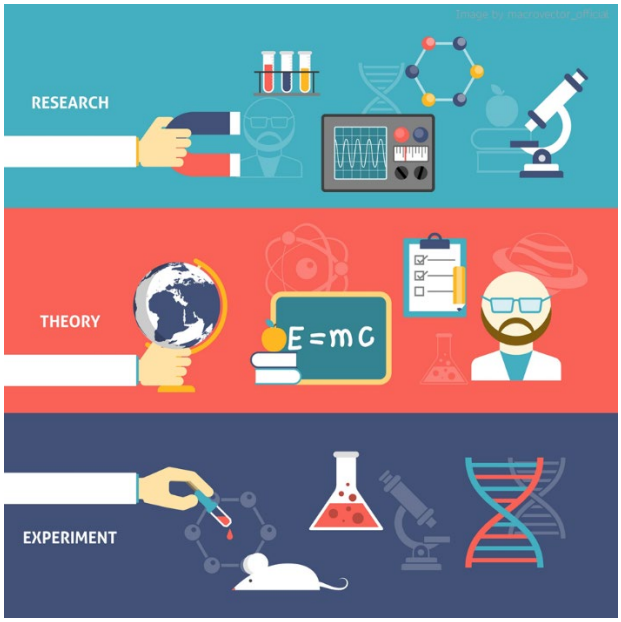
An investigation is used to collect data for evidence

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 question is then answered with a conclusion backed up by evidence from observations and data

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**.



Independent, Dependent and controlled variables

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**. How it is changed, how it is measured, and the units must all be described along with a suitable range stated.

During your investigation you should be able to measure something changing which is called the **dependent** variable. How it is measured must be described and the units stated.

The factors you keep the same in your experiments (fair test) are called **control variables.** Each variable must be stated and how/why they will be controlled is to be described.

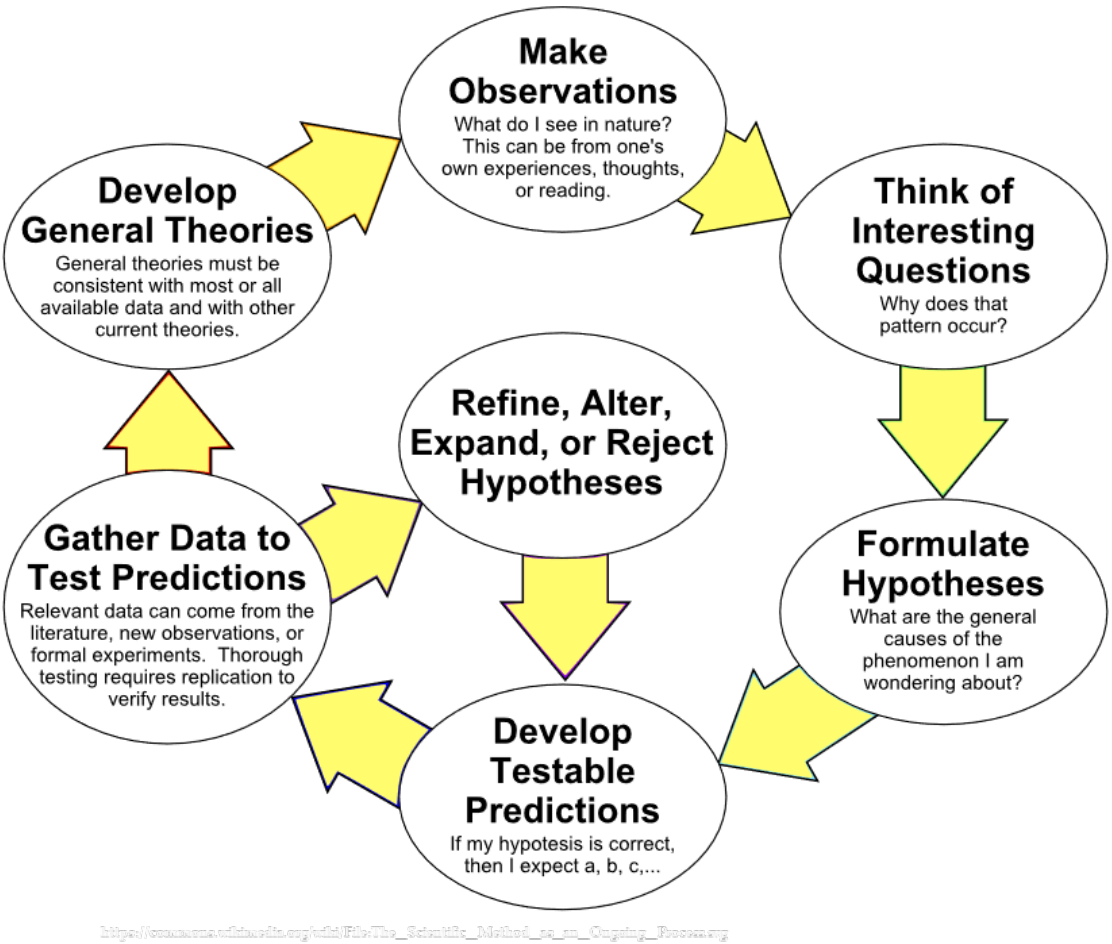
Steps of the Scientific Method.

In your science lessons 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.

The Scientific Method is an ongoing process

The scientific method is a continuous cycle with data and results being used to challenge the hypothesis or initial question, and then further investigation occurs.



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)

EXAMPLE

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

Planning the Method

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

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).

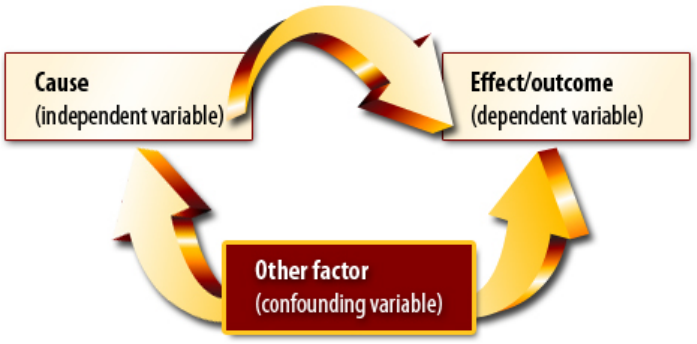
Your method must be repeatable by another person and include:

- ❑ independent (variable changed) and dependent (variable measured) variables that are clearly stated with units given
- ❑ All variables listed that must be controlled (kept the same) **AND** how they are controlled
- ❑ Techniques used to increase **accuracy** (closer to actual value) and **reliability** (consistently the same when repeated)

Controlling the Variables

It is important that all variables are controlled – so that they are the same in every trial and do not **influence or confound** the final results

You will need to discuss how you have controlled at **least 3 variables** and how they might have affected the results if they were not controlled.



What is a Suitable Range?

A decision must be made about the highest and lowest values (the range) to choose for the **independent variable.**

The range should be as large as possible (**at least 4**).

When the highest value that can be chosen has been found, the other values that will be chosen must be worked out. If the dependent variable is found to be too hard to measure, then a new highest value for the independent variable will need to be found-this involves carrying out further trials. Usually 0 is an unsuitable value to use

Sometimes in an experiment, the number of values that could be used for the independent variable are limited, therefore it is not possible to improve accuracy by using a large number of different values.

Independent variable	Range
Dropping a bouncy ball at different heights	25cm, 50cm, 75cm, 100cm

Reliability and Accuracy in Method

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.

Accuracy 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.

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

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)

Collecting Data

Data that is collected from an investigation can be analysed easier if placed into a clearly labelled and laid out **data table**.

The table must have:

- A heading linked to the aim/hypothesis,
- Labelled quantities, units and symbols,
- 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.

By repeating the investigation, a number of times and averaging out the measurements, you can reduce random errors and **increase reliability.** This value is called the **mean**.

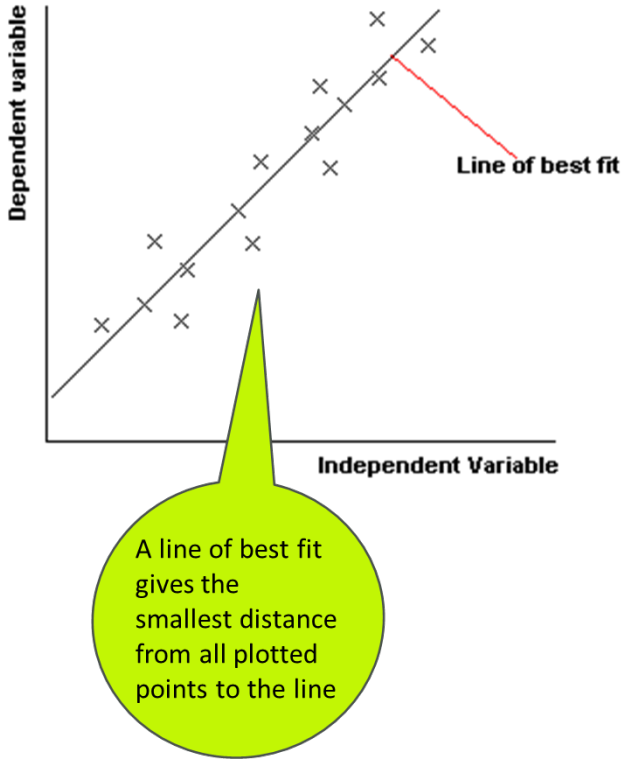
The mean is the most common measure of average.
To calculate the mean add the numbers together and divide the total by the amount of numbers:
Mean = sum of numbers ÷ amount of numbers

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



When a line graph is used to analyse data from a fair test the **dependent variable (variable measured) must be placed on the y axis** and the **independent variable (variable changed) must be on the x axis**.

Use the acronym SALT when plotting graphs:

Scales **A**xes **L**abelling **T**itle

A **line of best fit** is used to generate a straight line – this shows the trend and allows a gradient to be calculated. The points that do not touch the line are evenly spread either side of the line and are as close to the line as possible.

Use **crosses** instead of dots for plotting

Do not join the points

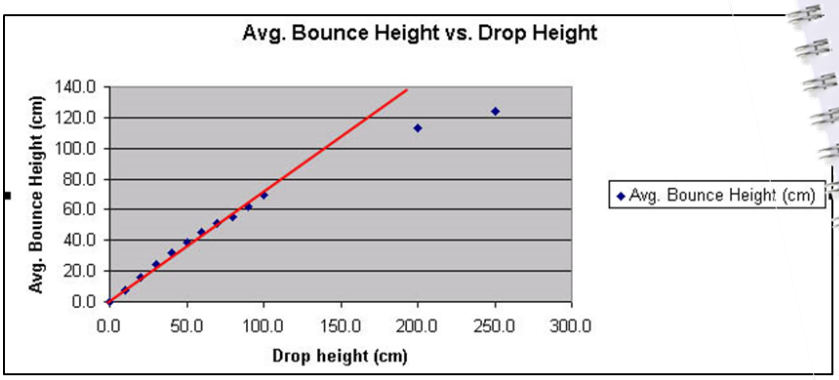
Writing a conclusion

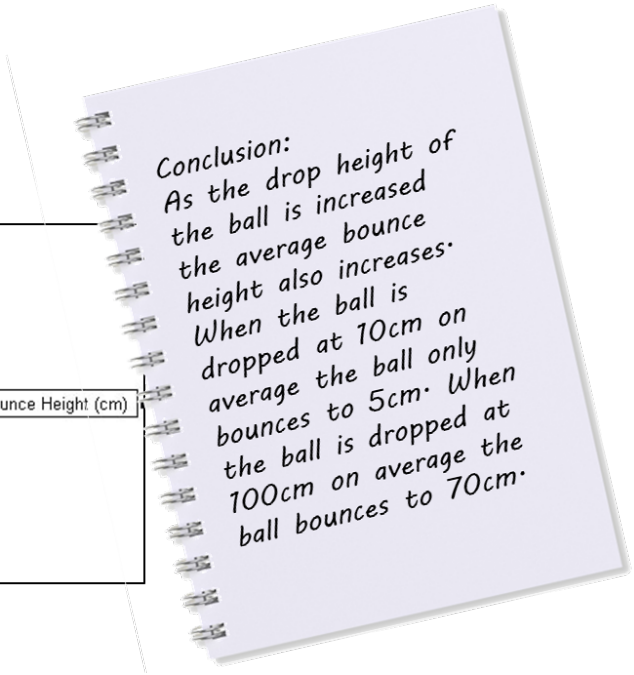
A conclusion looks for patterns in collected data from an investigation.

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

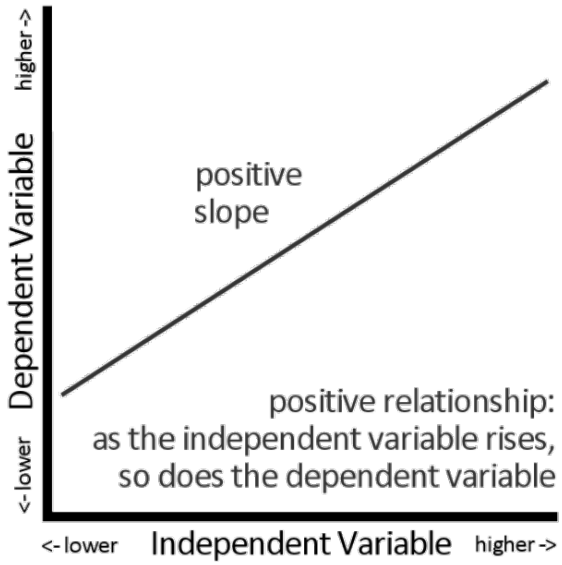
The **data is used as evidence** in the conclusion. The conclusion can also be used to answer the original aim

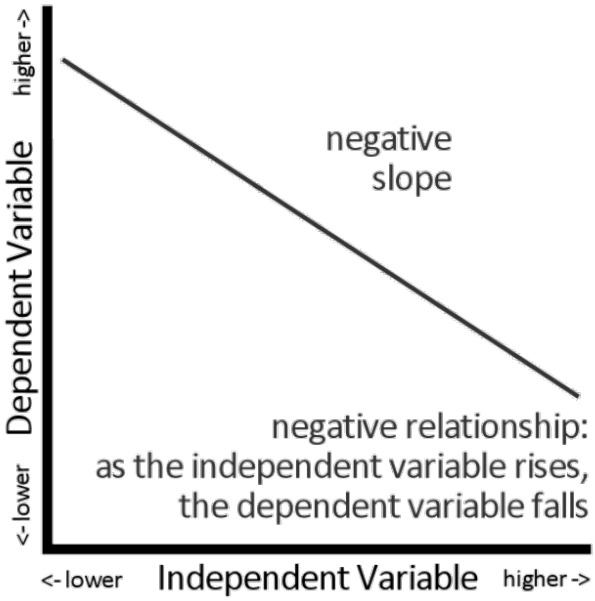
EXAMPLE





Writing a conclusion based on the gradient





A gradient of a line will be **positive** when the **rise** of the variable changed causes the **rise** of the variable measured. A gradient of a line will be **negative** when the **rise** of the variable changed caused the **fall** of the variable measured. **You must include either statement (positive or negative) in your conclusion based on your results**

Discussion

This part of an investigation covers what you did to **increase reliability with repeats**, and discussion how you **kept all other variables controlled**. Accuracy is discussed along with the **techniques used to ensure accuracy** such as **reducing parallax errors** and anything else to make sure your data was collected without error, such as **correcting for zero error**.

report on your investigation.

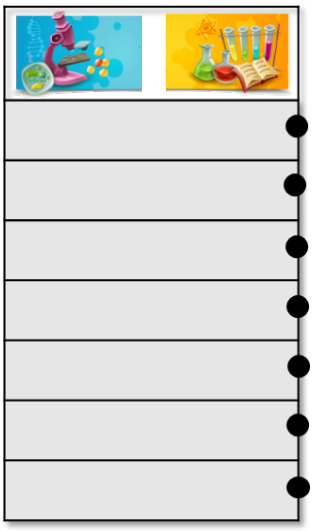
Areas of the investigation that could have been improved (and were modified to improve them) are discussed as well as known unavoidable errors are made.

Science ideas that could explain the results and conclusion are discussed here. Any relevant equations (including the mathematical relationship equation from the graph) can be included and further explained.

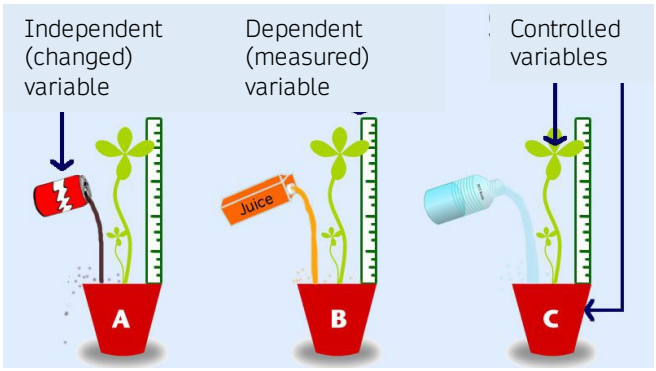
Any differences between your results and expected results based on known Science ideas can be discussed.

The discussion is an **in-depth**

1. In the chart below, place the steps of the Scientific Method **in order** THEN draw a line to match the steps of the Scientific Method with their definition



2. Draw a line to connect the description with the correct planet
The things that you need to do the investigation
Science ideas to explain your results, possible improvements to the investigation, how you managed to control the other variables.
What you are trying to find out or prove by doing the investigation
Data, tables and graphs collected from investigation
What your results tell you – linked back to the aim and hypothesis
What you think will occur when an investigation is carried out
A simple, clear statement of what you will do – and can be repeated by another person



2. Using information of the variables from the diagram above, **write an aim** for this investigation

3. Complete the chart for measurements in Science

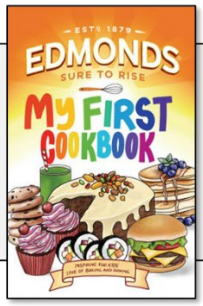
Quantity	Unit	Symbol	Equipment used
Volume	litre		Flask
		mL	Measuring cylinder
	Celsius	°C	
Mass	kilograms		Scales
		g	Scales
		m	
	millimetres		Hand ruler

4. Complete the chart below to identify the independent (changed) variable and the depenedent (measured) variable

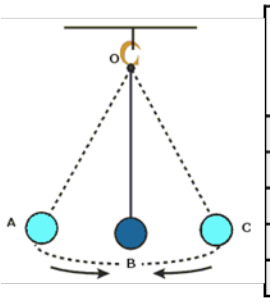
Scenario		Independent (changed variable)	Dependent (measured variable)
1. One field of maize corn is sprayed with insecticide, while another field the same size that is planted out is not. The amount of maize in kg that is harvested from both is recorded		Adding insecticide to planted maize	Weight of maize harvested (in kg)
2. Two friends decide to study for tests in different ways; one reads his notes and then makes shorter study notes, while the other uses past practice questions. After the test they both compared their test scores.			
3. Two bean seeds were planted and were placed in potting mix, and watered well. One was placed in a shaded back corner of the room, while the other in full sunlight by a window. The plant growth was then measured by removing whole plant, removing dirt and weighing			
4. Marbles were rolled down a ramp that was set at different heights – then students measured how far they rolled			
5. Slaters were placed in a tank with one shaded area and one open area – every five minutes the number found in each area was recorded			
6. Cyclists were measured for their maximum power output on trainers then given different brands of energy gels – and retested 30mins later			
7. The amount of time that students were on their phones each day was compared to how well they did on a standard Science test			

5. For investigation 3 from above (bean plants) identify variables that will need to be kept the same (control variables) to make the investigation a fair test

6. An author of a cookbook is very careful to write out recipes that produce the same result every time someone uses it to cook food. Explain how this is **similar to writing the method** of an investigation and **why this is important.**



7a. Make the **headings for the data table** (in the shaded boxes) below from the following Aim: How does the length of string on a bob of a pendulum, affect the time for one complete swing?



	Trial 1	Trial 2	Trial 3	Average
10cm	0.7s	0.7s	0.8s	
15cm	0.8s	0.9s	0.9s	
20cm	1.3s	1.3s	1.4s	
25cm	1.5s	1.5s	1.6s	
30cm	1.8s	3.8s	1.9s	

7b. From the data above which of the values does not appear to look correct? _____

When a value looks much different from what an expected value it is called an **outlier** and we remove it by placing a line through it.

7c. Average the following data in the table above. (After removing the outlier) – to do this add all three values together on each line then divide by three

7d. Using the above **average** information draw a line graph below. Include title, line of best fit, labels and units