The Scientific Method (Experimental Design)

The science fair project is an investigation using the scientific method to discover the answer to a scientific problem. Before starting your project, you need to understand the scientific method. The scientific method is the “tool” that scientists use to find the answers to questions. It is the process of thinking through the possible solutions to a problem and testing each possibility for the best solution. The scientific method involves the following steps: identifying the problem, stating a hypothesis, conducting project experimentation, and reaching a conclusion.

**Problem:**

The problem is the scientific question to be solved. It is best expressed as an “open-ended” question, which is a question that is answered with a statement not just a yes or a no. For example, how does light affect the reproduction of bread mold on white bread?

**Do** limit your problem. Note that the previous question is about one life process of molds – reproduction; one type of mold – bread mold; one type of bread – white and one factor that affects its growth – light. To find the answer to a question such as “How does light affect mold?” would require that you test different life processes and an extensive variety of molds.

**Do** choose a problem that can be solved experimentally. For example, the question “What is mold?” can be answered by finding the definition of the word in the dictionary. But, “at room temperature, what is the growth rate of bread mold on white bread?” is a question that can be answered by experimentation.

**Hypothesis:**

A hypothesis is an idea about the solution to a problem, based on knowledge and research. While the hypothesis is a single statement, it is the key to a successful project. All of your science fair project is done with the goal of expressing a problem, proposing an answer to it – the hypothesis, and designing project experimentation. Then all of your project experimenting will be performed to test the hypothesis. The hypothesis should make a claim about how two factors relate. For example, in the following sample hypothesis, the two relating factors are light and bead mold growth. Here is an example of a hypothesis for the earlier problem: “I believe that the bread mold doesn’t need light for reproduction on white bread because my hypothesis is based on facts I researched.”

**Do** state facts from past experiences or observation on which you based your hypothesis

**Do** write down your hypothesis before beginning the project experimentation

**Don’t** change your hypothesis even if experimentation does not support it.

**Experimentation:**

Experimentation is the process of testing a hypothesis. The things that have an effect on the experiment are called variables. There are three kinds of variables that you need identify: Independent, dependent, and controlled (consistent). The independent variable is the variable you purposely manipulate (change). The dependent variable is the variable being observed and measured in response to the independent variable. The variables that are not changed are called controlled (consistent) variables.

The independent variable for the experiment is light and the dependent variable is bread mold reproduction. A control is a test in which the independent variable is kept constant in order to measure changes in the dependent variable. In a control, all variables are identical to the experimental setup. Factors that are identical in both the experimental setup and the control setup are the controlled variables. For example, prepare the experiment by placing three or four loaves of white bread in cardboard boxes the size of a bread box, one loaf per box. Close the boxes so that they receive no light. If, at the end of a set time period, the mold grows, you might decide that no light was needed for mold reproduction. But, before making this decision, you must determine experimentally if the mold would grow with light. Thus, control groups must be set up of bread that receives light throughout the testing period. Do this by placing an equal number of loaves in comparable-size boxes, but leave them open. The other variables for the experimental and control setup, such as the environmental conditions for the room where the boxes are placed – temperature and humidity – and the brand of the breads used must be kept the same. There are controlled variables.

Note that when designing the procedure of your project experiment; include steps for measuring the results. For example, to measure the amount of mold growth, you might draw squares on a transparent sheet of plastic. This could be places over bread and the number of squares with mold growth could be counted. Also, as it is best to perform the experiment more than once, it is also good to have one control for every experiment setup.

**Do** have only one independent variable during an experiment

**Do** repeat the experiment more than once to verify your results

**Do** have more than one control, with each being identical

**Do** organize data in a data table

**Project Conclusion**

The project conclusion is a summary of the results of the project experimentation and a statement of how the results relate to the hypothesis. Reasons for experimental results that are contrary to the hypothesis are included. If applicable, the conclusion can end by giving ideas for further testing.

*If your results do not support your hypothesis:*

**Don’t** change your hypothesis

**Don’t** leave out experimental results that do not support you hypothesis

**Do** give possible reasons for the difference between your hypothesis and the experimental results

**Do** give ways that you can experiment further to confirm the results of your original experiment

*If your results support your hypothesis:*

For example, you might say – As stated in my hypothesis, I believe that light is not necessary for bread mold to reproduce. My experimentation supports the idea that bread mold will reproduce without light. After 21 days, bread mold had grown both on testing samples kept in the dark and also on the control samples in the light. It is possible that temperature is a factor and that temperature was higher inside the closed boxes due to lack of air circulation. For further testing, I would select temperature as the independent variable and test the effect of temperature changes on the growth of bread mold.