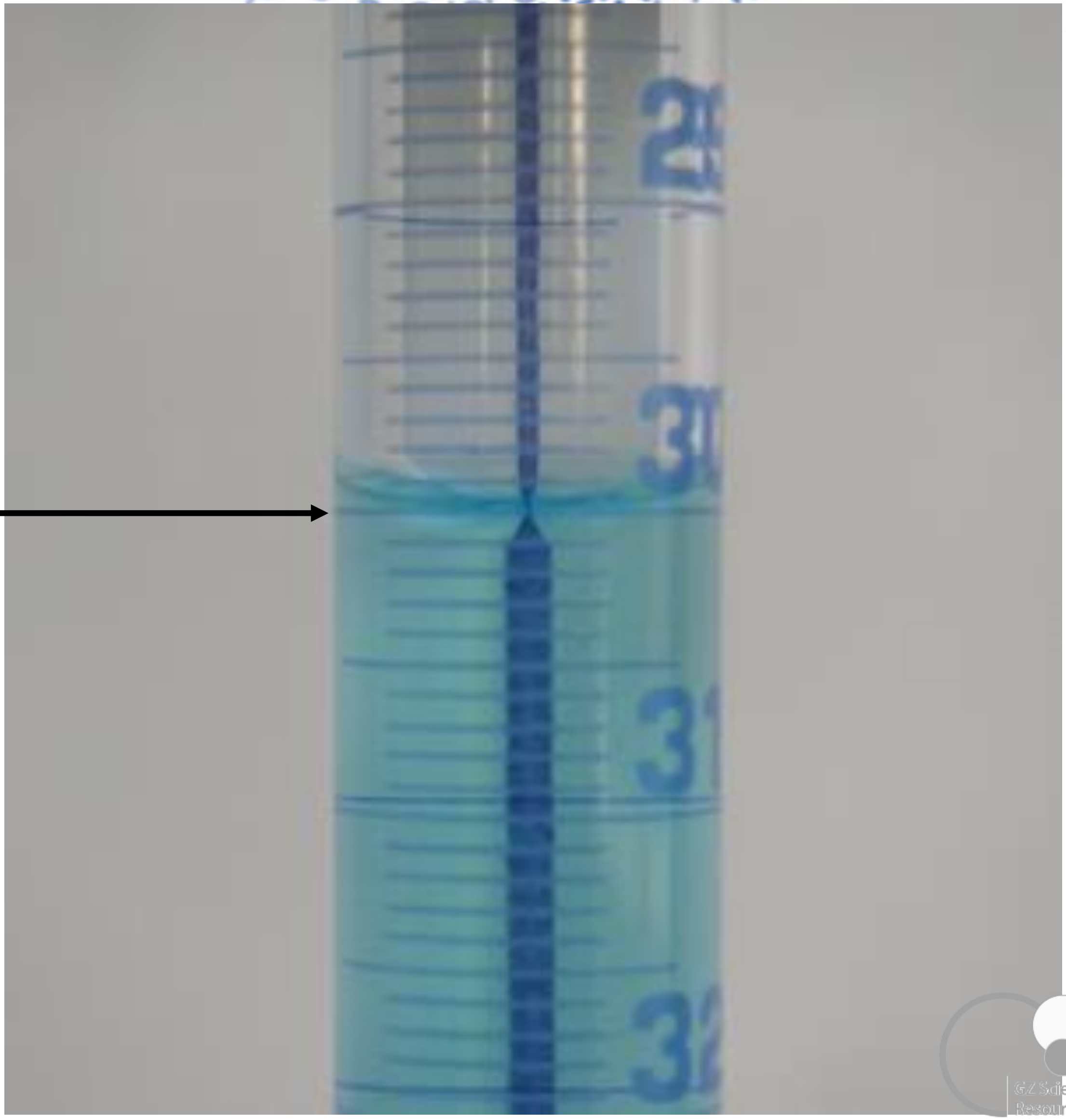
Where do we look from when reading measuring cylinders and pipettes?

Why is the surface of the liquid not flat?

GZ Science Resources

# Measuring volume

Water is a liquid that "sticks together". In a narrow tube or measuring cylinder the water surface tends to curve up the sides. This is called a **meniscus curve**. A measurement reading is to be taken from the **bottom** of the meniscus curve because only a very small volume of liquid is actually around the side.



## An investigation is used to collect data for evidence

Scientists ask questions to help work out what is occurring in the natural world around them. They then create testable ideas which they think may answer the question. Scientists test their ideas by predicting what they would expect to observe if their idea were true (called a **hypothesis**) and then seeing if that prediction is correct.
Scientists look for patterns in their observations and data.
Analysis of data usually involves putting data into a more easily accessible format (graphs, tables, or by using statistical calculations).

The process of creating a question, developing a hypothesis and carrying out a test to collect data which is then analysed to see if their hypothesis is proved or disproved is called a **scientific investigation**.

## A 'fair test' is one in which you only change one thing (variable).

**Variables** are all the things that could change during an investigation.

In a bouncing ball investigation,  where the height a ball bounces to is measured after it is dropped at different heights, many things could affect the results from one experiment to the next such as using a different ball, a different drop height or a different surface which the ball is dropped on.

You should only change one thing at a time in your investigation. This called the **independent variable**.(The height the ball is dropped at)

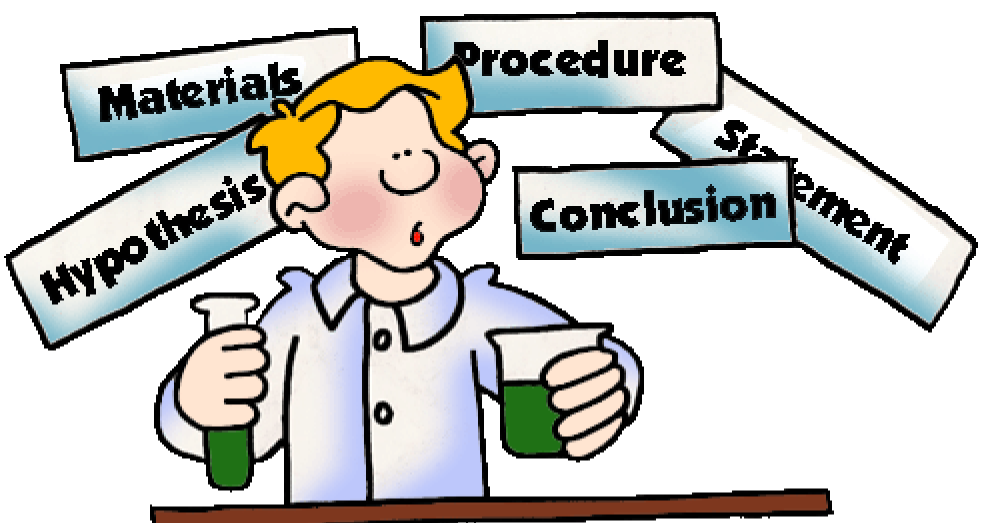
During your investigation you should be able to measure something changing which is called the **dependent** variable. (How high the ball bounces after being dropped)

The factors you keep the same in your experiments (fair test) are called **control variables**

## The typical way that scientists work is called the Scientific method.

Scientific investigations are typically written up in a standard way under the following headings:

**Aim (focus question):** what you are trying to find out or prove by doing the investigation
**Hypothesis:** what you think will occur when an investigation is carried out
**Equipment (or materials):** the things that you need to do the investigation
**Method :** A simple, clear statement of what you will do – and can be repeated by another person
**Results :** data, tables and graphs collected from investigation
**Conclusion :** what your results tell you – linked back to the aim and hypothesis
**Discussion :** Science ideas to explain your results, possible improvements to the investigation, how you managed to control the other variables.



# Focus Question / Aim

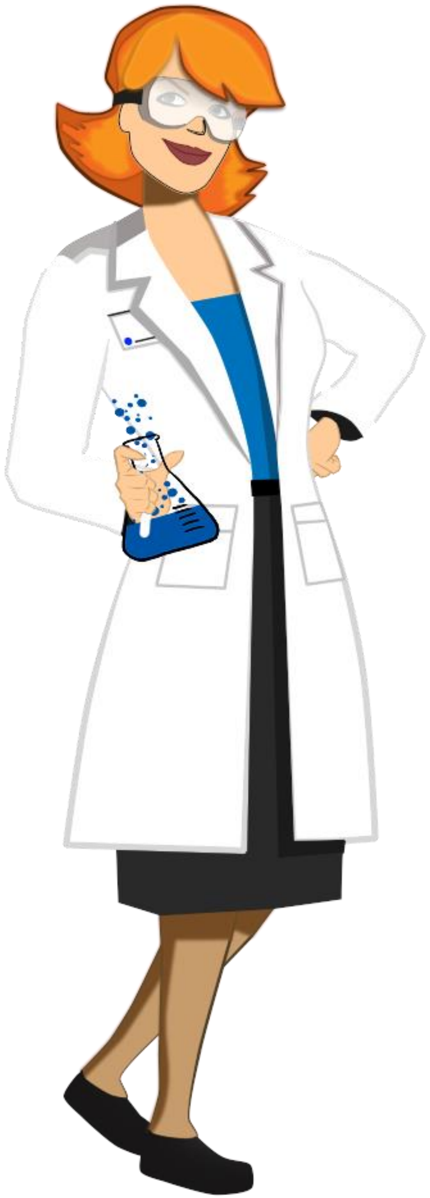
Your Aim or focus question must include both variables.
For example: If I change (independent variable) how will it affect (dependant variable)

Such as: If I change the temperature of the water (independent) how will it affect how much sugar I can dissolve into the water (dependant)

**Independent variable** – amount of light a plant receives
**Dependant variable** - height that plant grows

**Focus Question:** How does the amount of light a plant receives affect the height it grows to

# Writing the Method



A method must be written so that an investigation is **repeatable** by another person.

In order for results from an investigation to be **reliable** an investigation must be able to be repeated exactly the same way following the method. The results gained from each repeat must show the same pattern each time for the conclusion to be valid (or if not an explanation or fault in following the method given)

# Collecting Data

Data that is collected from an investigation can be analysed (in order to explain and interpret it) easier if placed into a clearly labelled and laid out **data table**. The left column is the data of the variable (factor) that you are changing. The right hand side columns are for the data of the variables you are measuring.

The table must have:

- ❑ **A heading linked to the aim**
- ❑ Labelled quantities, units and symbo
- ❑ Values (often numerical) of data collected

Data tables can also contain **processed data** such as results from multiple trials that have been averaged to give a more reliable value.

Data Collected

**This is chart of the numerical data collected in my experiment...**

| **Independent Variable** (This is the one thing I changed in my experiment.) | **Trial 1** | **Trial 2** | **Trial 3** | **Average** (Add the three trials together and divide by three.) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

# Processing Data - Averaging

When collecting and measuring data in investigations, such as that for calculating speed, errors can occur. This may be due to the measuring instrument and the way it is used. Data can also be recorded incorrectly.
Repeating the investigation a number of times and averaging out the measurements can help reduce random errors and **increase reliability.** This value is called the **mean**.

The mean is the most common measure of average.
To calculate the mean add the numbers together and divide the total by the amount of numbers:
**Mean = sum of numbers ÷ amount of numbers**

extra info

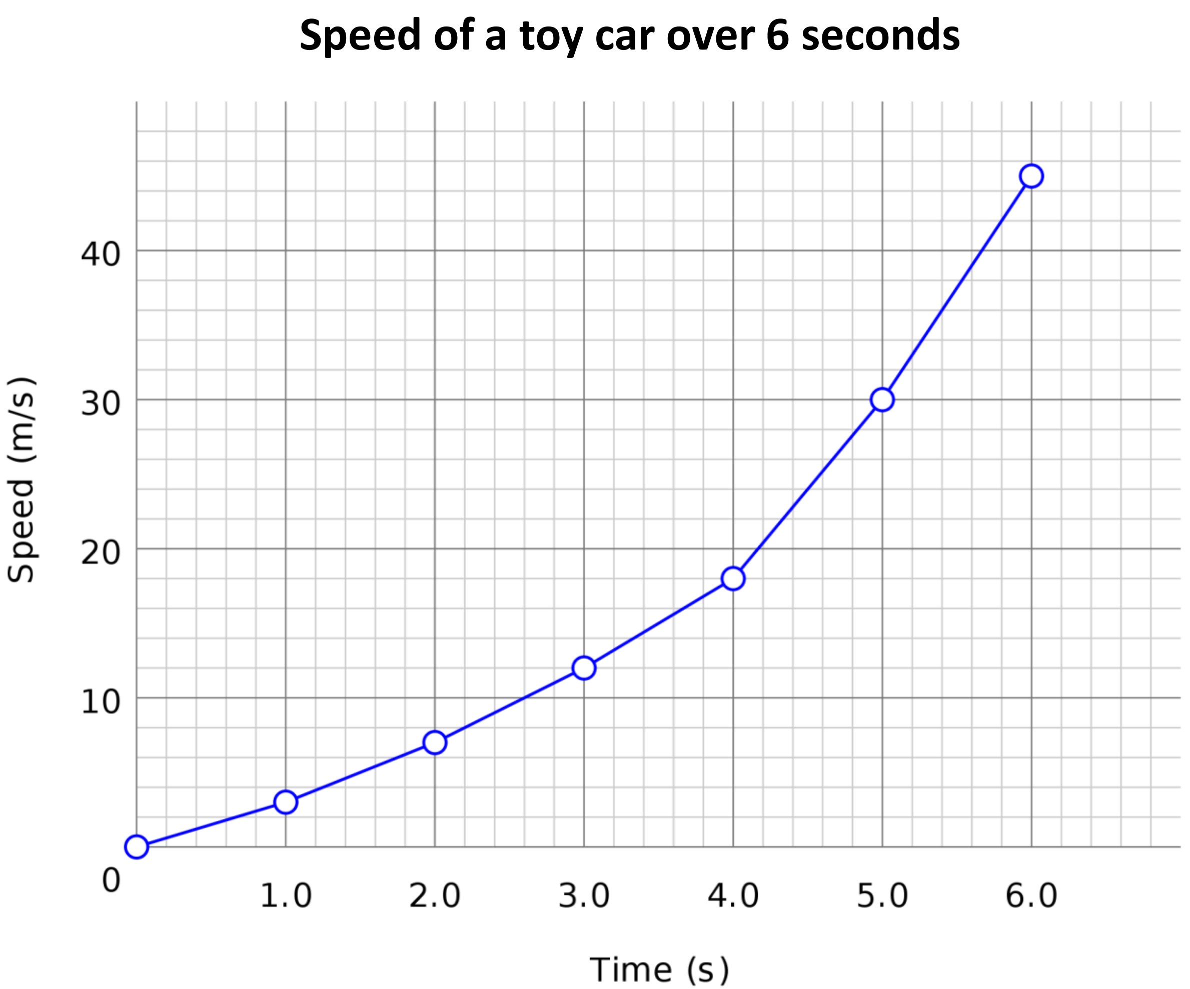
Distance walked in 1 minute

| | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Distance (m) | 113 | 121 | 119 |

Mean = (113 + 121 + 119 ) **÷ 3**
= **117.7** m

# Drawing a line Graph

Graphs are used to show patterns in data more easily than a data table. Often processed (averaged) data is used.



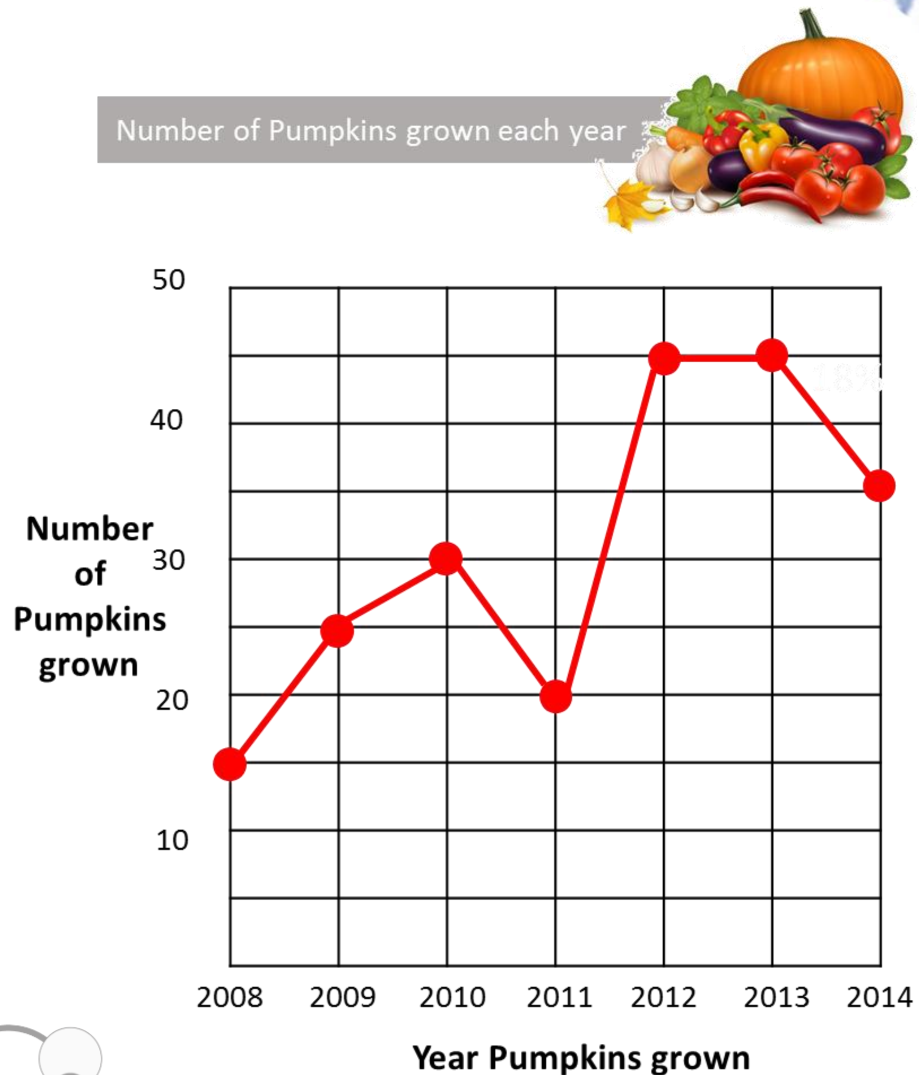

A well drawn line graph must have the following features:

- ❑ A suitable heading
- ❑ Evenly spaced numbered axes
- ❑ Labels with units
- ❑ Correctly plotted line.

Use the acronym SALT when plotting graphs:
**S**cales **A**xes **L**abelling **T**itle

GZ Science Resources

# Looking for patterns in results - Graphs




## Line Graph

A line graph is used to show changes in a variable. It could graph **discrete variables** - such as the number of pumpkins each year: 1 or 2 etc but not 2.5. It can also graph **continuous variables** – such as the weight of pumpkins grown: any value between a minimum and maximum.

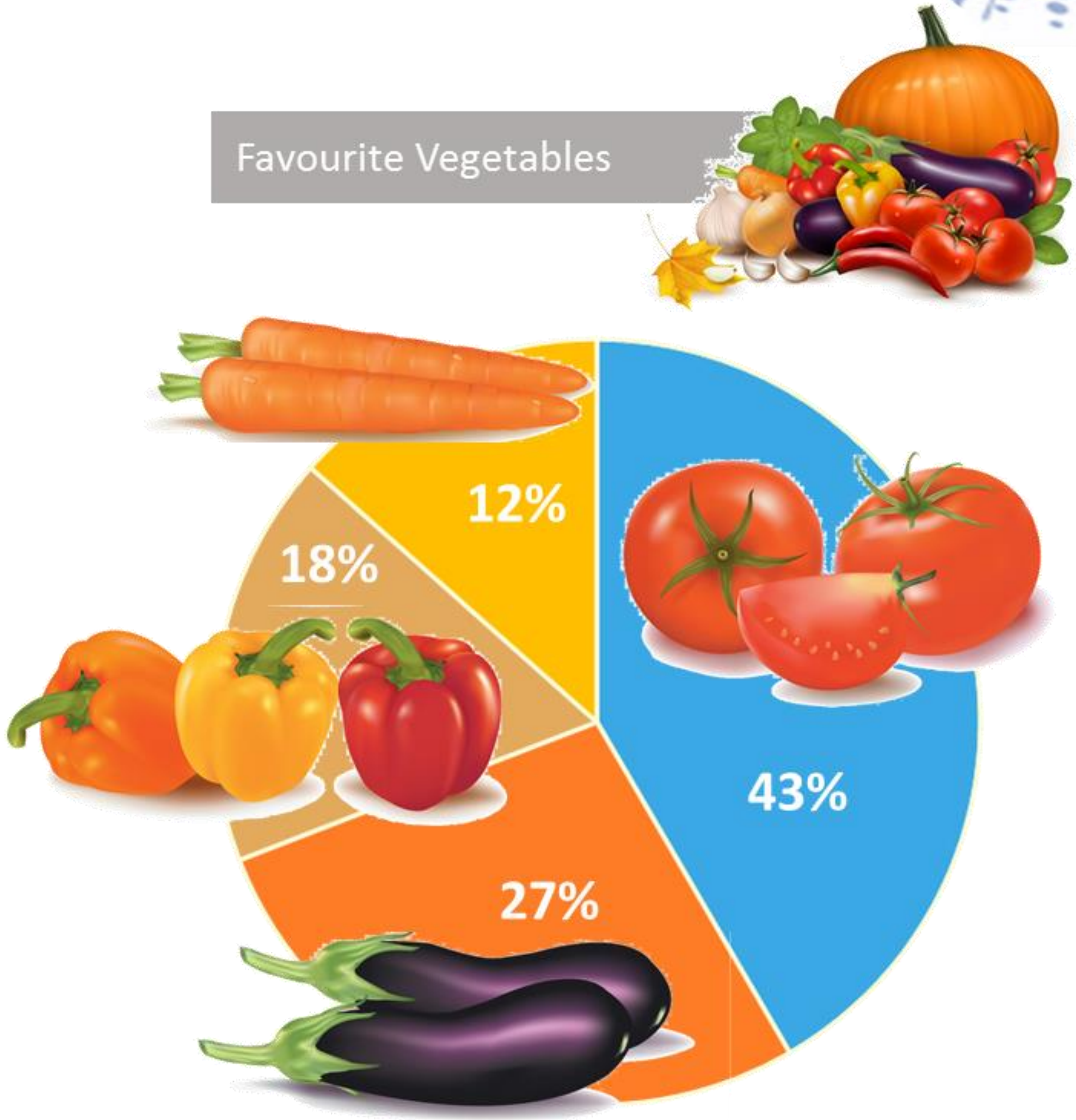
More than one set of data can be graphed to make comparisons.

extra info

GZ Science Resources

# Looking for patterns in results - Graphs

extra info

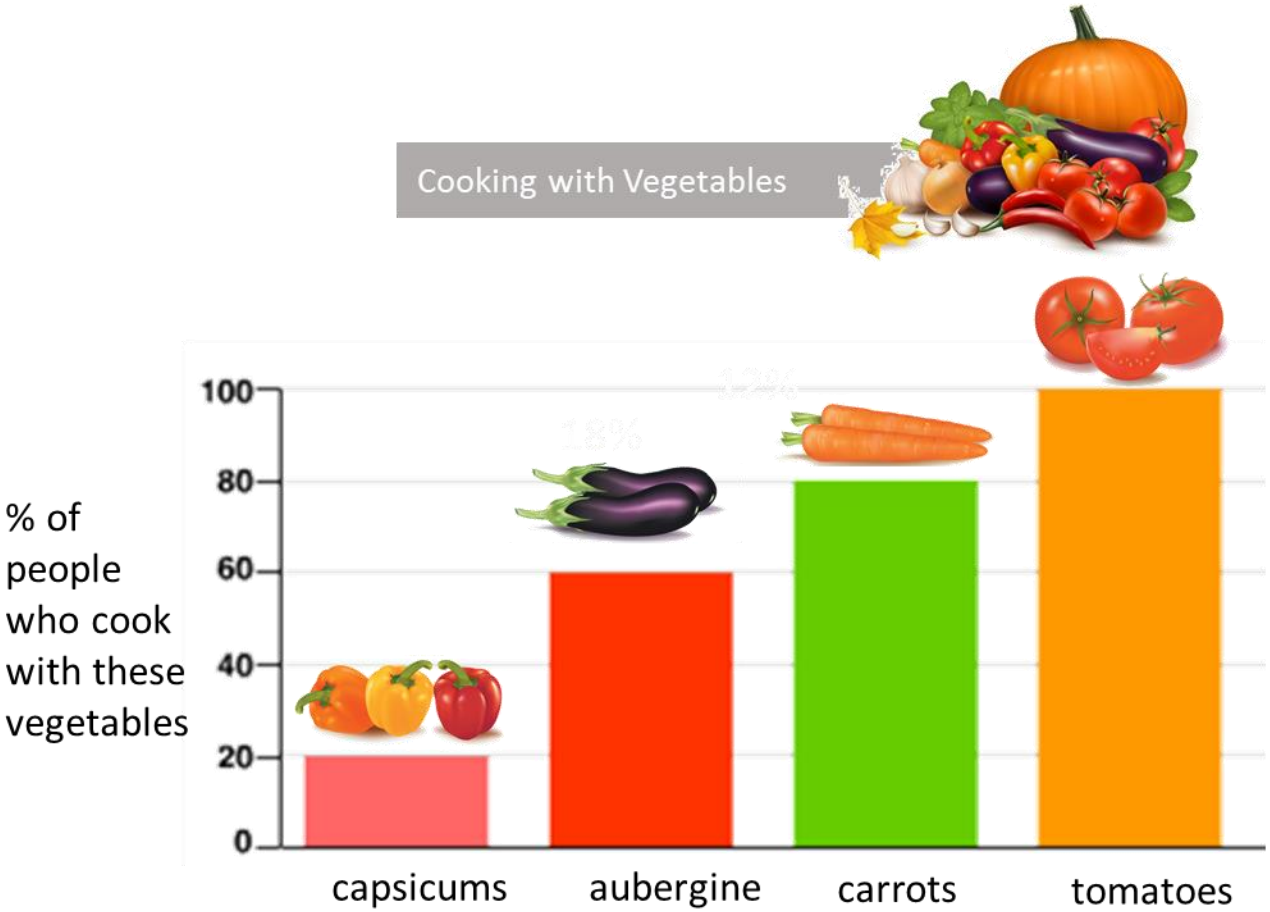



## Pie Graph or Chart

A circle that shows parts of a whole. Each segment represents a percentage adding up to 100%.

The pie chart is a good visual tool when you want to show proportions of variables in comparison to each other.

# Looking for patterns in results - Graphs

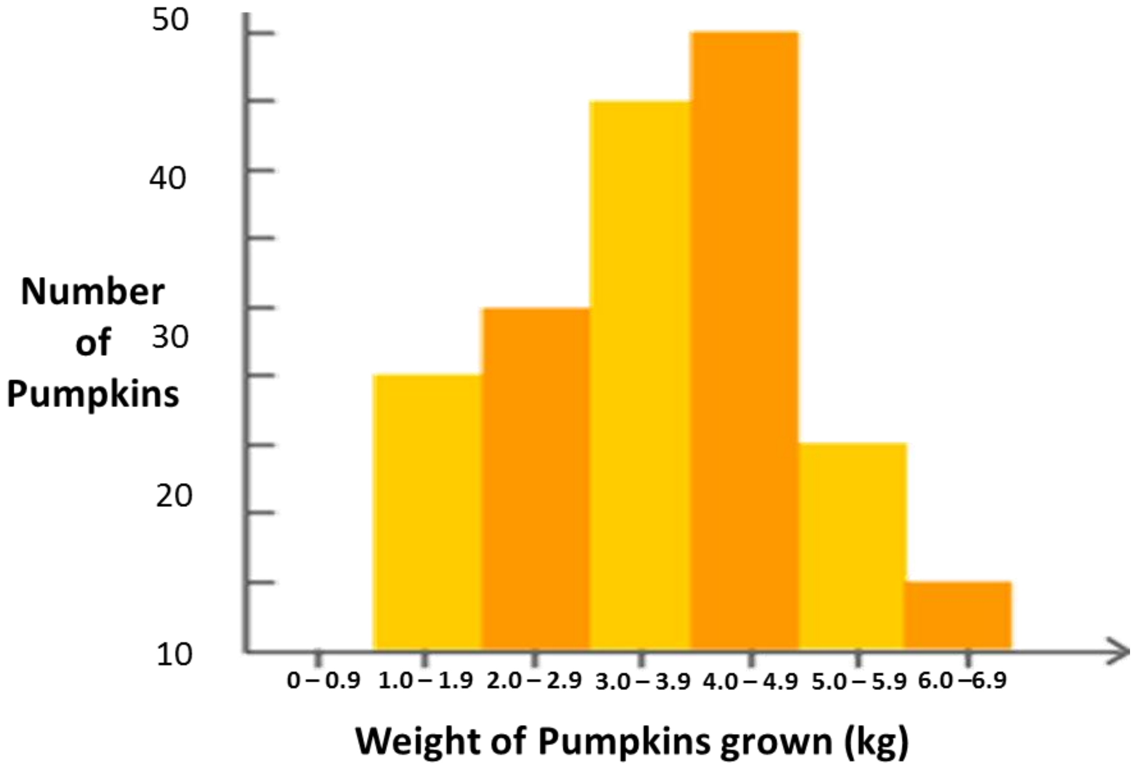



## Bar Graph

A bar graph is used to show changes in a **discrete variable**. The columns do not touch each other. The discrete variables mean they can be in one group (or have one value) or another but not be anywhere in between – as in half tomato and half carrot.

# Looking for patterns in results - Graphs

Weight of Pumpkins grown in 2013




## Histogram

Has columns that touch each other, shows comparisons between **continuous data**.

The weight of the pumpkin can be any value between zero and possible maximum.

The histogram shows the **frequency** of data. The most frequent weight of pumpkins is between 4.0 and 4.9 kg

# Writing a conclusion

A conclusion looks for patterns in collected data from an investigation and used to answer the original Aim (or to agree or disagree with the hypothesis)

Both the variable that is changed (independent) and the variable that is measured (dependant) must be included in the conclusion statement.

The data is used as evidence in the conclusion.

# Reliability and Validity

**Reliability** means that that any results produced in a scientific investigation must be more than a one-off finding and be **repeatable**.

Other scientists must be able to perform exactly the same investigation using the same method and generate the same results.

**Validity** is the extent to which a investigation measures what it is supposed to measure. In a valid investigation the results gained will be as close to reality as possible if only one variable is changed and all other variables are kept the same.