

Science and the Scientific Method

Anyone who has ever read a mystery novel or seen a “whodunit” on TV, has seen the scientific method in action. Anyone who has ever tried to figure out what happens to the refrigerator light when you close the door, or where that other sock goes after you put it in the drier, has used the scientific method. The scientific method is not a mystical, incomprehensible rite that only “polyester plaid” science nerds use to solve esoteric problems. Instead, it is a logical, organized mechanism for identifying and researching a problem, and devising a strategy for solving it.

The scientific method is split up into five major steps:

1. **Determining the problem or question.**

- In this step, you (the researcher) must decide what it is that you will be studying. This sounds like a simple procedure, but it is actually very important. It identifies exactly what you wish to learn and it allows you to focus only on that material.

2. **Development of a hypothesis.**

- The hypothesis is not a just a random W.A.G (Wild @\$#\$& Guess) to your problem. Instead, the hypothesis is an Educated Guess. In other words, it involves researching the problem and finding out what other people have learned, and using that information to help devise an answer. An important aspect of the hypothesis is that it should answer the original question, and it should be testable!

3. **Design an experiment to test the hypothesis.**

- Design an experiment whose results will either support or disprove your hypothesis. If your hypothesis is supported, then the results of your experiment will indicate that your hypothesis is correct. However, this does not mean that your hypothesis is 100%, beyond a shadow of a doubt, correct. There may be other factors that will influence the results that you haven't tested. Therefore, it is important to say that the hypothesis is supported, you should never say that it is proven! However, the results of your experiment can prove your hypothesis wrong!

- There should be at least two groups in your experiment. The first group is the experimental group. This group is the group that has the factor that is being tested (Experimental Variable). It is easy to identify the experimental variable, since it is usually stated in the hypothesis. The second group is the control group. The control group is identical to the experimental group in every way, except that they lack the experimental variable. (If there were other differences, then they would invalidate the results of the experiment.)

4. **Conduct the experiment and collect the data.**

- Run the experiment that you have so carefully constructed. In this step, you will be measuring the dependent variable. This variable (DO NOT confuse it with the experimental variable) is the thing that is being observed or measured. Any pieces of information that you collect regarding the dependent variable are called DATA.

5. **Draw Conclusions from your data.**

- Here, it is stated directly whether the hypothesis was supported or disproven.

- If your hypothesis is supported, it should be repeated, since one of the basic foundations of the scientific method is that it is repeatable. The more an experiment is repeated, the more valid the results are. However, if there is a hypothesis that is supported by many experiments and a lot of data, we call that hypothesis a **theory**.

- The word theory is often misused in everyday language. Theory and hypothesis are *not* synonyms, a hypothesis is just an educated guess that perhaps has been supported once or twice by an experiment. A theory was once a hypothesis, but is now supported by a lot of data and is accepted as being correct, until new information is discovered to disprove it.

1. List the parts of the scientific method in order.

2. Suppose you work for a Blabbit Labs, the developer of many different pharmaceutical products. Your research division has stumbled across a new drug that you believe cures male pattern baldness. Before you can start selling the drug, you must demonstrate to the U.S. Food and Drug Administration that the drug is effective.

a. What is the question being asked?

b. What is the hypothesis?

You design an experiment with 500 men who have been diagnosed with male pattern baldness. They are divided up into two groups, group A men receiving the drug while group B men receive a placebo, a drug that is known not to effect baldness. The drug is referred to as the **experimental variable**, since this is what is being tested. As a hint, the hypothesis will usually identify the experimental variable of a study.

In this study, the men receive the drug or a placebo once a day. All of the men will have the number of hairs per square inch of scalp measured in a clinic once per week. The number of hairs per square inch will be the **dependent variable** since this variable depends on the effectiveness of the experimental variable. The dependent variable is also what we use to determine if the experimental variable is actually acting according to the hypothesis and the data collected will usually tell what the dependent variable is.

Men in group A belong to the **experimental group**, since they received the experimental variable. Men in group B belong to the **control group**. The control group is important since it gives the researchers something to compare the experimental group to. For instance, if the men in the experimental group were shown to have hair growth, then that would indicate that the hypothesis was supported and the drug grows more hair. However, if the control group also grew hair, then something in the environment besides the drug was responsible for hair growth.

c. Define dependent and experimental variables?

d. Compare and contrast the experimental and control group.

4. You are conducting an experiment to determine if increased ultraviolet radiation from the decrease in the ozone layer is killing off frog tadpoles. After examining all of the data available in the library, you decide to go with a hypothesis that increased ultraviolet radiation from the sun is killing off the tadpoles.

You design an experiment with a control and an experimental group. Group 1 involves 100 tadpoles in a five gallon container of water, which is covered by glass (knowing that the glass will filter out the ultraviolet radiation). Group 2 will be set up exactly like group 1, except that instead of being covered with glass, it is covered with an acrylic plexiglass, which will not filter out the U.V. radiation. You then place the groups outside for a period of a month, and observe the results.

	<u>Results</u>	
	<u>Group 1</u>	<u>Group 2</u>
Number of tadpoles started with	100	100
Number finished	96	96

Using this information, answer the following questions.

- What is the experimental variable and what is the dependant variable?
- Does the information from this experiment support the hypothesis?
- If no, then what might be causing the decrease in frog populations?
- Which is the control group, and which is the experimental group?
- What is the difference between the two groups? Should they be different in any other way?

5. Niko Tinbergen (1907-1988) was a Swedish Ethologist (animal behaviorist) famous for studying animals in their native habitats. One of his classic experiments involved a bird called the black-headed gull (*Larus ridibundus*). Black-headed gulls build nests of twigs on the ground and lay light brown eggs that are covered with dark brown spots. However, the inside of the egg is white in color. Tinbergen noticed that adult gulls pick up the eggshells shortly after a chick has hatched, and fly them to a location far from the nest, where they are left. Since this behavior required expending energy and time that could have been spent feeding and protecting the chicks, Tinbergen wanted to know why the birds did this.

Problem: Why do black-headed gulls remove eggshells from the nest?

Hypothesis: The white interior of the shell is not camouflaged and attracts predators to the nest. Therefore, the gulls remove the shells to decrease predation.

Test: Tinbergen and his co-workers collected gull eggs and painted 69 of them white and left 68 of them with their natural color. (Statistically, these numbers are close enough to be considered equal.) The researchers then scattered the eggs next to a gull breeding area and observed from a nearby blind. Predation rates were recorded for white versus natural colored eggs.

Data:	Original Number of Eggs	Eggs Taken by Predators
White Eggs	69	43
Natural Eggs	68	13

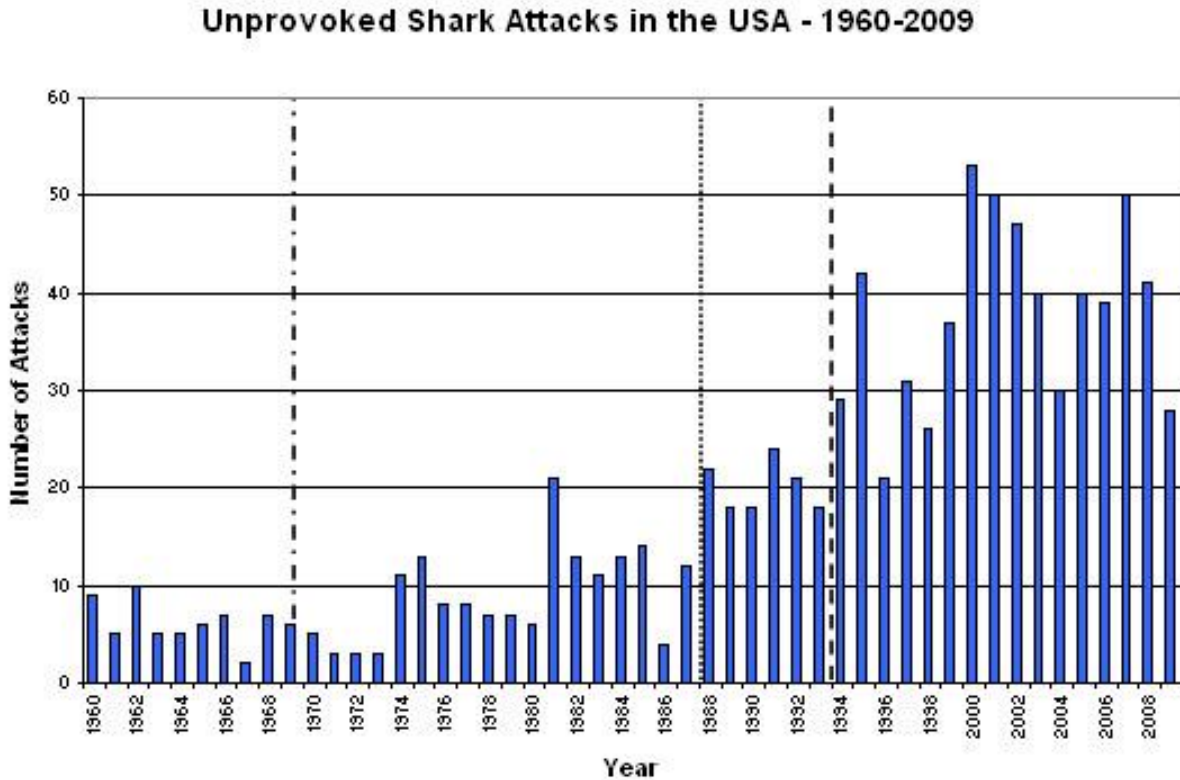
a. Do the results of this experiment support the hypothesis? Why, Why not?

b. Are you 100% sure (without a doubt) that your hypothesis is correct? (Is it proven?)

c. If you were working with Tinbergen, what would you suggest be done next?

d. Identify the experimental and dependent variables

6. The media has given a lot of attention recently to shark attacks on humans, due in part to several high profile incidents. Are the numbers of shark attacks becoming more frequent, or are we just hearing about them more often than before because of the previous cases in the news? The following chart was made using data from the ISAF (International Shark Attack File) a group that tracks shark attacks world-wide.



Unprovoked shark attacks for Florida from 1960 through 2009. The drop in recorded attacks in 1969 (dashed-dotted line) is a result of a loss of funding to support the ISAF, and hence less effort reporting and organizing of attacks (see The History of the International Shark Attack File). The apparent increase in attacks after 1987 (dotted line) is in part an artifact of the ISAF moving to the Florida Museum of Natural History, resulting in an increased scope of coverage and reporting of attacks. The apparent increase in attacks after 1993 (dashed line) is in part an artifact of a breakthrough in communication with Volusia County (FL) emergency responders and lifeguards, resulting in the reporting of a greater number of minor attacks that had previously gone unreported. Volusia County, Florida has a high number of shark-human interactions as a result of extremely high aquatic recreational utilization of its waters by residents and tourists, especially surfers. Most of these interactions result in minor bites or abrasions from small sharks. *Data current as of: May 3, 2010*

Source:

"ISAF 2010 Worldwide Shark Attack Summary." International Shark Attack File.
 2005. Florida Museum of Natural History. 13 October, 2010.
<http://www.flmnh.ufl.edu/fish/sharks/statistics/trends2.htm>

a. One hypothesis that attempts to explain these attacks, says that the increase is do to “shark feeding” programs introduced in the late 1980’s and used at vacation resorts to attract divers and snorkelers. People pay tour operators to put dead fish (chum) into the water to lure sharks, so that they can interact and sometimes feed the sharks. The hypothesis states that sharks become used to humans feeding them, and then bite other humans when they don’t get fed. Design an experiment to test this hypothesis. Be sure to identify the variables and the groups.

Question: Why is there an overall increase in the number of shark attacks?

Hypothesis: Shark feeding programs are causing an increase in shark attacks.

b. The data from International Shark Attack File indicate that there is a general increase in the number of shark attacks? Do the *data* here tell us why this is happening?

C. From the chart, it is obvious to see that there is an overall increase in the number of shark attacks, even though some years (such as 1996) have fewer than others. However, is it possible that some other factor may be influencing the results? One thing the chart doesn’t say is that many shark attacks occur in areas of Florida where there aren’t a lot of people. With the introduction of the internet and cellular communication in the 1990’s, would you expect the ability of biologists to RECORD the number shark attacks to increase?

D. One problem with data like those provided in the shark attack table is that it doesn't always indicate other factors that might influence the results. This is why it is so necessary to repeat and continue to test hypotheses. The ISAF states on their web site that while this data is accurate, it doesn't take into account the fact that human populations are increasing world-wide. With this increase in population, there are more people around, therefore there will be less habitat for the sharks to hunt for food (since humans are now living and playing on beaches not inhabited before). Could this increase in contact between humans and sharks result in more attacks.

E. Does the chart now say the same thing to you that it did before? It is very important when looking at a study to be objective. You may be surprised to learn that not everything that you see on the internet or in the media is as it seems on the surface. In this class, we will learn to look objectively and think critically about information.

Answers to Selected Questions

1. Determine the question or problem, form a testable hypothesis, design an experiment, run the experiment and collect data, draw conclusions from the data.
 - 2a. Is the new drug effective / does it cure male pattern baldness?
 - 2b. The drug is effective at curing male pattern baldness.
 - 2c. The experimental variable is the variable that is being tested. The dependent variable is the variable that is measured as a way of determining whether the hypothesis is supported or disproven.
 - 2d. The experimental group is the group with the experimental variable. The control group is identical to the experimental group in every way *except* it is not exposed to the experimental variable.
- 3a. The hypothesis is that a virus, bacteria or fungus is killing off the bees.
- 3b. When designing the experiment, be sure to have at least two groups, one group that is exposed to the pathogen and one group that is not (the control).
- 3c. If the hypothesis is supported, a significant number of bees in the experimental group should die, while most or all of the bees in the control group should live.
- 3d. If the hypothesis is disproven, there shouldn't be a significant difference between the control and experimental groups.

Biology 120
Scientific Method Worksheet

Name _____ Date _____

Write in the word or short phrase needed to answer the question or complete the statement in the space provided. This page may be collected for homework.

- _____ 7. Give the general name for the factor that is tested in an experiment.
- _____ 8. Give the general name for the factor that is observed, measured or counted in an experiment.
- _____ 9. Which group contains the variable that is being tested?
- _____ 10. Which group is identical the group above in every way EXCEPT for lacking the variable that is being tested?
- _____ 11. Name the term used to indicate a hypothesis that is supported by repeated experiments and a lot of data.
- _____ 12. If a hypothesis is tested and found to be incorrect, then we say that the hypothesis has been:
- _____ 13. In question number 4 dealing with the tadpoles, which group (give the number) was the control group?
- _____ 14. In question number 4 dealing with the tadpoles, what was the experimental variable?
- _____ 15. In question number 4, was the hypothesis supported or not?
- _____ 16. According to the graph on page 12, it appears that the number of shark attacks are increasing world-wide. However, other factors not necessarily related to the shark attacks themselves may sometimes be responsible for altering data. Name one of the two factors that may have caused an increase in the number of shark attacks reported on the graph without necessarily indicating an increase in the number of actual shark attacks.