

(Modified by Mr. Carpenter from "The Biology Corner" www.biologycorner.com)

The Scientific Method

Science is ultimately based on **observation** (perceiving objects or events using one of the five senses)

Observations often lead to questions ---> which lead to experiments to answer the questions.

Scientific Process

- **Observations**—do this by using one or more of the 5 senses
- **Questions**—ask questions about what you are observing, Identify a problem
- **Hypothesis** (prediction)—this is a temporary explanation for a set of observations
- **Experimentation**—this is a controlled experiment, this is performed to test your hypothesis
- **Conclusions**—gather data, analyze data, summarize your results and form a conclusion

Hypothesis - a testable statement, can be shown to be true or false by experimenting or observation.

Examples

Good	Bad
<ol style="list-style-type: none">1. Plants will grow taller when given Miracle Grow.2. Girls will score higher on math tests than boys.3. Hermit crabs choose colorful shells over drab shells.	<ol style="list-style-type: none">1. Plants will grow better when given Miracle Grow.2. Girls are smarter than boys.3. Hermit crabs like colorful shells.

Following the formation of a hypothesis, a researcher can then make a **prediction**. A prediction is an expected outcome. If the statement is true, then you would expect a certain result.

A hypothesis is then tested by **experimentation** - a planned procedure designed to test the hypothesis.

Experiment

In science, you have to use a Controlled experiment (an experiment in which only 1 variable is changed)

Experimental Group -receives some kind of treatment or condition

Control Group - receives no treatment, used to compare

**Everything about the two groups except the factor you are testing must remain exactly the same. Why?

Example of an experimental design



Hypothesis: Plants will grow taller when given Miracle Grow.

Plants A & B are both given the same amount of light, water, and are stored at the same temperature. Plant A is given Miracle Grow.

All the **variables** are kept constant except the one you are testing.

Independent Variable - the factor you change, what you do to your exp. group. (Miracle Grow)

Dependent Variable - what happens as a result of that treatment, what you are measuring (height of plant)

Collecting Data

A scientist carefully collects and organizes data from the experiment. Data should always be presented in a neat fashion, usually tables or graphs.

Data Table Example

Date	Plant A	Plant B
2/1/02	10	7
2/4/02	25	15
2/7/02	45	20
2/10/02	60	35
2/13/02	68	45

Data can be powerfully displayed as a graph



Alternate Data Collection - what if you grew hundreds of plants, and exposed half of them to Miracle Grow. You might choose to measure all your plants at the end of a week.

	Height of Plants (cm)	Average
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Plants in Group A	4	5	4	11	6	6
Plants in Group B (control)	3	4	5	7	6	5

Conclusions—does your data support your hypothesis or does it not support your hypothesis

Based on the data, a scientist then determines whether the hypothesis was supported or refuted. Be careful here, scientists usually don't use the word "prove" because there are no absolutes in science. In science, every conclusion must assume that the conclusion is only "true to the best of our knowledge". This is an important distinction between science and other subjects. Science is subject to change when new evidence is found. And while experimentation and observations can provide strong evidence for a conclusion, it is not absolute proof.

What conclusions could you draw from the data tables. Is the hypothesis supported or refuted?

What is a Theory? –these only come about when a hypothesis is tested and retested numerous times and the data always supports the hypothesis. A well tested explanation that unifies a broad range of observations

A Theory is an explanation for natural events that is based on a large number of observations. Its important to realize that theories EXPLAIN what we observe. For instance, the Germ Theory explains why we get sick and why we get infections, in short it uses observation of viruses and bacteria as well as data from those who get ill to create a theory on what causes the illness.

Theories are changeable and expandable, and most importantly, theories are FALSIFIABLE.

In order to be a valid scientific theory there must be some way that an observation or experiment could prove it to be false. For example, Einstein's theory of Relativity made predictions about the results of experiments. These experiments could have produced results that contradicted Einstein, so the theory was (and still is) falsifiable.

In contrast, the theory that "the moon is populated by little green men who can read our minds and will hide whenever anyone on Earth looks for them, and will flee into deep space whenever a spacecraft comes near" is not falsifiable: these green men are designed so that no one can ever see them. On the other hand, the theory that there are no little green men on the moon is scientific: you can disprove it by catching one. Similar arguments apply to abominable snow-persons, UFOs and the Loch Ness Monster(s?).

So to recap, three important points of a scientific theory:

Theories must explain a wide range of observations

Theories must be falsifiable

Theories can be changed if new evidence presents itself

