

The Scientific Method

Observation

Made at every step of your experiment

1. Problem

Question you want to answer



2. Literature

Existing theory and research on your topic



3. Hypothesis

Best guess or prediction



4. Experiment Design

Independent and dependent variables
Control and experimental groups



5. Collect Data

Materials
Steps to do it (procedure)



6. Analyze Data

What you observed
-tables
-graphs
-charts
-diagrams



Discard or change hypothesis ← No ← 7. Conclusions → Yes → End
Is the hypothesis right?

Steps in the Scientific Method

- 1. Defining the Problem**
Selecting a topic for research and defining key concepts.
- 2. Reviewing the Literature**
Familiarizing oneself with the existing theory and research on a topic.
- 3. Forming a Hypothesis**
Defining the relationship between measurable variables so that they can be measured and the hypothesis tested.
- 4. Choosing a Research Design**
Selecting a method for study: experiment, survey, or field observation. To set up an experiment you will need to identify your independent variable, dependent variable, control group, experimental group, and procedure.
- 5. Collecting the Data**
Collecting the information that will test the hypothesis.
- 6. Analyzing the Data**
Working with and examining the data to shed light on the hypothesis.
- 7. Drawing Conclusions (inferring)**
Summarizing the outcome of the study, indicating its significance, relating the findings to existing theory and research, and identifying problems for future research.

Scientific Method:

Principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.

The Scientific Method

- Analyzing Data: The process of determining whether data are reliable and whether they support or refute a given prediction or hypothesis.
- Classifying: The process of sorting objects or events into groups based on their common features.
- Collecting Data: Gathering and recording of specific information based on observations.
- Communicating: Sharing information. Includes critiquing work of other scientists and gaining insight from other scientists that can benefit your own work.
- Controlled Experiment: Based on a comparison of a control group and an experimental group.
- Dependent Variable: The factor that changes as a result of the independent variable. The responding variable.
- Experimenting: The process of testing a hypothesis or prediction by carrying out data-gathering procedures under controlled conditions.
- Hypothesizing: The process of forming testable statements about observable phenomena, is often one of the first steps in a scientific investigation. A statement is testable if evidence can be collected that either supports the hypothesis or refutes it. Although a hypothesis may be refuted, it can never be proved true beyond all doubt. It can only be supported by evidence.

Independent Variable: The one factor that you change in an experiment. The manipulated variable.

Inferring: An Inference is an attempt to explain or interpret observations or to say what caused what you observed.

Measuring: The process of determining the dimensions of an object, the number of objects in a group, the duration of an event, or other characteristics in precise units.

Modeling: Involves constructing a representation of an object, a system, or a process that helps show relationships between data.

Observing: The use of one or more of the five senses to perceive objects or events.

Organizing Data: Involves placing observations and measurements in some kind of logical order, such as a graph, chart, table, or map.

Predicting: Stating in advance the result that will be obtained from testing a hypothesis. A prediction often takes the form of an "if - then" statement.

Sequencing: A sequence is an arrangement of things or events in a particular order.

Theory: Most probable explanation for a large set of data.



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17		E													

Across






1. The process of testing a hypothesis by carrying out data-gathering procedures.
5. During a controlled experiment this group does not receive the independent variable.
6. Choosing a research ___ is the step in which you identify your variables and outline your procedure.
8. The responding variable that you look for during an experiment.
11. ___ the data is the step in which you organize your data into tables and graphs.
14. Drawing ___ is the seventh step in the scientific method when you report on your outcomes.
16. The manipulated variable that you control during an experiment.
17. Stating in advance the result that will be obtained from testing a hypothesis.

Down

2. Defining the ___ is the first step of the scientific method.
3. An excellent hypothesis is written in the
4. A good hypothesis is worded so that you can ___ it with an experiment.
7. The process of forming testable statements about observable phenomena.
8. Collecting the ___ is the fifth step in the scientific method.
9. American Psychological Association report and bibliography format rules known as ___ style.
10. A carefully worded statement that predicts how the independent variable will effect the outcome.
12. Reviewing the ___ is the second step of the scientific method.
13. If a bibliographic citation is longer than one line, additional lines must be ___ five spaces.
15. The use of one or more of the five senses to perceive objects or events.

Identify the Controls and Variables

Name _____

 <p>Smithers thinks that a special juice will increase the productivity of workers. He creates two groups of 50 workers each and assigns each group the same task (in this case, they're supposed to staple a set of papers). Group A is given the special juice to drink while they work. Group B is not given the special juice. After an hour, Smithers counts how many stacks of papers each group has made. Group A made 1,587 stacks, Group B made 2,113 stacks.</p>	<p>Identify the:</p> <ol style="list-style-type: none"> Control Group Independent Variable Dependent Variable What should Smithers' conclusion be? How could this experiment be improved?
 <p>Homer notices that his shower is covered in a strange green slime. His friend Barney tells him that coconut juice will get rid of the green slime. Homer decides to check this out by spraying half of the shower with coconut juice. He sprays the other half of the shower with water. After 3 days of "treatment" there is no change in the appearance of the green slime on either side of the shower.</p>	<p>6. What was the initial observation?</p> <p>Identify the-</p> <ol style="list-style-type: none"> Control Group Independent Variable Dependent Variable What should Homer's conclusion be?
<p>Bart believes that mice exposed to microwaves will become extra strong (maybe he's been reading too much Radioactive Man). He decides to perform this experiment by placing 10 mice in a microwave for 10 seconds. He compared these 10 mice to another 10 mice that had not been exposed. His test consisted of a heavy block of wood that blocked the mouse food. he found that 8 out of 10 of the microwaved mice were able to push the block away. 7 out of 10 of the non-microwaved mice were able to do the same.</p> 	<p>Identify the-</p> <ol style="list-style-type: none"> Control Group Independent Variable Dependent Variable What should Bart's conclusion be? How could Bart's experiment be improved?
 <p>Krusty was told that a certain itching powder was the newest best thing on the market, it even claims to cause 50% longer lasting itches. Interested in this product, he buys the itching powder and compares it to his usual product. One test subject (A) is sprinkled with the original itching powder, and another test subject (B) was sprinkled with the Experimental itching powder. Subject A reported having itches for 30 minutes. Subject B reported to have itches for 45 minutes.</p>	<p>Identify the-</p> <ol style="list-style-type: none"> Control Group Independent Variable Dependent Variable Explain whether the data supports the advertisements claims about its product.
<p>Lisa is working on a science project. Her task is to answer the question: "Does Rogooti (which is a commercial hair product) affect the speed of hair growth". Her family is willing to volunteer for the experiment.</p> 	<p>20. Describe how Lisa would perform this experiment. Identify the control group, and the independent and dependent variables in your description.</p>

Scientific Method In Action

Name _____

The Strange Case of BeriBeri

In 1887 a strange nerve disease attacked the people in the Dutch East Indies. The disease was beriberi. Symptoms of the disease included weakness and loss of appetite, victims often died of heart failure. Scientists thought the disease might be caused by bacteria. They injected chickens with bacteria from the blood of patients with beriberi. The injected chickens became sick. However, so did a group of chickens that were not injected with bacteria.

One of the scientists, Dr. Eijkman, noticed something. Before the experiment, all the chickens had eaten whole-grain rice, but during the experiment, the chickens were fed polished rice. Dr. Eijkman researched this interesting case. he found that polished rice lacked thiamine, a vitamin necessary for good health.



1. State the Problem
2. What was the hypothesis?
3. How was the hypothesis tested?
4. Should the hypothesis be supported or rejected based on the experiment?
5. What should be the new hypothesis?

How Penicillin Was Discovered

In 1928, Sir Alexander Fleming was studying Staphylococcus bacteria growing in culture dishes. He noticed that a mold called Penicillium was also growing in some of the dishes. A clear area existed around the mold because all the bacteria that had grown in this area had died. In the culture dishes without the mold, no clear areas were present.

Fleming hypothesized that the mold must be producing a chemical that killed the bacteria. He decided to isolate this substance and test it to see if it would kill bacteria. Fleming transferred the mold to a nutrient broth solution. This solution contained all the materials the mold needed to grow. After the mold grew, he removed it from the nutrient broth. Fleming then added the nutrient broth in which the mold had grown to a culture of bacteria. He observed that the bacteria died.

6. Identify the problem.
7. What was Fleming's hypothesis?
8. How was the hypothesis tested?
9. Should the hypothesis be supported or rejected based on the experiment?
10. This experiment lead to the development of what major medical advancement?

How is the Surface Tension of Water Affected By Soap?

Name _____

Introduction: Surface tension refers to water's ability to "stick to itself". Surface tension can be measured and observed by dropping water (drop by drop) onto a penny. The number of water drops that can fit on a penny will surprise you.

1. Initial Observation: Observe surface tension by seeing how many drops of water can fit on a penny.
Number of Drops _____

Question: How does soap affect the water's surface tension?

2. Develop a hypothesis that answers the experimental question. Write your hypothesis below.

3. Test your hypothesis by comparing the number of drops of tap water that can fit on a penny to the number of drops of soapy water that can fit on a penny. Because water drops may vary depending on how well you drop the water, it is best to run many trials and take an average. Record your data in the table below



	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Average
Tap Water						
Soapy Water						

4. Analyze the data and draw conclusions. Write a paragraph below (using complete sentences) that explains how soap affects the surface tension of water, using your data to help you answer the question. Suggest a reason for your observations (Why did it happen). Support or reject your hypothesis

Post- Lab Analysis

5. Explain what surface tension is.

6. Why were many trials taken and averaged?

7. In this experiment, what was your control group?

8. Identify the independent variable in the experiment.

9. Identify the dependent variable in the experiment.

10. What if the experimental question was "How does sugar affect the surface tension of water?" Describe how you would answer this question using the scientific method. If you have time, you can test this.

Writing Hypotheses

Purpose: To learn how to write hypotheses using the “**if** and **then** format.”
(If = the CAUSE ⇒ then = the *EFFECT*)

What Is a Hypothesis?

A hypothesis is an estimate or “educated guess” for solving a problem based on facts, observations, and data.

Example Scenario: A student wants to see if the amount of sunlight effects the growth cycle of a pansy. The student places one pansy on a window sill (natural light), and another in the living room (only artificial light). **Hypothesis:** If a pansy is placed in natural light then it will *grow two inches higher* than a pansy grown in the artificial light.

A hypothesis is a tentative statement that gives a possible explanation to some phenomenon or event. A useful hypothesis is a **testable** statement which may include a prediction. A hypothesis should not be confused with a theory. Theories are general explanations based on a large amount of data.

When Are Hypotheses Used?

The key word is **testable**. That is, you will perform a test of how two variables might be related. This is when you are doing a real experiment. You are testing variables. Usually, a hypothesis is based on some previous observation such as noticing that in November many trees undergo color changes in their leaves and the average daily temperatures are dropping. Are these two events connected? How?

Any laboratory procedure you follow without a hypothesis is really not an experiment. It is just an exercise or demonstration of what is already known.

How Are Hypotheses Written?

Example:

If skin cancer is **related** to ultraviolet light, **then** people with a high exposure to uv light will have a *higher frequency of skin cancer*.

If leaf color change is **related** to temperature, **then** exposing plants to low temperatures will result in *changes in leaf color*.

Notice that these statements contain the words, **if** and **then**. They are necessary in a formalized hypothesis. But not all if-then statements are hypotheses. For example, "If I play the lottery, then I will get rich." This is a simple prediction. In a formalized hypothesis, a tentative relationship is stated. For example, if the *frequency of winning* is

related to frequency of buying lottery tickets. "Then" is followed by a prediction of what will happen if you increase or decrease the frequency of buying lottery tickets. If you always ask yourself that if one thing is related to another, then you should be able to test it.

Formalized hypotheses contain two variables. One is "independent" and the other is "dependent." The independent variable is the one you, the "scientist" control and the dependent variable is the one that you observe and/or measure the results. In the statements above the independent variable is underlined and the *dependent variable is in italics*.

The ultimate value of a formalized hypothesis is it forces us to think about what results we should look for in an experiment.

Practice:

Please write three different hypotheses that you might use for your BirdSleuth report or this year's science fair project. Please underline the independent variable and circle the dependent variable in each of your "if and then" hypotheses.

1.

2.

3.