Introduction

Scientific Method

The scientific method is a process used to by scientists to learn about the world around them. It all starts with a simple question. Why do birds build nests? From that one question a speculation is made. This speculation is based on your knowledge or observations surrounding the question. It is called a hypothesis. So, based on observations and reviewing the knowledge of other scientists via a literature review you make an educated guess that might answer your question. Now you need some evidence to support your hypothesis. In order to gain this evidence, you need to design an experiment that will test your hypothesis. Once you have conducted your experiment you have either supported or denied your hypothesis. The next step is to repeat the experiment to make sure you get the same results and make revisions as necessary. If you denied your hypothesis you will have to figure out why and redesign.

Scientist strive for results that are reproducible and verifiable. The scientific method is really a set of principles or guideline designed around observation and reasoning with a goal to ensure that our understanding of the world is as accurate as possible. The main principles of the scientific method are:

1. Observation
2. Ask a question
3. Hypothesize
4. Make a prediction according to the hypothesis
5. Experiment
6. Observe the results and modify hypothesis.
7. Repeat steps 4-6 until you support your hypothesis

Experimental design can be tricky because you want your experiment to test your hypothesis and have no bias. Bias in science is bad because it can cause your data to point in the wrong direction and your question will be answered incorrectly. Your control bias by controlling the variables in your experiment. Variables are factors that you measure or maintain during an experiment. It is a cause and effect relationship. You should have 3 variables in your experiment:

1. Independent Variable – the one factor that is changed by the scientist.
2. Dependent Variable – the factor that the scientist measures. The dependent variable is relying upon the independent variable and is quantitatively measured.
3. Control Variable – the factors that remain the same during the experiment and do not affect the outcome.

Here is an example. We notice that plants that are growing near the window appear taller and healthier than the plants that are growing far away from the window. Why are the plants near the window growing better than the plants away from the window? That is our question. What can we observe, what do we already know, and what can we find in the literature about our question? It is common knowledge that plants need sunlight to grow and sunlight comes through the window. Our hypothesis is: plants that have access to more sunlight will grow taller and healthier than plants that have don't have access sunlight. How do we test this hypothesis? What are the 3 variables for an unbiased experiment?

Variable Type	Factor
Independent	Plants grown in sunlight, plants grown in dark
Dependent	Height of plant, Number of leaves on plant
Controlled	Pot size and type, amount of water, type of soil, fertilizer

To test your hypothesis, you grow 25 plants in the sun and 25 plants in the dark for a predetermined amount of time, say 1 month. You keep all the controlled variables exactly the same for both treatments (light and dark). At the end of your month period you measure the height of the plants and the number of leaves on each plant. What do you think the data would show? Is the hypothesis supported? If our experiment works like we think it should, the plants grown in the sunlight will be taller and have more leaves.

Oh no! You just found out that two different brands of fertilizer were used in your experiment. How do you know if it's the sunlight or the fertilizer that made the plants taller and leafier? Your experiment is now biased because the type of fertilizer is another independent variable. Having more than one independent variable taints your results because even if you did support your hypothesis you are not sure which of the variable was responsible for the outcome. What is your next step? Refine and retest.

So, what are theories, principles, and laws? These are hypothesis that has been tested and retested and the outcome is always the same. A theory is a hypothesis that has stood the test of time. Examples include Einstein's Theory of Relativity and Darwin's Theory of Evolution. A law is a sequence of natural phenomenon that is observed and occurs the same every time under the same conditions. Laws will typically have a mathematical relationship that is consistently found to be true. Examples include Newton's Law of Gravity and the Laws of Thermodynamics.