**Scientific Investigations- Notes**

**Science**- knowledge that attempts to explain the world around us.

Science is a way of understanding the world, not a mountain of facts. Before anyone can truly understand scientific information, they must know how science works. Science does not prove anything absolutely -- all scientific ideas are open to revision in the light of new evidence. The process of science, therefore, involves making educated guesses (hypotheses) that are then rigorously and repeatedly tested. (taken from <http://www.pbs.org/wgbh/evolution/library/09/index.html>)

Thinking critically and analytically is a key component to understanding scientific ideas. One has to make constant observations, inferences and connections between ideas. To gather information and evidence about ideas, scientific investigations are performed. These investigations are completed in systematic and organized manner.

**The Scientific Method**

**Scientific Method**- Process scientists use to investigate nature. The scientific method allows scientists to conduct scientific investigations in a systematic manner.

**STEPS OF THE SCIENTIFIC METHOD**

**Purpose** – idea or question to be investigated; a testable question. The purpose of an investigation is usually in the form of a question and this question must be testable.

**Research-** gathering information about the purpose. Once an idea is chosen to be investigated, then must find as much information as possible about the topic. This information can be found in textbooks, reference books (encyclopedias, for example), experts on the subject, periodicals (newspapers, magazines, etc.), and the internet. Discretion must be used when gathering information from the internet, not all information is accurate at times.

**Hypothesis-** a statement that attempts to answer the purpose. A hypothesis is based on the research that was gathered during the research step. It is also referred to as an educated guess. It is a statement that proposes a possible explanation to some phenomenon or event.

**Experiment-** an activity that tests the hypothesis. There are different types of experiments and various components that make up an accurate experiment. Observations are made and recorded.

**Analysis-** what happened in the experiment. In this step, the observations from the experiment are analyzed, charts and graphs are sometimes made so that relationships can be seen.

**Conclusion-**is the hypothesis true or false. What can be concluded based on the information that was gathered in the experiment? Should another experiment be designed? In this step, we sum up all the things that occurred throughout the process and publish the results where necessary.

**Purpose**

The purpose of a scientific investigation involves stating a testable question. So what is a testable question? A testable question is one that can be answered by designing and conducting an experiment. It usually asks how something **affects** something else. (You’ll learn later that the something and the something are variables). For example,

1) How does the brand of shoe you wear affect how fast you run?

2) How does Miracle grow affect plant growth?

3) How does the size of a birdhouse affect whether robins will live there?

Sometimes testable questions may be in a different format and it can be difficult to determine if it is in fact testable. To figure out if a question is testable, try changing into the format “How does \_\_\_\_\_\_\_\_\_\_\_ affect \_\_\_\_\_\_\_\_\_\_\_\_?” For example,

1) Why do roses grow better in the Sun than in the shade?

2) Which drug is better to use for headaches?

3) Where is best location to plant tomatoes?

4) What temperature is best for sleeping?

Can be changed to

1) How does location affect rose growth?

2) How do different drugs affect pain from headaches?

3) How does location affect tomato growth?

4) How does temperature affect sleep patterns?

Questions about opinions, emotions, and supernatural events do not make good testable questions. Opinions are not always based on proven facts, emotions are very hard to measure consistently, and supernatural events are extremely difficult to simulate in an experimental situation.

**Hypothesis**

A *hypothesis* is an educated guess or a statement that proposes a possible explanation to some phenomenon or event. Hypotheses are based on observations or other information gathered through research.

When forming a hypothesis, it is important to make sure that it has the following traits:

* *The hypothesis is written as a statement.* Since a hypothesis is meant to be a possible explanation, it should not be written as a question. So, "Why do some objects fall faster than others?" is not a good hypothesis, but "Objects fall at different speeds due to their shapes" is an example of a good hypothesis.
* *The hypothesis should be clear.* Vague terms should not be used when forming hypothesis. Instead, these terms should be clearly defined. For example, the statement, "Sometimes there is morning dew on the grass" is not a clear hypothesis, but "When the temperature drops below 50°F at night, the grass will have dew in the morning" is a clear hypothesis because it details the exact conditions under which dew is expected to appear.
* *The hypothesis should be testable.* It must be possible to carry out a scientific investigation and gather evidence that will either support or disprove the hypothesis. "Dogs are happier than cats" is not a testable hypothesis because it is not possible to clearly define "happy" nor is it possible to design an experiment to test this hypothesis.

Good hypotheses should exhibit all of the above traits to be considered meaningful or *valid*. It is not necessary, however, for a hypothesis to be proven correct in order to be valid. Even if a hypothesis is eventually found to be incorrect, meaningful data can still be derived from experiments related to the hypothesis.

**Theories and Opinions**

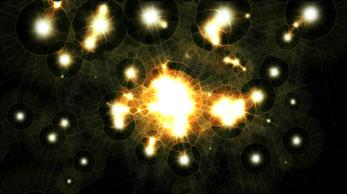
*A* ***scientific theory*** *is a well-tested explanation for a wide range of observations or experimental results. Although it may not be possible to definitively prove a scientific theory, theories can be supported by scientific evidence.*

Theories are different from opinions and hypotheses. An opinion is a personal viewpoint on a specific topic. A hypothesis is an educated guess or a proposed explanation for a phenomena. Scientific theories are different from opinions and hypotheses.

Although some theories may begin as opinions or hypotheses, scientific theories must be supported by scientific evidence, or data, such as observations and/or experimental results, that has been collected over time.

**Examples of theories**

A good example of a theory is the big bang theory. Although this theory has not been definitively proven, scientists have observed that the universe is expanding and accelerating in all directions. This evidence suggests that at one time, all the matter in the universe was located at the same place, but then, for some reason, began accelerating outward in all directions. According to the big bang theory, a giant explosion started this outward acceleration.



Other examples of theories include the theory of relativity, atomic theory, cell theory, the theory of plate tectonics, and the theory of evolution.

**Theories change over time**

Although theories must be supported by a great deal of evidence before they are accepted, even accepted theories can be shown to be incomplete or incorrect by new evidence. New evidence often surfaces with the invention of new technology.

Also, a scientist will sometimes come up with one new theory that is able to explain several phenomena that were each formerly governed by their own individual theories. When this occurs, the new theory replaces all of the old theories.

Theories can be overturned either by new theories that better explain natural phenomena or by new evidence that disproves the old theory. More often than not, however, the changes that take place in scientific theories are small modifications of prior knowledge rather than major shifts in the overall scientific view of how the world works.