**Experimental Method**

1. **Variables** - Changing quantities in an experiment are called variables, and an experiment usually has three kinds: independent, dependent, and controlled.

The independent variable is the one that is changed by the scientist. In an experiment there is only one independent variable. Remember: Independent variable is what the scientist change.

As the scientist changes the independent variable, he or she observes what happens.

The dependent variable changes in response to the change the scientist makes to the independent variable.

The new value of the dependent variable is caused by and depends on the value of the independent variable. For example, if you increase the temperature to 37°C (the independent variable), the amount of product formed (the dependent variable) in an enzyme catalyzed reaction increases. The number of dependent variables in an experiment may vary and there is often more than one.

Experiments also have controlled variables. Controlled variables are quantities that a scientist wants to remain constant, and must be observed as carefully as the dependent variables. For example, if we changed the pH and the temperature at the same time, we cannot be sure if the amount of product formed is affected by pH or temperature. Most experiments have more than one controlled variable or controlled factor.

**Experimental question** | **Independent variable** | **Dependent variable** | **Controlled variables**
--- | --- | --- | ---
Does fertilizer make a plant grow bigger? | Amount of fertilizer measured in grams. | Growth of the plant measured by its height. Growth of the plant measured by the number of leaves. | Same plants. Same soil. Same size pot. Same amount of water and light. Measurements of growth at the same time.
Does temperature affect the rate of enzyme activity? | Temperature in each test tube. | 1. The amount of enzyme activity. 2. The amount of substrate used. 3. The amount of product produced | Same enzyme & substrate. Same size test tubes. Same amount of time for enzyme activity. Same pH.
Does pH affect the rate of enzyme activity? | pH in each test tube. | 1. The amount of enzyme activity. 2. The amount of substrate used. 3. The amount of product produced | Same enzyme & substrate. Same size test tubes. Same amount of time for enzyme activity. Same temperature.

2. **Control group (control)**

Goes through all parts of the experiment except the factor being tested (independent variable). Used as a comparison to see if the experiment is working (independent variable has any effect)

<table>
<thead>
<tr>
<th>Experimental question</th>
<th>Test</th>
<th>Control (control group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does fertilizer make a plant grow bigger?</td>
<td>Plants in soil + fertilizer. Amount of fertilizer varies in each test.</td>
<td>Plants in soil with no fertilizer.</td>
</tr>
<tr>
<td>Does temperature affect the rate of enzyme activity?</td>
<td>Substrate + enzyme. Each test in a different temperature.</td>
<td>Substrate with no enzyme. Each control in a different temperature.</td>
</tr>
</tbody>
</table>

3. **Data Precision (accuracy)**

a. Reliability - refers to the reproducibility of a measurement. You increase reliability simply by taking several measurements or doing the experiment a number of times.

b. Validity – refers to whether the data actually measures what it claims to be measuring.

refers to the extent to which the data collected gives a true measurement.

c. Sample size – the larger the sample size (amount of data collected) the more reliable it is.
Experimental Design Worksheet

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.

Identify the:
1. Control Group
2. Experimental Group
3. Independent Variable
4. Dependent Variable
5. What is Smithers' conclusion?
6. What was the initial hypothesis?

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.

Identify the:
7. Control Group
8. Experimental group
9. Independent Variable
10. Dependent Variable
11. What should Homer's conclusion be?

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.

Identify the:
12. Control Group
13. Experimental group
14. Independent Variable
15. Dependent Variable
16. What should Bart's conclusion be?
16. 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".

The scientific method assumes that she follow certain steps. The steps listed below are out of order. Put them in the correct order.

_____ Design and carry out a controlled, repeatable experiment to test the hypothesis
_____ Use knowledge, experience, insight and imagination to formulate a hypothesis that can test your original question
_____ Research information related to the question
_____ Report the results to others
_____ Observe natural phenomena which leads to the clear statement of a question
_____ Determine whether the data obtained support or reject the hypothesis.

Amylase is an enzyme that digests starch to maltose. Amylase is produced in your salivary glands and secreted into your mouth. Your task is to design an experiment to test the effectiveness of amylase when exposed to different pH levels.

17. State a hypothesis regarding the effect of pH on the function of the digestive enzyme amylase.

18. Using any of the materials listed below, design an experimental procedure which could be used to test the hypothesis. Briefly write out the experimental procedure as a series of numbered steps:
   • A bottle containing 25 mL of amylase solution.
   • Five bottles, each containing 10 mL of a solution buffered to maintain the following pH levels (pH 3, 5.7, 9 and 11).
   • A bottle containing 50 mL of starch solution.
   • 10 test tubes and test tube rack.
   • A water bath capable of maintaining the bottles at a constant temperature of 37 °C.

19. How would you set up controls (control groups) for this experiment?

20. What is the purpose of the control group?