Name ______________________________ Date __________ Period ______

The Scientific Method: An Introductory Reading

Do you like detective or mystery stories? Why do you like them? Detectives and investigators decipher the clues and try to figure out a logical explanation for what happened and, above all, who did it! Or do you like to play games that make you think and figure out a strategy or an answer? If you enjoy mysteries and figuring out answers to questions or problems, then the chances very good are you already know something about the scientific method. It's just that you haven't called it the scientific method yet.

The scientific method is basically an organized way to investigate something that interests you, when you want to find out why something happens the way it does. The scientific method starts with a *question*. Because the method is scientific, the question you ask needs to be something you can *measure* so you can compare results you are interested in. Maybe there's already a good answer to your question so it's important to do *background research*, looking in the library or searching through the Internet to find out what's already written about your question.

Just like a detective might come up with a list of suspects who might be responsible, the next step in the scientific method is to *formulate a hypothesis*. This hypothesis is an educated guess about how the things you're asking about actually work. For example, "If I give my plants fertilizer in the spring, they will have more flowers." is a simple hypothesis about how plants grow. An important part of formulating a hypothesis is making sure it is something you can *measure*. In this example, you can count the number of flowers. What are some of the other "suspects" that might be responsible for plant growth? Did you come up with water, light and temperature? Take a moment to write some other hypotheses (plural of hypothesis) about plants.

The next step in the scientific method is to show that the hypothesis is correct (true) or incorrect (false). When scientists are doing research into complicated areas of science, many of their hypotheses are false. Scientists are patient and persistent and keep looking for answers. The way to show that a hypothesis is true or false is to design and complete an *experiment*. Scientists must be careful in how they design an experiment to make sure that it tests exactly what the hypothesis states. A proper experiment compares two or more things but changes only one *variable* or factor in the experiment.

In an experiment, one group is the *control group* and the other is the *experimental group*. If a scientist was testing the flower and fertilizer hypothesis, she would select one species of flower to test with and buy a dozen plants. Six of the plants would be the control group and six the experimental group. All the plants would be kept in the same greenhouse and given the same amount of light and water. The experimental group would get a measured amount of fertilizer on a regular schedule while the control group would not get any fertilizer. The scientist would write down everything that she did, keeping good records in a *laboratory notebook.* Keeping detailed accurate records is an important part of the scientific method.

The scientist would conduct this flower experiment for a few weeks until the flowers bloomed. Then she would count the number of flowers in the control group and compare it with the number of flowers in the experimental group. Real science experiments use hundreds or thousands of *experimental subjects* to insure that the results apply to more than just a few subjects.

The next step in the scientific method is to *analyze the results.* Scientists use sophisticated *statistics,* a type of mathematical analysis, to analyze results. Different kinds of statistics are used in different fields of science. Simply using numbers from an experiment will not prove scientific hypotheses in real science experiments.

Let's look at the flower example again. What if the control group produced 20 flowers and the experimental group produced 40 flowers. In this case, since the difference in the number of flowers is huge, you might draw the *conclusion* that the fertilizer did increase the number of flowers and your hypothesis is true. What if the control group produced 20 flowers and the experimental group produced 23 flowers? Just because 23 is larger than 20 doesn't mean that the fertilizer improved the number of flowers. There weren't enough subjects (plants) in this experiment to determine that. But with lots more subjects and using statistics, a scientist could conduct a valid experiment that shows the difference between 20 and 23 flowers is due to the fertilizer. Whether a hypothesis is true or false isn't decided by the measurement numbers themselves but by the statistical analysis.

After scientists complete an experiment they report their *conclusions.* Each branch of science has a report format for publishing the results of experiments. If you do an experiment for a science fair project you will report your conclusions on a poster board for everyone to see. Your school probably has a format for science fair posters just like scientists have report formats.

What happens if the experiment does not show that the hypothesis is true? Does that automatically mean that the hypothesis is false? Absolutely not! Scientists are persistent in their research and will try another slightly different experiment. In the flower example, maybe we didn't use enough fertilizer to make a difference. Maybe we didn't use the right kind of fertilizer for the kind of plants we used. The next step might be to run another experiment with a larger amount of fertilizer. Repeating experiments or setting up new experiments to pinpoint the real relationship underlying the question we're trying to answer is called an *iterative process.*