76

Scientific Method

When you encounter a problem, how do you solve it? Do you consider what you already know about the problem, think of a possible answer, and then see if your answer is correct? If so, you are using the scientific method. The scientific method is a way of carefully collecting evidence about a question or problem, using that evidence to form a possible answer, and then testing the answer to see if it is accurate.

You can use this method as a tool for solving problems in science class and in many other areas of your life. For example, it could help you figure out why your pencils keep disappearing, how to wrap your sandwich so it does not dry out by lunchtime, or why your dog no longer likes his favorite food.

What are the steps in the scientific method? The scientific method has six steps, described below. They will help you solve all kinds of problems, in and out of school.

Step 1: State a problem or ask a question.
Step 2: Gather background information.
Step 3: Form a hypothesis.
Step 4: Design and perform an experiment.
Step 5: Draw a conclusion.
Step 6: Report the results.

Step 1: State a problem or ask a question. To begin using the scientific method, think about the world around you. You may see something that makes you curious, such your sandwich drying out by lunchtime on some days but not on others. You might see an unexplained light in the sky. You might hear a statement that you are not sure is true. For example, a friend might tell you that wearing glasses makes your eyes become weaker.

Put your curiosity into the form of a problem or question, such as these:

- Why does my sandwich dry out some days but not others?
- What is that light in the sky?

You do not have to be a scientist to use the scientific method.
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- Does wearing glasses make your eyes weaker?

Step 2: Gather background information. Read more about the problem or question. Observe it closely.

Step 3: Form a hypothesis. Now use what you know about the situation to think of a possible answer for your question. This answer, or guess, is your hypothesis. A hypothesis is an idea in the form of a statement that can be tested by observations and/or experiment. You will use what you already know about the situation to form a hypothesis. Here are possible hypotheses to answer the questions above:

- Plastic bags that seal keep more moisture in bread than waxed paper or plastic bags without seals do.
- That light in the sky is an airplane.
- Wearing glasses does not make your eyes become weaker.

All of these hypothesis are testable: You can make observations, do research, or set up experiments to determine whether each hypothesis is correct. Here are some examples of hypotheses that are vague and untestable:

- Sandwiches taste better when you seal them in plastic bags. *How can you measure "taste better?"*
- The light in the sky might be a reflection or something. *How can you measure "might be" or "something?"*
- Wearing glasses might make your eyes weaker, if you wear them long enough. *How long is "long enough?"*

The ancient Greeks often hypothesized about the causes of natural events. However, they assumed they could figure out the correct explanations just by thinking about the situation long enough. They usually did not experiment to find out whether their explanations were accurate. Aristotle, a famous Greek philosopher, developed theories that led to many discoveries, but his theories were based mostly on reasoning, not experimentation. For example, he hypothesized that the flies that he found on rotting fruit just appeared out of the air. He did not experiment to find out whether his hypothesis was true.

Step 4: Design and perform an experiment. In this step, you go beyond the ancient Greeks: you prove or disprove your hypothesis. You might be

Hypotheses: Is the light in the sky just an airplane—or something else? PHOTO RESEARCHERS INC.

able to establish whether your hypothesis is accurate by research, such as checking the local airport to see if an airplane flew over your house at a certain time last night. Or you might gather expert opinions about how wearing glasses affects people's eyesight. For the sandwich problem, the best approach is an experiment.

An experiment is a controlled observation. The experimenter carefully changes one condition at a time, such as the type of sandwich wrapping, and observes what happens. In most experiments, a control experiment is set up with the same conditions as the actual experiment. The conditions remain the same in the control experiment but are changed in the actual experiment, one condition at a time. If something happens only in the actual experiment and not in the control, it is clear that it was caused by changing a condition in the actual experiment. The control experiment for our sandwiches might be leaving a slice of bread unwrapped to see what happens to it and comparing it to those in various wrappings.

Conditions that change during an experiment and affect the results are called variables. The variables in our sample experiment include the type of bread, how fresh it is, the size of the piece of bread being wrapped, any fillings used with the bread, the length of time the bread is wrapped, the temperature of the wrapped bread during the experiment, and the type of sandwich wrapping. Only one variable is changed at a time during

Is your sandwich still fresh at lunchtime? KELLY A. QUIN.

the experiment. The variable being changed is called the independent variable, which in our experiment is the type of sandwich wrapping.

What might happen if we change two variables at a time, such as wrapping wheat bread with waxed paper and putting rye bread in a sealed plastic bag? If the rye bread is fresher than the wheat bread at the end of the experiment, we cannot be sure which variable is the cause—the type of bread or the type of wrapping.

The condition that changes during an experiment is called the dependent variable. In our example, the dependent variable is the amount of moisture in the bread. Results of experiments must be measurable, so we need a way to measure this moisture. We decide to weigh each slice of bread before and after the experiment. The difference in the weight would be the amount of moisture that evaporated.

Experiments must also be repeatable. We must write down our procedure and follow it carefully, so that someone else could carry out the same procedure and see if the same results occur.

Step 5: Draw a conclusion. The next step in the scientific method is to graph or chart our results, analyze them, and determine whether our hypothesis was correct. For some experiments, we might have quite a bit of data to analyze. For our sample experiment, we compare the loss in weight of each bread slice after the wrapping is removed. What is our conclusion? Did our results support our hypothesis?

Even if the results did not support our hypothesis, we have learned something just by asking the question and doing the experiment. Often there is no "right" answer when we use the scientific method. Instead, we simply gather more information about the problem, which is valuable in itself.

Step 6: Report the results. Reporting our results allows other scientists to build on our work—and to repeat our experiment to see if they get the same results. Without the sharing of results, little scientific progress would be made. Scientists publish their findings in scientific journals as a way of sharing what they have learned.

In the two experiments that follow, you will use information you gather to identify mystery powders, and you will use the scientific

WORDS TO KNOW

Control experiment: A set-up that is identical to the experiment but is not affected by the variable that affects the experimental group.

Dependent variable: The variable in an experiment whose value depends on the value of another variable in the experiment.

Experiment: A controlled observation.

Hypothesis: An idea phrased in the form of a statement that can be tested by observation and/or experiment.

Independent variable: The variable in an experiment that determines the final result of the experiment.

Scientific method: Collecting evidence and arriving at a conclusion under carefully controlled conditions.

Variable: Something that can change the results of an experiment.

method to prove or disprove Aristotle's hypothesis that fruit flies appear out of thin air.

EXPERIMENT 1

Using the Scientific Method: What are the mystery powders?

Purpose/Hypothesis In this experiment, you will begin with three mystery powders and ask yourself, "What are these powders?" Then you will gather information from a chart that shows how three kinds of powder react when mixed with water, iodine, and vinegar. Next, you will hypothesize the identity of each mystery powder. Then you will test how each powder reacts with water, iodine, and vinegar. You will compare your results with the chart and draw a conclusion about the identity of each powder. Then you will know whether your hypothesis was correct.

A hypothesis should explain these things:

- the topic of the experiment
- the variable you will change
- the variable you will measure
- what you expect to happen

A hypothesis should be brief, specific, and measurable. It must be something you can test through observation. Your experiment will prove or disprove whether your hypothesis is correct.

Level of Difficulty Easy/moderate.