The Scientific Method

A science project is an investigation using the scientific method to discover the answer to a scientific problem. Before starting you project, you will 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 to find the best solution. The scientific method involves the following steps:

- **Doing research**
- **Identify the problem (in question form)**
- **State the hypothesis**
- **Conduct an experiment**
- **Observe and record your data**
- **Reach a conclusion**

Doing Research

Research is the process of collecting information from your own experiences, knowledgeable sources, and data from exploratory experiments. Your first research is used to select a project topic. This is called **topic research**. For example, you observe a black growth on bread slices and wonder how it got there. Because of this experience, you decide to learn more about mold growth. Your topic will be about fungal reproduction.

After you have selected a topic, you begin what is called **project research**. This is research to help you understand the topic, express a problem, propose a hypothesis, and design one or more project experiments- experiments designed to test the hypothesis. Investigate what others have already learned about your question. The result of this experiment and other research give you the needed information for the next step – identifying the problem.

- Do use as many references from printed sources – books, journals, magazines, and newspapers – as well as electronic resources – computer software and online services.
- Do gather information from professionals – instructors, librarians, scientists, such as physicians and veterinarians.
- Do perform other exploratory experiments related to your topic.

Identify the 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 yes or no. These questions may begin with the word how, why, or when but shouldn't begin with the word does or is.

- Do limit your problem
- Do choose a problem that can be solved by performing an experiment.

State a 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 project research 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. Here is one example of a hypothesis:
"I believe that bread mold does not need light for reproduction on white bread. I base my hypothesis on these facts: (1) organisms with chlorophyll need light to survive. Molds do not have chlorophyll and (2) in my exploratory experiment, bread mold grew on white bread kept in a dark bread box."

- Do state facts from past experiences or observations on which you base your hypothesis.
- Do write down your hypothesis before beginning the project experimentation.
- Don't change your hypothesis even if experimentation does not support it. If time permits, repeat or redesign the experiment to confirm your results.

Conduct an Experiment

Project experimentation is the process of testing a hypothesis. The things that have an effect on the experiment are called variables. There are two kinds of variables that you need to identify in an experiment: independent and dependent. The **independent variable** is the variable that you purposely manipulate (change). The **dependent variable** is the variable that is being observed, which changes in response to the independent variable. The control is not changed.

A controlled test is one in which the independent variable is kept constant in order to measure changes in the dependent variable. In the control, all variables are identical to the experimental setup – your original setup – except for the independent variable. Factors that are identical in both the experimental setup and the control setup are the controls.

Scientists run experiments more then once to verify that results are constant. Each time that you perform your experiment is called a run or a trial. As it is best to perform an experiment more then once, it is also good to have more then one control. You might have one control for every experimental setup.

- Do have only one independent variable during an experiment.
- Do repeat the experiment more then once to verify your results.
- Do have a control.
- Do have more then one control, with each being identical.
- Do organize data.

Reach a 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.

<u>If your results do not support your hypothesis:</u>

- DON'T change your hypothesis.
- DON'T leave out experimental results that do not support your hypothesis.
- DO give possible reasons for the difference between your hypothesis and the experimental results.
- DO give ways that you can experiment further to find a solution.

<u>If your results do support your hypothesis:</u>

You might say, for example, "As stated in my hypothesis, I believe that light is not necessary during the germination of bean seeds. My experiment supports the idea that bean seeds will germinate without light. After seven day, the seeds tested were seen growing in full light and in no light. It is possible that some light reached the 'no light' containers that were placed in a dark closet. If I were to improve on this experiment, I would place the 'no light' containers in a light-proof box and/or wrap them in light-proof material, such as aluminum foil."

Scientific Logbook

Students must keep a logbook of their experiment. A log book is a single subject, bound notebook in which all of the records of the experiment are kept. The logbook will become part of the science fair display, along with the board and the research paper. It is the piece of information that the student will refer to if something about the experiment has to be double checked. The logbook can also be referred to when writing the research paper. Judges will want to see the original logbook. Don't rewrite it if it is not neat. Judges look for evidence that the logbook was used every time a part of the experiment was worked on.

What to put in your logbook:

- Data Entries – every entry should be **dated** and written on a **separate page**. You should **number each page** up in the corner. Whether the entry is made daily or only once a week will depend on your experiment. Every time you do part of your experiment, you should make a new page. Write or print so you can read it!

- The final plan of the experiment – once you have settled on the final plan, called the **research plan**, for your experiment, you should write it in your logbook for reference.

- Include gathering materials together, borrowing or buying things you need for the project. Record the cost of materials and where you purchased them.

- Description of setting up your experiment – write a detailed account of what was done in setting up the experiment. Be sure to write down the date when you begin the experiment. Describe everything that you do and everything that happens. Write it down immediately, while you still remember and the details are fresh in your mind.

- Ideas and questions – an idea may occur to you while you are working. Write it down in your logbook. You may not see any immediate use for the idea, but if you record it, it may be important later. If you have a question, write it down so you can look up the answer when you have a chance.

- Problems or weak parts of the experiment – your investigation may have weak spot that you didn't know about when you started. Write them down as you discover or realize them. If your experiment is repeated, the weak spots can be corrected or compensated for. When you report your results, these weak spots should be listed and explained. If some of the ways you are measuring are not working well, write it down so you can make a change.

- Charts and tables of data – the tables and charts where you record your measurements may be the basis of the charts, tables and graphs that you make for your display board and include in your research paper. Label accurately.

Preparing an Abstract

What is an Abstract?

An abstract is a summary of your project. It is not just a general description. After finishing research and experimentation, you will write:

- A 250-word
- A one page abstract printed on a single sheet of paper
- It will be in the form of a three paragraph essay
- You will attach it to the lower right hand corner of your science project board
- If you are not entering your project into the fair, you will hand in your abstract after you have presented your project to the class

The following should be included in your abstract:

- Title – "Title of your project – Abstract"
- **Paragraph 1 – Purpose:** The purpose states the usefulness of the study. It answers the question why you chose the project.
- **Paragraph 2 – Procedure:** The procedure gives a brief summary of what you did; you can explain step by step how you did your experiment. **Data:** What actually happened? You do not need to put graphs, charts or tables for this. They will appear on your project board and in you research paper. Just explain what kind of measurements you obtained.
- **Paragraph 3 - Conclusion**: The conclusions provide a statement about the results of the investigation. Did you prove or disprove your hypothesis? You can also identify unsolved aspects of the original problem or any new problems identified. You should also include any possible future research uses for your findings.

Do not include your name, school, acknowledgements (thank you's) or any work/procedures done by a lab scientists or teacher that may have helped you.

- **Abstract must be typed.**
- **Abstract is limited to one page.**
- **It must be located on your display board in the lower right corner**.
- **Use the Chart on page 12 and 13 to help write the abstract**.

Helpful Hints for Designing Your Display Board

You want to attract and inform. Make it easy for interested spectators and judges to access your study and the results you have obtained. Make the most of your space using clear and concise displays. Make headings stand out, and design graphs and diagrams clearly label them correctly. Leave your glassware and chemicals at home.

Good Title
Your title is an extremely important attention-grabber. A good title should simply and accurately present your research. The title should make the casual observer want to know more.

Take Photographs
Many projects involve elements that may not be safely displayed at the fair, but are an important part of the project. You might want to take pictures of important parts/phases of your experiment to use on your display. If you put pictures of other people, you must have their consent. Do not put any pictures of yourself on your display board.

Be Organized
Make sure your display is logically presented and easy to read. A quick glance should allow anyone to locate the title, the experiment, the results, and the conclusions. When you arrange your display, imagine you are seeing it for the first time.

Pay Attention to Detail
Be sure to adhere to size limitations and safety rules when building your display. Make sure it is sturdy so it will last a long time. Make sure that your name is on the back of your display board.

Be Creative
Make your display stand out. Use colorful headings, charts, and graphs to present your project. Pay attention to the labeling of graphs, charts, diagrams, and tables. Each item should have a descriptive title. Anyone should be able to understand the visuals without further explanation.

Make Sure Your Abstract is on Your Board
All display boards must have the abstract posted in the lower right corner of the board.

Proofread
Make sure to carefully review all of the materials you put on your display board.

Table Space
Don't forget the table space. You may have more then just the display board to show off your project. You should also include your logbook, research paper, and any appropriate models on the table space in front of your display.

Do Not Use Double Sided Tape
Rubber Cement works well, make sure you have parent supervision.

Fill in Empty Spaced on your Board with pictures or diagrams

References, Bibliography or Works Cited

Don't Forget:

- Double space the page
- Use the title "References," "Bibliography," or "Works Cited" at the top of the page
- List your sources in alphabetical order by author (or title if there is not author)
- Use a hanging indent for each entry (the first line of every entry should be at the margin, the next line of it should be a indented ½ inch)
- Follow MLA punctuation carefully

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http://owl.english.purdue.edu/owl/resource/747/01/

This website provides step-by-step directions and examples for different types of sources.

<u>A Parent's Role in the Science Project</u>

- Encourage, support, and guide your child
- Make sure your child feels it is his or her project
- Make sure work is done primarily by the child
- Realize the main goal of the science project is to help your child use and strengthen the skills he or she has learned (especially the scientific method) and develop higher level thinking skills
- Help your child find information by providing rides to libraries or other sources of information
- Help your child use the internet
- Be sure your child is properly supervised and the project is safe
- Develop and follow a timeline to prevent "last minute projects"
- Feel a sense of pride and accomplishment when the project is complete, you and your child have