

# The Scientific Method

## **What is the Scientific Method?**

-The scientific method is a multi-step process that is used by scientists to answer questions or solve problems. This process uses a type of logic called hypothetico-deductive reasoning. Essentially, you use general principles to predict the outcome of a specific problem. This is the opposite of inductive reasoning, where you use individual (specific) observations to come up with a general conclusion that explains all of those observations. Inductive reasoning is mostly used in “discovery science.”

## Examples of Deductive/Inductive Reasoning

*Deductive: If all men are 6 feet tall (general), and Johnny Depp is a man, then Johnny Depp must be 6 feet tall (specific).*

*Inductive: If one fish has large fins (specific), then all fish must have large fins (general).*

## **Steps of the Scientific Method**

### **1) Observations**

Make observations and conduct research on whatever it is you are studying. Make note of anything that you think is relevant.

### **2) Question**

Raise a question about what you have observed. When you ask a question, you can conduct an experiment to find out the answer to that question. For example, let's say that we are observing the color of leaves on a tree. Let's pretend for a moment that we didn't know why the leaves are green in color, and we wanted to find out. Our question that we would later investigate would be: Why are leaves on a tree green in color?

### **3) Hypothesis**

Next you form a hypothesis. A hypothesis is a temporary answer to your question. Essentially, it is an “educated guess” that explains your observation. Once you come up with a hypothesis, you can create an experiment to see if your hypothesis holds up...or if it proves to be incorrect. It is **VERY IMPORTANT** that your hypothesis is **testable!** If it cannot be tested, it is not an acceptable hypothesis.

*Acceptable Hypothesis: Sunlight causes the leaves on the tree to turn green. (This hypothesis can be tested, therefore it is acceptable)*

*Unacceptable Hypothesis: Aliens are responsible for making the leaves green. (This would be unacceptable because it cannot be tested)*

\*\*Note: It is actually a pigment called chlorophyll that gives leaves their greenish color, but for the sake of this example, we will pretend that we didn't already know that. ☺

#### 4) Testing the Hypothesis

Once your hypothesis is formed, use deductive reasoning to make prediction about what you think will happen. Then, you can set up an experiment to test those predictions.

*Example of a Prediction:*

*If sunlight is responsible for giving leaves their greenish color, leaves that are exposed to little or no sunlight will lose their greenish color. Those that are exposed to a higher than “normal” amount of sunlight will become greener than usual.*

The experiment that you conduct must be controlled. A controlled experiment has two groups, a control group and an experimental group (in many experiments, there will usually be multiple experimental groups). The two groups are treated the same way, except one variable in the experimental group will be manipulated. In other words, the control group is the group that doesn't receive “treatment”, while the experimental group(s) does. In our leaves example, the leaves in the control group would receive a “normal” day's worth of sunlight (no treatment), and the leaves in the experimental groups would receive a predetermined amount of sunlight that differs from the control group.

*Example of a Control and Experimental Group*

*Experiment: The Effect of Sunlight on the Color of Leaves*

*\*Pretend that we gathered some leaves and divided them into four groups: one control and three experimental groups. The experiment lasts one week.*

*Control Group:* *These leaves will receive a “normal” amount of sunlight each day (i.e. one day's worth of sunlight)*

*Experimental Groups:*

*1<sup>st</sup> Group: Collection of leaves that will receive 50% less sunlight compared to the control group each day. (i.e. ½ day's worth of sun light)*

*2<sup>nd</sup> Group: Collection of leaves that will receive 50% more sunlight compared to the control group each day. (i.e. 1 ½ day's worth of sunlight)*

*3<sup>rd</sup> Group: Collection of leaves that will receive NO sunlight throughout the duration of the experiment.*

#### 5) Collect Data/Results

Gather data during and after the experiment, and record the results. Your results can be in the form of words, tables, graphs, calculations, etc.

#### 6) Analyze Results and Draw a Conclusion

In this step, you look over your results, and determine whether or not they correlate with your hypothesis. Draw a conclusion, and discuss why you believe

the results came out the way they did. Your conclusion should include a statement (made by you) that either rejects or accepts your hypothesis. Usually, if the experimenter rejects their hypothesis they would return to step 3, revise their original statement, and repeat the process again. Your conclusion should also contain recommendations on how to improve and further your research.

### Important Points to Remember

\*It is important to remember that a hypothesis can be proven false, but it can NEVER be proven true with 100% certainty.

\*A hypothesis differs from scientific theories and laws. A hypothesis is a tentative explanation for a certain observation. Even if a certain hypothesis is supported by experimentation, it is not widely accepted until it is further (and repeatedly) investigated. A theory, however, *is* widely accepted by the scientific community. In addition, a scientific theory is broad in scope, and is supported by extensive evidence. An example of a scientific theory would be Darwin's Theory of Evolution. A scientific law is a principle that is universally accepted to be true. The major difference between a law and theory is that a law *describes* phenomena, while a theory *explains* them. An example of a scientific law would be Newton's Law of Gravity.

Terms to Know:

Deductive Reasoning: reasoning that flows from general to specific.

Ex: If all men are 6 feet tall (general), then Johnny Depp must be 6 feet tall (specific).

Inductive Reasoning: reasoning that flows from specific to general.

Ex: If one fish has large fins (specific), then all fish have large fins (general).

Hypothesis: A tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation.

Variable: aspect of an experiment that changes.

Independent Variable: the variable that the experimenter manipulates in order to determine its effect.

Dependent Variable: the variable that changes as a result of the independent variable. For instance in our “leaves” experiment, the dependent variable would be the leaf’s color, which changed because of sunlight (independent variable) acting upon it.

Controlled Variable: variable in an experiment that does not change.

Theory: A formulation of relationships or underlying principles of certain observed phenomena which have been verified by extensive evidence.

Law: a phenomenon of nature that has been proven to invariably occur whenever certain conditions exist or are met

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